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[CZ/CZ]; Osvetová 724, 149 00 Praha 4 (CZ). **BURDA, Michal** [CZ/CZ]; Matechova 9, 140 00 Praha 4 (CZ).

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(74) Agent: **REICHEL, Pavel**; Lopatecká 14, 147 00 Praha 4 (CZ).

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(71) Applicant (for all designated States except US): **MDI TECHNOLOGIES, S.R.O.** [CZ/CZ]; Ohradni 1394/61, 140 00 Praha 4 (CZ).

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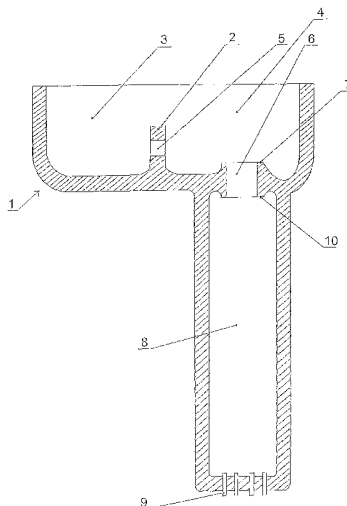
(72) Inventors; and

(75) Inventors/Applicants (for US only): **JAKES, Petr**

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(54) Title: APPARATUS AND PROCESS FOR PRODUCTION OF MINERAL OR GLASS FIBRES.



(57) Abstract: The apparatus for preparing a homogeneous silicate melt, intended for placing in a microwave oven, comprises a melting chamber (3) with an outlet (5) for the outflow of the melt into the superheating chamber (4), where the superheating chamber (4) consists of a vessel whose outlet (6) is arranged at the bottom of the vessel and is furnished with a raised overflow rim (7) situated with an offset below the lowest point of the outlet (5) of the melting chamber (3), while the outlet (6) from the superheating chamber (4) leads into a vertically or horizontally arranged oblong fiberizing tank (8) furnished with its own heating, in the bottom of which there is an outlet. The outlet (6) of the superheating chamber (4) in the direction of the fiberizing tank (8) can have an offset outlet rim (10). The outlet of the fiberizing tank (8) can consist of a set of nozzles (9) for drawing the continuous mineral or glass fibres. The melting chamber (3), superheating chamber (4) and fiberizing tank (8) are made of ceramic material, for example sintered alumina, or sintered alumina in combination with SiO₂. The nozzles (9) are formed of ceramic elements or elements made of ceramic metals, passing through and projecting from the bottom of the fiberizing tank (8). They can be made of a refractory ceramic material selected, for example, from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al. The nozzles (9) can be furnished with a means for heating them. The melting chamber (3) and superheating chamber (4) are positioned in a microwave oven in the area of the microwave radiation, while the fiberizing tank (8) with its own heating

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is arranged outside this area. The subject of the invention is also a method of uninterrupted production of continuous mineral or glass fibre where the crushed raw material, for example basalt, is exposed to microwave radiation at a frequency of 2450 MHz, whereby it is melted, the molten material, above the area of sedimentation of unmelted remains, continuously passes through into a separate space in which it is heated again by microwave radiation to a temperature of at least 200°C higher than the temperature of the liquidus melt, and from that space it flows continuously across the overflow rim into the column-shaped space beneath it, outside the area of operation of the microwave radiation, in which by electric or high-frequency heating the melt stabilizes at a temperature corresponding to the required viscosity, whereupon it is extruded into the outer space through at least one opening in the bottom, by means of hydrostatic pressure proportional to the overall depth of the melt above this bottom. The area of the openings in the bottom of the column-shaped space is heated to a temperature in the range of 1250 to 1700°C. A charge for the melting chamber (3) for preparing a silicate melt for the production of continuous mineral or glass fibre, which comprises crushed basalt of loose gravelly consistency, can advantageously further include crushed recycle glass made from ordinary recycled bottle glass in quantities of 10 to 80% wgt., or 25 to 50% wgt. Or 25 to 35% wgt. And/ or phonolite. The invention further concerns the use of mineral fibre with a bonding agent for the creation of composite material for the surface finish of objects, for example plastic or metal pipes.

