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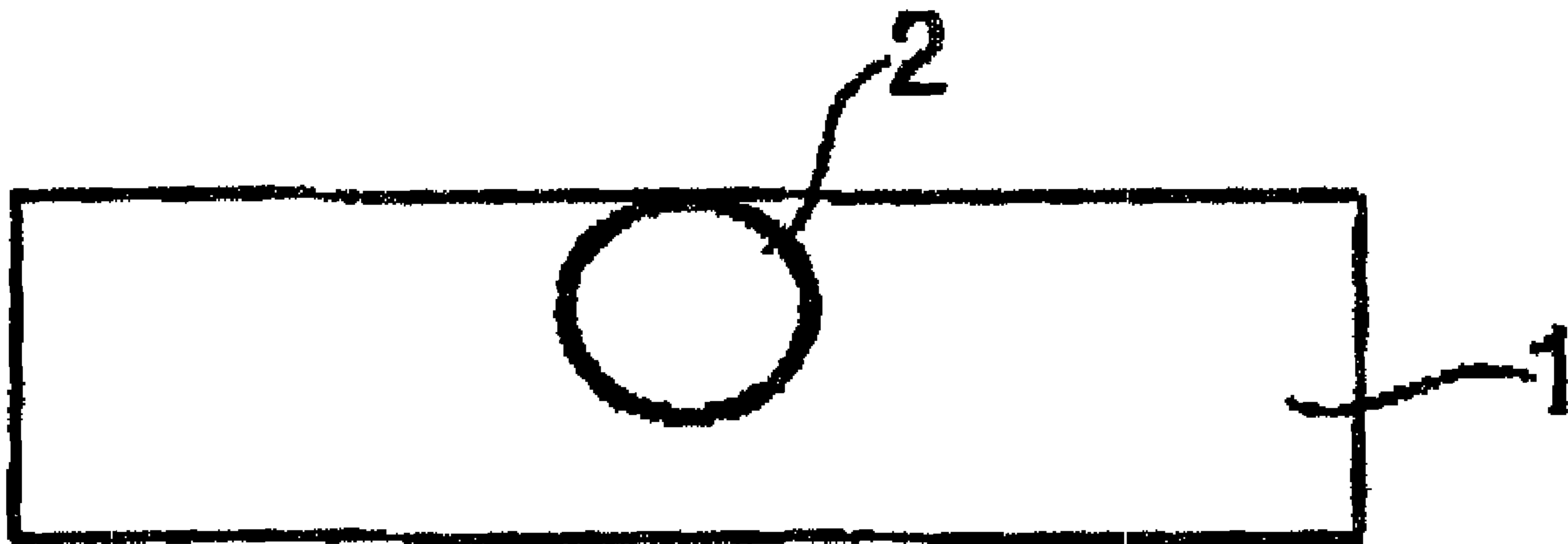
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(54) Titre : PLAQUES THERMO-CONDUCTRICES EN GRAPHITE EXPANSE ET METHODE DE PRODUCTION
(54) Title: HEAT-CONDUCTING PLATES MADE FROM EXPANDED GRAPHITE AND METHOD FOR THEIR
PRODUCTION



(57) Abrégé/Abstract:

The invention relates to heat-conducting plates made from compressed expanded graphite material, the layer planes of which are preferably arranged so as to be parallel to the surface so that the heat conduction in a lateral direction is preferred to the heat conduction that is perpendicular to the plate plane. The heat-conducting plates in accordance with the invention are suitable for the transmission of heat of floor-, wall-, ceiling- and other flatly arranged heating systems, air-conditioning ceilings, for the transmission of heat and the dissipation of heat in buildings, motor cars, in machines and installations and containers. The heat-conducting plates are dimensionally stable without the addition of binder and aggregates and can be produced in a continuous process.

Abstract

The invention relates to heat-conducting plates made from compressed expanded graphite material, the layer
5 planes of which are preferably arranged so as to be parallel to the surface so that the heat conduction in a lateral direction is preferred to the heat conduction that is perpendicular to the plate plane. The heat-conducting plates in accordance with the invention are
10 suitable for the transmission of heat of floor-, wall-, ceiling- and other flatly arranged heating systems, air-conditioning ceilings, for the transmission of heat and the dissipation of heat in buildings, motor cars, in machines and installations and containers. The
15 heat-conducting plates are dimensionally stable without the addition of binder and aggregates and can be produced in a continuous process.

Heat-conducting plates made from expanded graphite and
method for their production

Description

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The present invention relates to heat-conducting plates made from expanded graphite without binding agents with preferred heat conduction parallel to the plate surface, and also to a method for their production.

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The heat-conducting plates in accordance with the invention are suitable *inter alia* for the transmission of heat of floor-, wall-, ceiling- and other flatly arranged heating systems, air-conditioning ceilings. In addition to these applications in building engineering, the heat-conducting plates in accordance with the invention can be used for the transmission of heat and dissipation of heat in motor cars, in machines and installations and in temperature-controlled containers, for example for preserving foodstuffs.

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Special heat-conducting heating layers are used in conjunction with floor-, wall- and ceiling-heating systems, in order to achieve pleasant room air conditions. Conductive flooring plaster, building plaster and other heating layers that contain additives made from graphite in order to improve the heat conductivity are known from Patent Applications DE 196 22 788 A, DE 100 49 230 A and DE 198 02 230 A, DE 195 38 686 A, and DE 196 00 228 A.

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In Patent Applications DE 41 17 077 A, DE 41 17 074 A and DE 40 167 10 it has been proposed that moulded bodies made from expanded graphite be used in the construction of floor-heating systems and other heating installations and also in devices for sound-insulation and electromagnetic shielding. These moulded bodies are produced in that either

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- expandable graphite is incompletely expanded in a fluidized bed or already in the final mould whilst subject to a moderate heat supply and subsequently the expansion is brought to an end at an increased temperature in a mould, or
- expandable graphite that has been incompletely expanded whilst subject to a moderate heat supply is pressed in a mould to form a preform and subsequently the expansion is brought to an end in the mould at a comparatively high temperature, or
- a moist preparation of expandable graphite is expanded in a mould whilst subject to a supply of heat.

The final stage of the expansion is thus in each case effected in the final mould, and after completion of the expansion there is no compacting. The mould must be designed in such a way that on the one hand it is substantially closed so that the material takes on the desired geometry, but on the other hand it permits the escape of air. The moulded bodies that are obtained with this method are to be dimensionally stable and have homogeneous density. In preferred variants of the above-mentioned methods, various aggregates and auxiliary substances, in particular binding agents, are added to the expandable graphite.

Since the expansion of the expandable graphite that is uniformly distributed in the mould takes place in all directions in space in the method of production described above, the layer planes of the graphite in the moulded bodies do not take on any distinct preferred orientation and the heat conductivity of these moulded bodies will therefore hardly be directionally dependent. For use in connection with flatly arranged heating elements, such as, for example, wall-, ceiling- or floor-heating systems, however, preferred heat conduction in plane is desirable in order to achieve rapid and uniform heat distribution over the surface. Further disadvantages of the prior

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art described above are the discontinuous method of production and the comparatively high outlay for the production of the ventable moulds.

In contrast, in accordance with the invention
5 heat-conducting plates are provided that contain compressed expanded graphite material, in which plates the heat conduction is preferentially effected along the plate plane. These heat-conducting plates are dimensionally stable without the addition of binder and aggregates. Furthermore,
10 a method is set forth with which such heat-conducting plates that are made of expanded graphite can be produced in a continuous manner.

In one aspect, the invention provides a lightweight, heat-conducting plate made from binder-free
15 compressed expanded graphite material, wherein the heat conductivity parallel to the plate surface is at least 50% higher than the heat conductivity perpendicular to the plate surface.

In a further aspect, the invention provides a
20 composite or composite component comprising one or more lightweight, heat-conducting plates according to the invention.

In a still further aspect, the invention provides use of the lightweight, heat-conducting plate or the
25 composite according to the invention, in floor-, ceiling-, or wall-heating systems, or air-conditioning ceilings, for the transmission of heat and dissipation of heat in buildings, motor cars, machines, installations or containers.

30 In a yet further aspect, the invention provides a method for the production of a lightweight, heat-conducting

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3a

plate according to the invention, wherein continuously supplied expanded graphite material is compressed in a pre-compressor between textile bands to form a web from which plates are cut to a predetermined length.

5 The production of expanded graphite (expanded graphite material) is known *inter alia* from US-A 3 404 061. To produce expanded graphite, graphite-intercalation compounds or graphite salts, for example graphite hydrogen sulphate or graphite nitrate, are heated in a shock-like
10 manner. Thereupon, the volume of the graphite particles is increased by the factor 200 to 400 and the bulk density drops to 2 to 20 g/l. The so-called expanded graphite material thus obtained consists of vermiform or concertina-shaped aggregates. If the completely expanded graphite is
15 compacted under the directional action of a pressure, the layer planes of the graphite are preferably arranged so as to be perpendicular to the direction of action of the pressure, with the individual aggregates hooking up with each other. As a result, planar structures, for example
20 webs or plates, can be produced that are self-supporting without the addition of binders. It is on this effect that is known from the production of graphite foils with a thickness of 0.15 to 3 mm, used, for example, as semi-finished products for the production of flat seals, that the
25 production and mode of functioning of the heat-conducting plates in accordance with the invention are based. On account of

the directional action of the pressure during the compacting of the expanded graphite material, the heat-conducting plates in accordance with the invention have a structural anisotropy and from this results the advantageous anisotropy of certain properties of the heat-conducting plates in accordance with the invention. On account of the preferred orientation of the graphite layer planes parallel to the plate surface, the heat conduction in the heat-conducting plates in accordance with the invention that is parallel to the surface (that is, in a lateral direction) is preferred to the heat conduction that is perpendicular to the plate surface. Thus the heat-conducting plates in accordance with the invention combine the heat-conductivity anisotropy that is known from graphite foil with other properties of expanded graphite that are advantageous for the intended applications, such as low weight, high temperature stability, capability of providing electromagnetic shielding, flame-retarding effect, corrosion-resistance and good adaptation to adjacent surfaces.

Further details, features and advantages of the invention emerge from the following detailed description, the figures and the exemplary embodiments. In the figures:

Figures 1 a-c show cross-sectional representations of the heat-conducting plate in accordance with the invention with pipes for the distribution of a heat-carrier;

Figure 2 shows a cross section through a component for an air-conditioning ceiling with the heat-conducting plate in accordance with the invention;

Figure 3 shows a plan view of a heat-conducting plate in accordance with the invention with a heating spiral embedded therein.

5 Typically, the heat-conducting plates in accordance with the invention are between 8 and 50 mm thick. However, plates having thicknesses between 20 and 40 mm are particularly preferred. Typical dimensions for wall, floor and ceiling elements used in structural
10 engineering lie between 100 x 60 and 300 x 100 cm. The heat-conducting plates in accordance with the invention are not, however, tied to these dimensions. The length and width can be selected in accordance with the intended application, since the production method does
15 not set any narrow limits. The density of the expanded graphite in the heat-conducting plates in accordance with the invention lies in the range of 0.01 to 0.5 g/cm³, preferably between 0.05 and 0.25 g/cm³. For use in structural engineering, the heat-conducting
20 plates in accordance with the invention therefore meet the demands with respect to lightweight plates (bulk density < 400 kg/m³).

The heat conductivity of the heat-conducting plates in
25 accordance with the invention in the direction parallel to the plate surface amounts to at least 5.5 W/m*K and in the direction perpendicularly to the plate surface amounts to 3.6 W/m*K. The heat conductivity parallel to the surface is thus at least 50% greater than
30 perpendicularly to the surface. The ratio of the heat conductivity parallel to the plate surface to the heat conductivity perpendicularly to the plate surface is greater, the more intense the compression of the expanded graphite is, that is, the greater the density
35 of the heat-conducting plate is.