Apparatus and process for production of mineral or glass fibres.

Field of the invention

The invention relates to the arrangement of an apparatus for preparing a homogeneous silicate, particularly basalt melt, an apparatus for uninterrupted production of continuous mineral or glass fibre, a melting chamber and/or superheating chamber and/or fiberizing tank and/or nozzles for uninterrupted production of continuous mineral or glass fibre, a method of uninterrupted production of continuous mineral or glass fibre and a charge for the melting chamber for preparing a silicate melt for the production of mineral or glass fibre and composite material for surface finish of objects.

Description of the prior art

The temperature of a basalt melt under atmospheric pressure is between 1150 – 1300° C. Basalt melts have important rheological properties for industrial use. These properties which influence the geological behaviour of basalts are also important for technological processes. These properties involve the function of its chemical composition, the temperature, the pressure and the content of volatile components. They are the viscosity/visco-elasticity, density, compressibility, content of volatile components, diffusivity, surface stress, wetting property, strength (for example of the fibre). Only a few types of basalt with a certain chemical composition are suitable for melting and the production of continuous fibres.

The classic use for molten basalt is in the form of castings – for example basalt tiles or pipes which are used in industry – for example to convey loose materials - because they have several properties that are better than metal materials. A short basalt fibre is produced by blowing out the molten basalt or by moulding it on a rotating disc. The products are known under a series of names, but most often as mineral fibres. They are excellent insulating materials and are used in construction.

Long, continuous basalt fibres are used in the textile industry, they are called silk or thread and they are intended for twining and subsequently for weaving or for the production of woven textiles. They are manufactured particularly in the countries of the former USSR, in Russia, Ukraine and Georgia. While basalt fibres are comparable to glass fibres (in resistance and strength) the input raw materials in basalt are basically less expensive than the input raw materials for the production of glass. An advantage of basalt fibres compared to glass fibres lies in their greater heat range for use (in glass up to 400°, whilst for basalt it goes up to 700°) and greater resistance to alkalis and acids. Basalt fibres also have somewhat greater strength. Because of the easy access to the raw materials and particularly

because of their superior qualities (superior, in several applications, to those of glass fibres) continuous basalt fibres are in wide use as basalt composites, reinforcement in concrete, insulating panels, filters – screens for molten aluminium, carriers for catalysers in chemical processes etc. The properties of basalt melts, and thus the properties of basalt fibres can be easily modified, both chemically and by heat conditions. It is thus possible to a significant degree to adapt the properties of the fibre to the user's needs (for example refractory fibres for automobile exhausts). Like glass fibres, basalt fibres are more environmentally friendly by comparison with asbestos. Epidemiological studies did not reveal carcinogenic properties either in basalt or in glass fibres, provided a certain ratio was maintained between their length and diameter. Moreover, basalt fibres provide a screen against electro-magnetic radiation.

The classic method of producing continuous basalt fibres at the present time is as follows. The basalt is fed into an oven in crushed form, in the form of gravel or in larger fragments about 18 cm in size. It is melted in classic gas-heated shaft ovens or in electric resistance heating ovens. In order to achieve a perfectly homogenised melt, the basalt stays in the oven for at least ten hours, in some cases for several days (however little the content of crystals and unmelted components, it will cause the fibre to rupture during drawing), several methods of production moreover involve superheating the melt to about 150° C above liquidus. This method of production is being replaced by microwave heating and melting. The use of microwave heating in melting material is known and is described in available literature. It is found for example in US Patents 4,061,451 (from 6.12.1977), 5,254,818 (from 19.10.1993), 5,653,778 (from 5.8.1997), 5,822,879 (from 20.10.1998), European Patent 0 507 668, CZ Patents 288978, 289191 and 289193 etc. In classic melting, for example in an electric resistance oven or an oven heated by gas, the transfer of heat by conduction takes place from the surface to the centre of the particles. In the case of silicates, it is a very slow process, since silicates are not good heat conductors. The circumference of the oven acts like a "radiator", and in using an electrical current, energy in the amount of about 4 kWh was consumed to melt one kilogram of rock. For good homogeneity of the melt, it must remain in the oven for about 10 hours. The fiberizing unit is manufactured from Pt-Rh materials.