The heat-conducting plate in accordance with the invention can be used, for example, in conjunction with heating systems that utilize a fluid heat-carrier or

even in conjunction with electrical heating systems. Pipes made from metal, for example copper, or plastics material, for example polypropylene or cross-linked polyethylene, are provided in the heat-conducting plate in accordance with the invention for the transportation of a fluid heat-carrier, for example water. Pipes made from metal are preferred on account of the superior heat transfer. A pipe 2, for example, is embedded so far in the heat-conducting plate 1 that it ends so that it is flush with the plate surface (Figure 1a) or is partly embedded therein, that is, a portion of the circumference of the pipe 2 projects out from the surface of the heat-conducting plate 1 like a relief (Figure 1b). The space 3 around the pipes projecting out of the plate surface is filled in with a suitable material, for example flooring plaster or ground graphite material to which flooring plaster is applied. Heating wires for electrical heating can be laid on the plate surface or pressed into the plate surface. Alternatively, pipes 2 or heating elements can also be laid between two heat-conducting plates 1 and 1' which are then pressed together (Figure 1c). It has been shown that such composite plates made from two heat-conducting plates of expanded graphite that have been pressed together are very stable; they cannot work loose again at the boundary surface of the plates. Plates of little thickness are preferably used for this variant in order to obtain a composite plate whose thickness only slightly exceeds the diameter of the embedded pipe. A large distance between the plate surface and the heating element or pipe embedded in the plate is disadvantageous since the heat conduction in the heat-conducting plates in accordance with the invention perpendicularly to the plate plane is less than that parallel to the plate plane. The pipes or heating wires are arranged in such a way that they enable there to be uniform distribution of the heat over the plate surface, for example in a meander-shaped

or spiral pattern. For this reason, the heating wires of electrical heating systems are preferably arranged in a grid- or meander-shaped manner. On account of the high level of heat conductivity of the heat-conducting plate in accordance with the invention, the heating pipes or wires on the surface that is to be heated need not, however, form such a dense grid system as that required in the case of conventional wall-, ceiling- or floor-heating systems in order to achieve uniform heat distribution. This means that the meshes of the grid, the loops of the meander or the windings of the spiral need be less narrow and fewer grid meshes, meander loops or spiral windings are required per area. As a result, the length of the pipe or heating wire is reduced. The need for pipe material or heating wire can thus be reduced by up to 50% with the heat-conducting plate in accordance with the invention in comparison with wall-, ceiling- or floor-heating systems without a heat-conducting plate.

Embedding pipes and heating wires in the heat-conducting plate in accordance with the invention takes place either directly at the construction site or else prefabricated components consisting of the heat-conducting plates in accordance with the invention and heating wires or pipes are used.

In their simplest embodiment, the heat-conducting plates in accordance with the invention consist completely of expanded graphite. Aggregates and auxiliary substances, in particular binding agents, are not required for the functioning and dimensional stability of the heat-conducting plates in accordance with the invention. However, the heat conductivity and the mechanical stability of the plates in accordance with the invention can be increased by adding metal and/or carbon fibres to the starting material expanded graphite material. The length of these fibres

preferably amounts to 0.2 to 5 mm. The mass fraction of the fibres preferably lies between 5 and 40%.

A further embodiment of the heat-conducting plate in accordance with the invention is characterised in that

5 the heat-conducting plates are completely or partly impregnated with plastics materials, for example resins or thermoplastics, in order to increase the density and the resistance to mechanical and other environmental effects.

10 Alternatively or in addition, one or more surfaces of the heat-conducting plates can be provided partially or completely with coats of paint, coverings or coatings that perform certain functions, such as *inter alia* the improvement of the visual effect and facilitation of
15 the handleability of the heat-conducting plates, fire-protection, effect as a water-vapour barrier, improvement of the heat-insulation and sound-insulation and reduction in the susceptibility to shock.

A covering, for example a layer of varnish, or a layer
20 of plastics material on the plate surface preferably gives rise not only to an improvement in the visual effect and the ease of handling, but also takes over or assists with certain functions in terms of building physics. For example, an improvement in the
25 electromagnetic shielding is achieved with a metalliferous layer of varnish. A reflective layer of varnish improves the radiation of heat into the adjacent space. These functions are also performed by a coating with a metal foil, for example aluminium
30 foil.

Heat-insulating coatings consist, for example, of expanded polystyrene, polyurethane or glass wool or rock wool. These are preferably provided on the surface of the heat-conducting plates that is remote
35 from the space to be heated in order to avoid heat losses.

Further suitable materials for coating the heat-conducting plate in accordance with the invention with

a further functional layer are non-woven fabrics, and papers, wood veneers, planar textile materials (woven fabrics, layered fabrics, warp-knitted fabrics, knitted fabrics and similar), perforated sheets and also films or foils made from plastics material or metal. These laminated composites are particularly advantageous, because they perform additional functions in terms of building physics (see above) in addition to heat conduction and because the mechanical stability of the heat-conducting plate is strengthened by the composite. The end faces of the heat-conducting plates are preferably coated with suitable materials, for example for improving the visual effect and reducing the susceptibility to shock, for example with wood veneers, plastics or metal bands.

For further use, in terms of structural engineering, of the heat-conducting plate in accordance with the invention it is advantageous to provide at least one surface partly or completely with a coating that enables there to be connection to other building materials. Suitable coating materials for this are filler, building-plaster and flooring-plaster and also mortar and concrete masses.

The heat-conducting plates in accordance with the invention made from expanded graphite are not restricted to the simple flat plate form. The heat-conducting plates in accordance with the invention contain, for example, structural elements, such as depressions, grooves or beads, knurls and diamond-shaped knurling or grained surfaces, joints and openings and other partial deformations. Furthermore, it is possible to plug into the plates in accordance with the invention pins, angle irons, hollow punches, hooks, anchors or other connecting elements that project from the plate surfaces or end faces and establish a form-locking and/or force-locking

connection with adjacent heat-conducting plates or other components.

- Complete components, preferably lightweight components, can also be produced from the heat-conducting plates in accordance with the invention in conjunction with standard materials pertaining to structural engineering. These composite components comprise at least one heat-conducting plate in accordance with the invention and at least one further component, for example wooden boards, gypsum plaster boards, bricks, pumice, lime sandstone, fireclay bricks, tiles, cellular concrete stones or slabs, Liapor stones, or clinker.
- For the production of the above-mentioned composites made from heat-conducting plates of expanded graphite and the above-mentioned laminates or building materials, either the heat-conducting plate or/and the other constituent of the composite is provided with an adhesive or another means that effects the adhesion of the composite partners, for example filler or building plaster or mortar or another binding agent, on the surface that is to be connected to the other respective material. However, form-locking connections between the individual constituents of the composite are also possible, for example tongue-and-groove connections or snap connections, such as, for example, resilient hooks.
- The heat-conducting plates in accordance with the invention are produced in a continuous process that includes the following basic steps: (i) pre-compression of the expanded graphite material with optional post-compression to form a web of the desired density and thickness and (ii) reworking processes, if applicable, for coating, shaping and producing material composites. The reworking processes are advantageously effected as far as possible in a continuous manner on the web and

only as far as is necessary in a discontinuous manner on the plates cut to length from the web.

In the case of the known procedure for producing
5 graphite foil, the expanded graphite particles are guided over a pre-compressor and pairs of rollers, as a rule two pairs of rollers, with the expanded material being continuously supplied to the pre-compressor. Arranged between the pairs of rollers there are heating
10 zones in which the material is heated. The temperatures in these heating regions are approximately 600°C and are used to displace the air out of the material that is becoming denser. The expanded graphite material both in the pre-compressor and in the
15 pairs of rollers experiences a directional effect of pressure that gives rise to parallel orientation of the layer planes in the graphite particles. It is possible to obtain very thin foils (0.15 to 3 mm thick) with this method.
20 Such small thicknesses are not required for the heat-conducting plates in accordance with the invention. It has been shown that webs with a distinct orientation of the layer planes of the graphite are already obtained from expanded graphite material with a bulk density in
25 the region of 2.5 to 5 g/l by means of pre-compression between textile bands, that is, without further compression by pairs of rollers.

The webs can be processed further, for example
30 impregnated or coated with other materials, when coming directly out of the pre-compressor.
If applicable, carbon or metal fibres are added to the expanded material, used as the starting material, before it is passed to the pre-compressor.
35 If a plate thickness of only 10 to 15 mm and/or a high material density (around 0.5 g/cm³) is required, however, it is expedient to guide the graphite web, coming continuously from the pre-compressor, further

between one and/or two pairs of rollers, with heating between the pairs of rollers also being possible thereby. Advantageously, this rolling process is combined with the application of cover layers of other planar materials, such as, for example, non-woven fabrics, and papers, planar textile materials (woven fabrics, layered fabrics, warp-knitted fabrics, knitted fabrics and similar) and also films or foils of plastics material or metal.

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In the following stage of the method, which follows on either continuously or discontinuously, the graphite webs that are obtained from the continuous pre-compression process with optional post-compression or the plates that are cut or punched out of these webs are brought into the desired form for use. This stage of the method, generally termed reworking in the following, includes a wide variety of processing processes, such as impregnation, coating, partial re-shaping and/or compression of the plates/webs in a cold-press method, trimming, shaping by, for example, mechanically processing the webs/plates, embedding heating pipes or wires and also the production of composite components consisting of the heat-conducting plates in accordance with the invention and common building materials.

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There is a wide variety of suitable methods available in accordance with the prior art for the production of impregnations and surface coatings. Impregnation can be effected by, for example, using the dipping, spraying or printing method, using the vacuum method or using a combination of vacuum and printing methods and also in a fluidized bed.

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By the term coating all processes are understood here that are used to cover the surface of the plate in accordance with the invention with a layer of a different material. This material can not only be

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dissolved or dispersed in a fluid, but can also be present in a pulverulent form and also as a planar laminate. Such coatings can be produced by, for example, painting, varnishing, spraying, laminating or rolling-on methods, in which case in these methods, in contrast with the impregnation method, complete saturation of the interior of the plate in accordance with the invention does not take place. In a special embodiment of the invention the components are covered with a plastics melt. This takes place, for example, in a tempered fluidized bed, in an extrusion process or, if the plate size permits it, even in an injection-moulding process.

Composites formed between the heat-conducting plates in accordance with the invention and other laminates, such as paper webs, films, metal sheets, wood veneers, non-woven fabrics or planar textile formations or semi-finished building products, such as polystyrene and polyurethane plates, glass-fibre and rock-wool plates, wooden boards, gypsum plaster boards, fireclay bricks, bricks, lime sandstone, pumice, tiles, cellular concrete stones or slabs or Liapor stones, are produced by applying adhesives, binding agents, fillers, mortar and building plaster to one or both of the surfaces that are to be connected together or by constructing a form-locking connection between the materials, for example a tongue-and-groove connection or snap connections, such as resilient hooks.

By means of cold-press methods the graphite webs can again be shaped and compressed over their whole surface or partially by means of pairs of rollers or discontinuously by means of presses. By means of embossing rollers shaping can be carried out at the same time for compression purposes, for example to produce grooves or beads, knurls and diamond-shaped knurling or grained surfaces. This can take place both before and after the application of cover layers.

Suitable methods for producing grooves, joints or openings are, for example, cutting, punching, embossing, milling, turning and planing. A particularly preferred method of mechanical processing is water-jet cutting. Alternatively, abrasive particle jets (sand blasts, spherules of frozen CO₂) or laser beams can be used for processing.

If applicable, functional components, such as pipes for the distribution of a heat-carrier or heating wires, are also introduced at the reworking stage.

Alternatively, this can also take place directly in situ at the construction site.

Reworking is effected discontinuously in particular if coatings are produced from materials or composites with materials that are not available as rolled products, but only as plate products, for example metal sheets or plate products made from cardboard, gypsum and wood. The discontinuous procedure is also necessary if such surfaces that do not yet exist at all in the web obtained directly after compression, such as the end faces of the plates that first develop when cutting the webs/cutting the plates to length, have to be coated or processed in another way. Furthermore, discontinuous reworking allows the work sequences to be separated in time and space.