During microwave melting heat is transmitted by the radiation and the heating of the material depends on the character of the material, its ability to absorb microwave radiation, on the power input and the quantity of the substance. It involves volume heating and the temperature is highest in the centre of the heated body. The energy requirement is lower, the electrical output needed to melt one kilogram of igneous rock by this method being approximately 2.0 kWh.

In order to draw continuous fibres, a perfectly homogeneous melt is necessary, both from the point of view of the composition and the heat distribution. The goal of this invention is to achieve low energy

consumption and a situation in which the basalt melt is homogeneous without nucleus centres of crystallization, so that the drawn basalt fibre is uniform, without fluctuations in the composition and thickness.

Summary of the Invention

The subject of the invention is an apparatus for preparing a homogeneous silicate, for example basalt melt in a microwave oven, intended for a fiberizing unit for the production of fibre. The basis of the invention lies in the fact that the apparatus comprises a microwave melting chamber with an outlet for the outflow of the melt into the microwave superheating chamber, where the superheating chamber consists of a vessel whose outlet is arranged at the bottom of the vessel and is furnished with a raised overflow rim situated with an offset below the lowest point of the outlet of the melting chamber. The outlet from the superheating chamber leads into a fiberizing tank furnished with its own heating, in the bottom of which there is an outlet – nozzles. In one of the possible embodiments of this invention there can be an independent melting chamber positioned at least in part on an independent superheating chamber. In another embodiment a separate independent melting chamber can be joined by a pipe to an independent superheating chamber.

In the superheating chamber the melt is superheated at high temperatures, at least 200° above liquidus, whereby the melt emerges without crystals and a dissolution or melting of all the nucleus centres in the melt occurs. It is advantageous if the melting chamber and/or superheating chamber are open above, at least in part. It is thus possible to observe and assess the process of preparing a homogeneous basalt melt.

In an alternative embodiment, the melting chamber and the superheating chamber can be formed together as one vessel, furnished with an inner partition with at least one outlet. The vessels can also be arranged vertically. The fiberizing tank can consist of a pipe of suitable diameter and can be formed as an integral whole together with the vessel of the superheating chamber. The outlet of the superheating chamber in the direction of the fiberizing tank can have an offset outlet rim.

The outlet of the fiberizing tank can consist of a set of nozzles for drawing the continuous mineral and glass fibres, particularly basalt fibres.

In one of the embodiments of the invention the outlet from the melting chamber has a diameter in the range of 1 to 5 cm and is arranged above the bottom of the vessel of this chamber at a distance of about one quarter of its interior height, the offset overflow rim of the outlet from the superheating chamber is about 1 cm above the bottom of its vessel, the diameter of the outlet is in the range of 3 to 10 cm and the inner diameter of the fiberizing tank in the shape of a horizontally or vertically placed

pipe is in the range of 10 to 20 cm. The dimension of the fiberizing tank depends upon the number of nozzles used.

The melting chamber, superheating chamber and fiberizing tank are made of ceramic material, for example sintered alumina, or sintered alumina in combination with SiO₂. The nozzles are formed of ceramic elements or elements made of ceramic metals, passing through and projecting from the bottom of the fiberizing tank. They can be of a refractory ceramic material or metal selected, for example, from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al. This solution is significantly cheaper than the nozzles used to date, made from a material based on platinum – rhodium (for example the alloys Pt 90% Rh 10% or Pt 80% Rh 20%). The durability of ceramic compared to platinum nozzles is shorter, however the price of sintered aluminium oxide (alumina) and other ceramic metals compared to the price of platinum is substantially lower. Ceramic nozzles thus become a “consumable” material. Moreover, during use of alumina nozzles (Al₂O₃) a reaction of MgO, Cr₂O₃ and FeO with alumina occurs in the nozzles to form a new mineral phase - a mineral from the spinel group. The refractory nature of the spinel prevents further reaction of the molten basalt with the alumina and a protective layer of spinel forms in the nozzle, which significantly prolongs the life of the nozzle (such a reaction is not possible with glass fibres because no glass contains the components which create spinel in reaction with alumina).