Exemplary embodiment 1

A web having a thickness of 25 mm was produced by continuously compressing pulverulent expanded graphite material between two textile bands. A sample that had a length and a width of in each case 30 cm was cut out from this web and the density of this sample was determined. A value of 0.027 g/cm³ was ascertained. Moreover, the specific heat conductivity and the specific electrical resistance of the sample were measured in the x-, y- and z-direction. The results are compiled in Table 1.

Table 1

Measured variable	x-direction	y-direction	z-direction
Spec. electrical resistance/ $\Omega \mu\text{m}$	370	600	375
Spec. heat conductivity W/m*K	5.7	5.5	3.4

Both the electrical and the heat conductivity have distinct anisotropy. The conduction of heat and electrical current is preferably effected parallel to the plate surface, that is, along the graphite layer planes.

Exemplary embodiment 2

10 Laminated composite components, whose structure is shown in Figure 2, were produced with an area of 30 x 70 cm. The laminated composite comprises an 18 mm thick moulded fibre board 4, a 9 mm thick heat-conducting plate 1 made from compressed expanded
 15 graphite material and a 1 mm thick perforated sheet 5. The moulded fibre board 4 on the rear side of the heat-conducting plate is used for heat-insulation, the perforated sheet 5 on the front side being used to improve the visual effect. The moulded fibre board and
 20 heat-conducting plate were bonded together. The perforated sheet embraces the laminated composite on the longitudinal sides and is held fast by means of longitudinal slots 6, 6' in the moulded fibre board 4. This laminated composite is suitable, for example, for
 25 the construction of an air-conditioning ceiling. Embedded in the surface of the heat-conducting plate 1 that is remote from the moulded fibre board 4 there is a pipe that is wound in the form of an Archimedean spiral 7 (called heating spiral 7 in the following),

has a diameter of 6 mm and is made from plastics material, the pipe being embedded in such a way that it ends so that it is flush with the plate surface. The diameter of the outermost winding of the spiral amounted to 21 cm. The spiral 7 was positioned substantially in the centre of the plate 1, that is, the distance of the outermost winding of the spiral 7 to the right-hand edge of the plate 1 was approximately as great as to the left-hand edge of the plate 1, and the distance of the outermost winding of the spiral to the upper edge of the plate 1 was approximately as great as to the lower edge of the plate 1. Figure 3 shows this heat-conducting plate 1 in a plan view with the heating spiral 7 embedded therein. For comparison purposes, a laminated composite of the same dimensions was produced that contained, instead of the heat-conducting plate in accordance with the invention, a gypsum plaster board with three heating spirals embedded therein next to one another and of the same size as the heating spiral installed in the graphite plate. Hot water at a temperature of 50°C flowed through the heating spirals in both test arrangements. The change in the temperature distribution on the surfaces of both plates as a function of the duration of the through-flow of hot water was tracked by means of infrared thermography. At the beginning of the test, both surfaces had a temperature of 25°C; temperature gradients over the surface could not be identified. The further time characteristics of the change in temperature of the plates in the region surrounded by the heating spiral and in the periphery thereof can be seen in Table 2.

	Heating spiral in heat-conducting plate in accordance with the invention		Heating spiral in gypsum plate	
Duration/min	T/°C Region surrounded by heating spiral	T/°C Periphery	T/°C Region surrounded by heating spiral	T/°C Periphery
0	25	25	25	25
1:15	30-32	27-29	27-29	25
2:15	32-34	27-31	29-30	27-29
3:45	34-36	31-34	30-33	28-30
8	36-37	34-36	34-36	31-33
15	37-39	34-37	35-37	32-34

5 Clearly more rapid heating and more uniform temperature distribution are achieved in the test arrangement with the heat-conducting plate in accordance with the invention, owing to the high lateral heat conductivity of the expanded graphite, with just one heating spiral in contrast with the test arrangement with a conventional gypsum plate and three heating spirals.

List of Reference numerals

- 1,1' Heat-conducting plates
- 2 Pipe for the through-flow of a fluid heat-
- 5 transporting medium
- 3 Space filled in with flooring plaster or ground
graphite material
- 4 Moulded fibre board
- 5 Perforated sheet
- 10 6,6' Longitudinal slots
- 7 Heating spiral

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CLAIMS:

1. A lightweight, heat-conducting plate of a floor-, ceiling- or wall-heating system, or an air-conditioning ceiling, for the transmission of heat and dissipation of heat
5 made from binder-free compressed expanded graphite material, wherein the heat conductivity parallel to the plate surface is at least 50% higher than the heat conductivity perpendicular to the plate surface, and wherein the thickness of the plate is between 8 mm and 50 mm and the density of the plate material is
10 between 0.01 g/cm³ and 0.4 g/cm³.
2. The lightweight, heat-conducting plate according to claim 1, wherein the heat conductivity parallel to the plate surface is at least 5.5 W/m*K.
3. The lightweight, heat-conducting plate according to
15 claim 1 or 2, wherein the thickness of the plate is between 15 mm and 40 mm.
4. The lightweight, heat-conducting plate according to any one of claims 1 to 3, wherein the density of the plate material is between 0.05 g/cm³ and 0.25 g/cm³.
- 20 5. The lightweight, heat-conducting plate according to any one of claims 1 to 4, wherein the plate has an impregnation.
6. The lightweight, heat-conducting plate according to any one of claims 1 to 4, wherein at least one surface of the
25 plate is completely or partly covered with a varnish or a plastics material.

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7. The lightweight, heat-conducting plate according to any one of claims 1 to 4, wherein at least one surface of the plate is completely or partly coated with a metal or plastics foil or film, a perforated sheet, a textile flat-shaped
5 article, a wood veneer, a non-woven fabric, or paper.
8. The lightweight, heat-conducting plate according to any one of claims 1 to 4, wherein at least one surface of the plate is completely or partly coated with a heat-insulating material.
- 10 9. The lightweight, heat-conducting plate according to claim 8, wherein the heat-insulating coating contains expanded polystyrene, polyurethane, glass wool or rock wool.
10. The lightweight, heat-conducting plate according to any one of claims 1 to 4, wherein at least one surface of the
15 plate is completely or partly coated with a filler, building-plaster, flooring-plaster, mortar or concrete mass.
11. The lightweight, heat-conducting plate according to any one of claims 1 to 10, wherein the plate has at least one of a structural element selected from the group consisting
20 of depressions, grooves, beads, knurls, diamond-shaped knurling, grained surfaces, joints and openings.
12. The lightweight, heat-conducting plate according to any one of claims 1 to 11, wherein the plate has pins, angle irons, hollow punches, hooks, anchors or other
25 arrangements for establishing a force- or form-locking connection with another lightweight, heat-conducting plate.

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13. The lightweight, heat-conducting plate according to any one of claims 1 to 12, wherein the lightweight, heat-conducting plate contains pipes for the distribution of a fluid heat-carrier medium or wires for an electrical heating
5 system.

14. The lightweight, heat-conducting plate according to claim 13, having pipes for the distribution of a fluid heat-carrier medium, wherein the pipes are embedded in the plate surface in such a way that the pipe wall ends so that it is
10 flush with the plate surface.

15. The lightweight, heat-conducting plate according to claim 13, having pipes for the distribution of a fluid heat-carrier medium, wherein the pipes are embedded in the plate surface in such a way that a portion of the pipe circumference
15 projects out from the plate surface like a relief.

16. A composite consisting of two lightweight, heat-conducting plates according to any one of claims 1 to 12, lying one on top of the other, wherein pipes for the distribution of a fluid heat-carrier medium or wires for an
20 electrical heating system are embedded between the two plates.

17. The lightweight, heat-conducting plate according to claim 13, having heating wires for electrical heating, wherein the heating wires are embedded in the plate surface.

18. The lightweight, heat-conducting plate according to
25 claim 13, having heating wires for electrical heating, wherein the heating wires are laid on the plate surface.

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19. A composite component for use in structural engineering, comprising at least one lightweight, heat-conducting plate according to any one of claims 1 to 12, and at least one further component selected from the group
5 consisting of wooden boards, gypsum plaster boards, fireclay bricks, tiles, cellular concrete stones or slabs, bricks, lime sandstone, pumice, Liapor stones, and clinker.

20. The composite component according to claim 19, wherein the components are connected together by means of an
10 adhesive, an adhesion-promoter or a binding agent.

21. The composite component according to claim 19, wherein the components are connected together in a form-locking manner.

22. A method for the production of a lightweight, heat-
15 conducting plate according to any one of claims 1 to 4, wherein continuously supplied expanded graphite material is compressed in a pre-compressor between textile bands to form a web from which plates are cut to a predetermined length, wherein the thickness of the web is between 8 mm and 50 mm and the density
20 of the web material is between 0.01 g/cm^3 and 0.5 g/cm^3 .

23. The method according to claim 22, wherein the web obtained in the pre-compressor is subsequently compressed between pairs of rollers, with pre-compression and post-compression constituting a continuous process run.

25 24. The method according to claim 23, wherein the process of post-compression between pairs of rollers is combined with the application of a coating.

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25. The method according to any one of claims 22 to 24, wherein the pre-compressed web is impregnated or coated, wherein the steps of compression, impregnation or coating constitute a continuous process run.

5 26. The method according to claim 25, wherein the post-compressed web is impregnated or coated, wherein the steps of compression, impregnation or coating constitute a continuous process run.

10 27. The method according to any one of claims 22 to 26, wherein the web or the plates cut to length therefrom are mechanically processed and structured with a water jet, laser beam or an abrasive particle jet.

15 28. The method according to any one of claims 22 to 27, wherein the web or the plates cut to length therefrom are structured with embossing rollers.

29. The method according to any one of claims 22 to 28, wherein the web or the plates cut to length therefrom are shaped and compressed by means of cold-pressing.

20 30. The method according to any one of claims 22 to 29, wherein pipes for the distribution of a fluid heat-carrier medium are embedded in the surfaces of the web or the plates cut to length therefrom.