The nozzles can be formed from tubes with an inner diameter of about 4mm; it is advantageous if they are furnished with a means for heating them. If the nozzles remain hot and do not cool off (their temperature is kept above the temperature of the melt), the original viscosity of the basalt is preserved and the basalt flows better through the nozzles. The speed at which the fibre is drawn and the productivity of the whole manufacturing process are thus increased.

The apparatus for uninterrupted production of continuous mineral or glass fibre, for example basalt fibre according to this invention, which comprises a microwave melting chamber and a microwave superheating chamber as described above, is further characterised in that both these chambers are positioned in the oven in the area of the microwave radiation, while the fiberizing tank with its own heating is arranged outside this area. The fiberizing tank is heated by conventional electric resistance or high-frequency heating, where the temperature of the melt is stabilized at a temperature suitable for drawing. The fiberizing tank, like the nozzles, melting chamber and superheating chamber, without limiting their specific structural features for a given apparatus, can advantageously be made of a refractory ceramic material or metal selected from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al. The refractory ceramic material can be sintered alumina Al₂O₃ or sintered alumina in combination with SiO₂.

The subject of this invention is further a method of uninterrupted production of continuous mineral or glass, for example basalt fibre, the basis of which lies in the fact that the crushed raw material, for example basalt, is exposed to microwave radiation at a frequency of 2450 MHz or other in the frequency permitted in the given area, whereby it is melted, the molten material, above the area of sedimentation of unmelted remains, continuously passes through into a separate space in which it is heated again by microwave radiation to a temperature of at least 200° C higher than the temperature of the liquidus melt, and from that space it flows continuously across the overflow rim into the space beneath it, outside the area of microwave radiation, in which by electric or high-frequency heating the melt stabilizes at a temperature corresponding to the required viscosity, whereupon the melt is extruded into the outer space through at least one opening in the bottom, by means of hydrostatic pressure proportional to the overall depth of the melt above this bottom. The height of the column of melt in the fiberizing tank is maintained by means of a level gauge, or is controlled by the quantity of material introduced and by the intensity of the microwave radiation. The large area of the surface of the melt makes it possible to eliminate differences in the hydrostatic pressure on the bottom of the fiberizing tank. The area of the openings in the bottom of the space is heated to a temperature in the range of 1250 to 1700°C. After the extrusion of the melt into the outer space, it is caught up and individual fibres, formed by drawing, immediately cool and harden in the air, whereupon they are wound up.

A charge for the melting chamber for preparing a silicate melt for the production of continuous mineral or glass fibre, which comprises crushed basalt of loose gravelly consistency, can advantageously further include crushed recycled glass in quantities of 10 to 80 % wgt., or 25 to 50 % wgt. or 25 to 35 % wgt. and/or phonolite (rock from the basalt group having a higher content of SiO₂ and alkaline elements). The crushed glass can have granules of 2 to 15 mm. in size and can advantageously be made from ordinary recycled bottle glass. With the addition of recycled glass the basalt acquires properties suitable for drawing, the fibre draws well and it does not tear. The temperature range for melting increases and it affects the viscosity of the drawn fibre which is more supple and elastic.

The subject of the invention is also the use of mineral fibre with a bonding agent for the creation of composite material for the surface finish of objects, for example plastic or metal pipes. The mineral fibre can advantageously be basalt fibre in a layer 2 to 20 mm. thick, formed by a connected wound-up fibre with binding agent on the surface of the object, for example with an epoxy resin or polyurethane resin. In plastic pipes for conducting pressurized water, their strength is significantly increased. The layer of basalt fibre with resin reinforces the pipe against surface damage, but also against increases in internal pressure of the liquid in the pipe. In metal pipes their resistance against corrosion, the surrounding soil, water and weather is increased. The fibres can be wound directly onto the pipe from

the nozzles during drawing of the fibres. It is not necessary to lubricate the surface of the fibre when an organic substance is applied to the surface, for example silanes, modified starches or oil. Alternatively, the fibre can be wound around the pipe by means of drums, by use of the "roving" technique, that is with a bundle of fibres with minimal twisting, about two or three twists to a standard metre of fibre.