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Fig. 1a

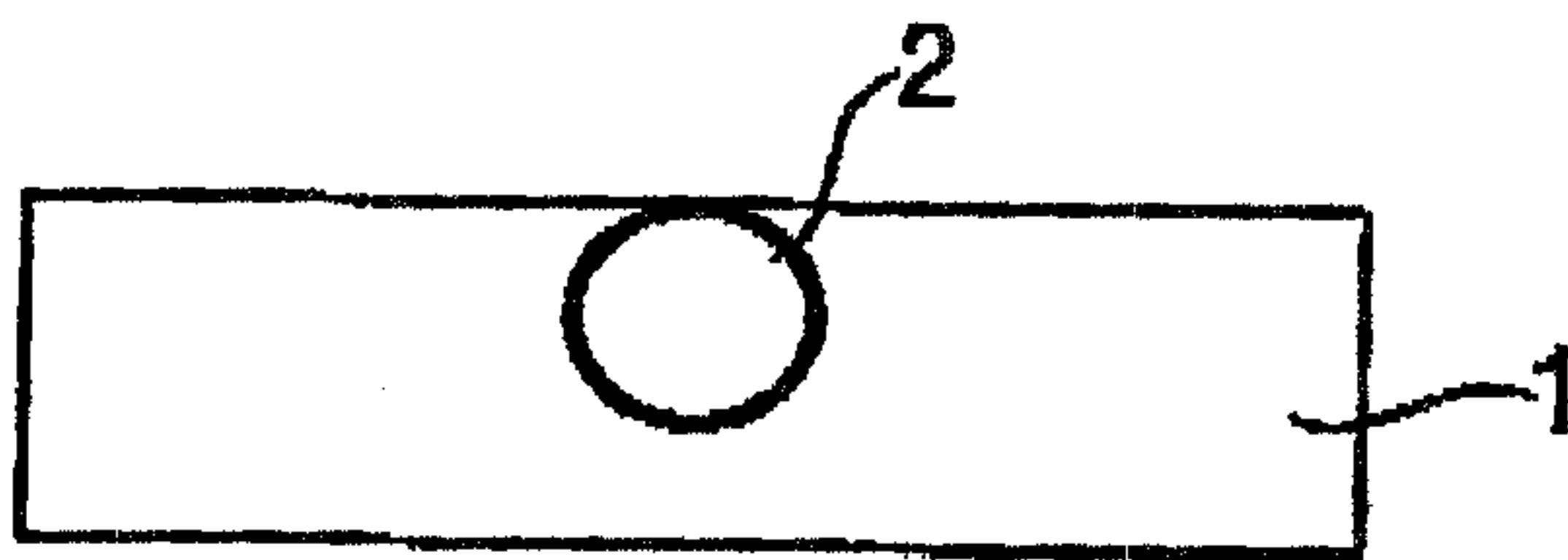


Fig. 1b

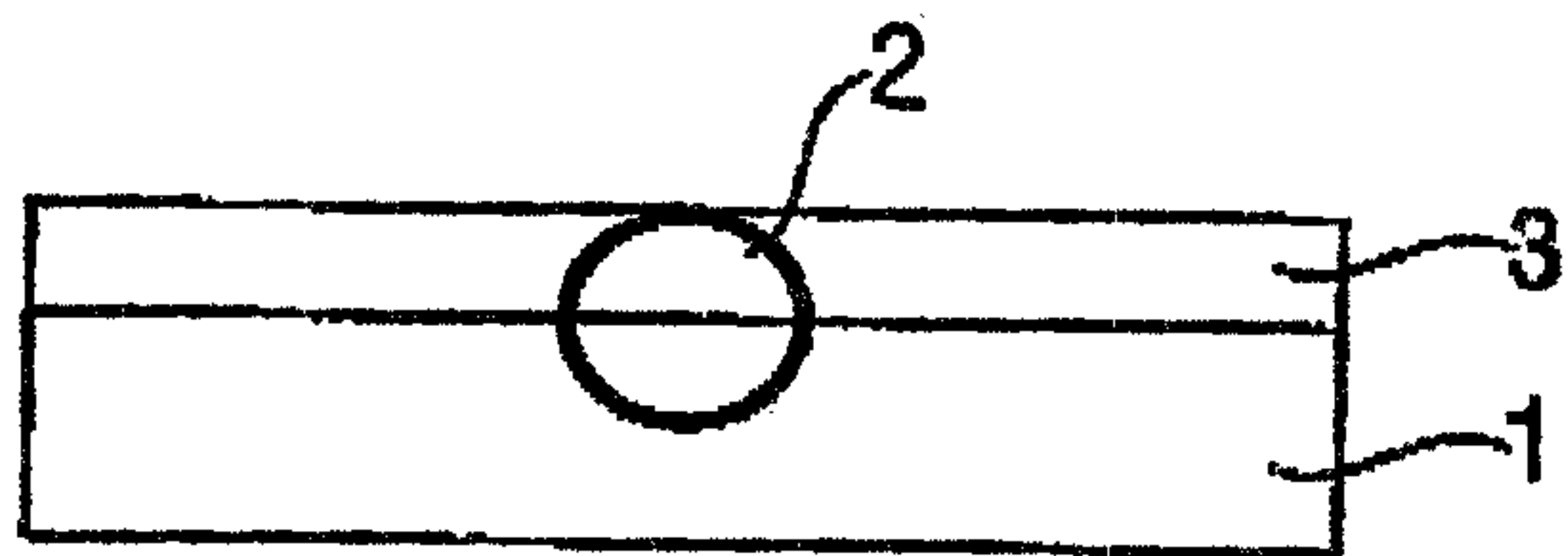
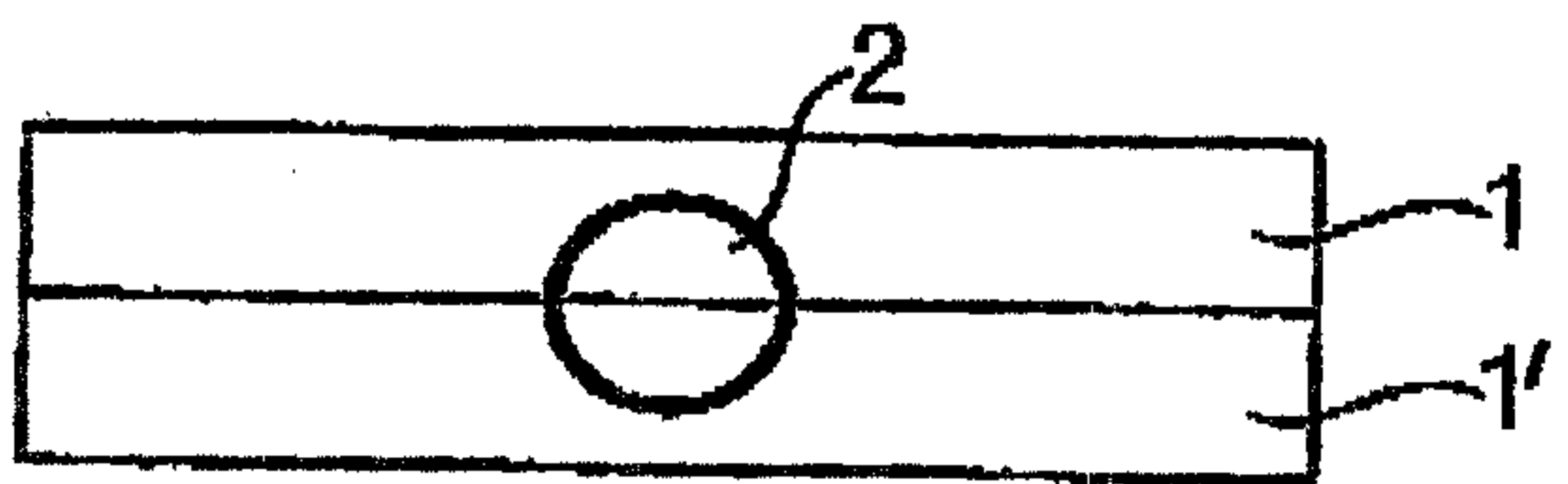
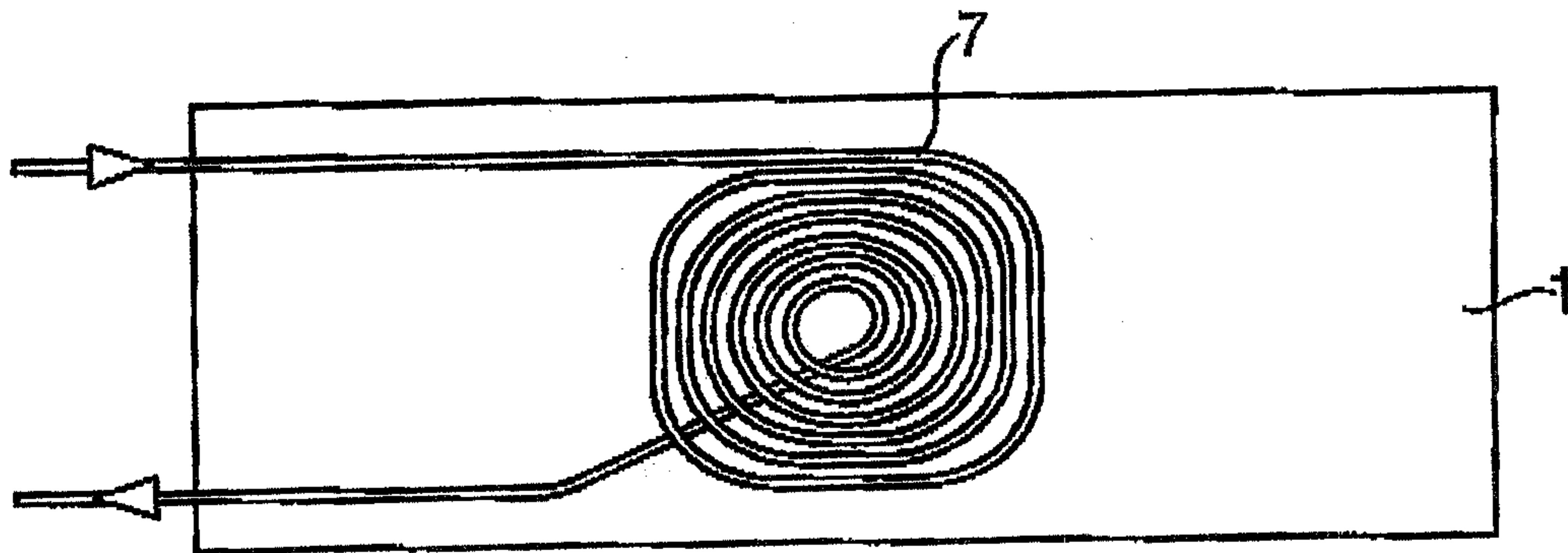
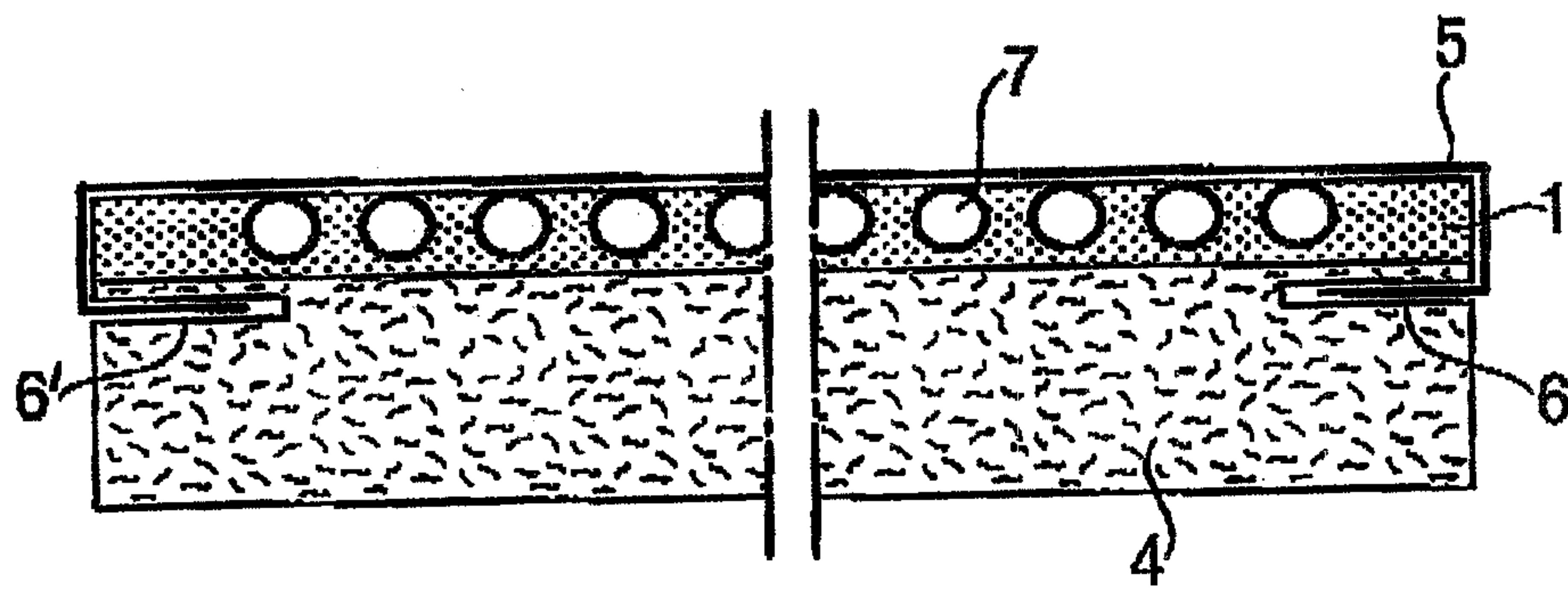


Fig. 1c



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Fig. 2**Fig. 3**