Brief description of the drawings

For a better understanding, a simplified embodiment of the invention is shown in Figures 1 and 2 and is then described in greater detail. The melting chamber and superheating chamber in Figure 1 are formed together as one vessel, furnished with an inner partition with one outlet. The fiberizing tank consists of a pipe and is formed as an integral whole together with the vessel of the superheating chamber. In Figure 2 the melting chamber is separated from the superheating chamber (it is positioned on it).

Examples of preferred embodiments

In the microwave oven a vessel 1 is arranged made of ceramic material (for example SiO₂, Al₂O₃ etc. which allows the passage of microwave radiation) in the shape of a circular or oblong bath which is furnished with an inner dividing partition 2. If the bath is of made of sintered alumina, it has a wall thickness of approximately 5 mm; if it is made of burnt shale it has a thickness of about 2 to 3 cm. The bath consists of a melting chamber 3 and a superheating chamber 4, separated by a partition 2 with at least one outlet 5 with a diameter of 1 to 5 cm for the flow of the melt from the melting chamber 3 to the superheating chamber 4. The outlet 6 of the bath is arranged in the bottom of the superheating chamber 4 and furnished with a raised overflow rim 7 situated with an offset below the lowest point of the outlet 5. This outlet 6 leads into an oblong vertically or horizontally arranged fiberizing tank 8, furnished with its own heating (electric resistance or high frequency) in the bottom of which there is a set of nozzles 9 for drawing the continuous basalt fibres. The melting chamber 3 and the superheating chamber 4 in this embodiment are formed altogether as one vessel, the fiberizing tank 8 consists of a pipe and is also formed as an integral whole together with the vessel of the superheating chamber 4. The melting chamber 3 and the superheating chamber 4 are positioned in the oven in the area of the microwave radiation, while the fiberizing tank 8 with its own heating is arranged outside this area.

The outlet 5 from the melting chamber 3 has a diameter in the range of 1 to 5 cm and is arranged above the bottom of the vessel of this chamber at a distance of about one quarter of its interior height, above the area of sedimentation of unmelted remains in the melting chamber 3. The offset overflow rim 7 of the outlet 6 from the superheating chamber 4 is about 1 cm above the bottom of the vessel, the diameter of the outlet 6 is in the range of 3 to 10 cm and the inner diameter of the fiberizing tank 8 in

the shape of a pipe is in the range of 10 to 20 cm. The height of the fiberizing tank 8, which depends upon the hydrostatic pressure required in the area of its bottom where there is a set of nozzles 9 (10 to 100 nozzles), is approximately 30 cm.

The method of uninterrupted production of continuous mineral or glass, preferably basalt fibre according to this invention is as follows. Crushed basalt of loose gravelly consistency of 4 to 20 mm in size is put into the melting chamber 3. It is possible to change the properties of basalt rocks by doping the rocks with such oxides and elements that change the character of the silicate melt, for example zirconium dioxide, zinc oxide, lead oxide, boron oxide. The changed composition of the melt changes the resulting properties of the basalt fibre, for example the strength, modulus of elasticity, suppleness, chemical resistance in acids, bases or in water. With appropriate changes and combinations of basalt with other rocks, for example phonolite, it is possible to achieve the desired properties of the fibre. For these reasons, the charge for the melting chamber 3 can advantageously further include crushed recycled glass in quantities of 25 to 35 % wgt., or 25 to 50 % wgt. (it can be in the range of 10 to 80 % wgt.). The crushed glass has granules of 2 to 15 mm. in size and is advantageously made from ordinary recycled bottle glass. With the addition of recycled glass the basalt acquires properties suitable for drawing, the fibre draws well and it does not tear. The temperature range for melting increases and it affects the viscosity of the drawn fibre which is more supple and elastic. In order to attain optimal properties of the fibre it is possible to use for example the following two- or three-component mixtures of basalt and recycled glass, basalt and phonolite, or basalt, phonolite and recycled glass (individual components are given in weight percentages):

Example 1

	Basalt	Recycled Glass	Mixture of Basalt and Glass (50-50)
SiO ₂	38.2	72.0	55.9
TiO ₂	6.4		3.2
Al ₂ O ₃	11.2	2.8	6.9
FeO tot.	14.7	0.5	7.8
MgO	7.5	1.7	4.8
CaO	18.1	10.7	13.7
Na ₂ O	2.0	11.6	6.0
K ₂ O	0.6	0.5	0.6
P ₂ O ₅	1.1		0.6

Example 2

Mixture of basalt (different composition from example 1) and phonolite (phonolite from the basalt group but with a higher content of SiO₂ and alkaline elements)

	% wgt. Basalt	% wgt. Phonolite	% wgt. Basalt 70% /Phonolite 30%
SiO ₂	46.1	58.0	49.7
TiO ₂	3.3	0.3	2.4
Al ₂ O ₃	15.5	23.9	17.7
FeO	11.4	1.7	8.5
MnO	0.4	0.1	0.3
CaO	11.3	0.6	8.1
Na ₂ O	3.9	10.5	5.8
K ₂ O	2.1	5.3	3.1

Example 3

Mixture of basalt 50 %, glass 25 % and phonolite 25%.

	Basalt	Glass	Phonolite	Mixture (50-25-25)
SiO ₂	38.2	71.8	52.0	52.0
TiO ₂	6.4		0.3	3.3
Al ₂ O ₃	11.2	2.3	23.9	12.0
FeO	11.5	0.3	1.7	8.0
MnO	0.1	0.1	0.1	0.1
MgO	7.5	2.2	0.2	4.3
CaO	18.1	10.8	0.6	11.6
Na ₂ O	2.0	11.3	10.5	6.1
K ₂ O	0.6	1.3	5.3	1.8

The melting chamber 3 in Figure 1 is positioned in a microwave oven with two generators with an output of 3.5 kW (each generator). Here the basalt (or the basalt with the added crushed glass) is exposed for a period of about 20 to 30 minutes to microwave radiation at a frequency of 2450 MHz, whereby it is melted. The effect of the microwaves is significantly greater in heated systems, depending also on the chemical composition of the initial rocks, but also on the phase, that is the mineralogical composition. The rocks are therefore advantageously preheated by classic heat in an electric resistance or gas oven. Minerals containing iron oxides and titanium oxides (magnetite, ilmenite) easily react with microwaves and it is not necessary to preheat them before the microwave heating. Preheating can also be carried out, so that cold material and also heated material in small quantities is added in a continuous operation to the surface of the molten rock. Thereby loss of heat, by radiation in the actual melting vessels situated in the area of microwave impact, is prevented. The molten material, above the area of sedimentation of unmelted remains of rock in the melting chamber 3, continuously passes through into a separate space, into the superheating chamber 4 (which can be

independent, situated apart from the melting chamber 3, or can be at least in part placed on an independent superheating chamber 4; in an alternative embodiment both chambers 3, 4 can be part of an integral whole, see description above). The passing of the molten material into the preheating chamber 4 is basically by way of a system of barriers or partitions, which are set up so that unmelted elements lighter than the melt, which float on the surface of the melt, and unmelted elements heavier than the melt, which settle on the bottom of the vessel, do not get into the other vessel. The melt can flow out of the melting chamber 3 at various levels; the partitions can also be “perforated”.

In the superheating chamber 4 the basalt melt is heated again by a method of microwave radiation at a frequency of 2450 MHz or other, in the frequency permitted in the given area, to a temperature of at least 200°C higher than the temperature of the liquidus melt. Here melting of all the nucleus centres in the melt occurs, without fragments of rock or crystals. From this space the melt then flows continuously across the overflow rim 7 into the space in the fiberizing tank 8, arranged beneath it, outside the area of operation of the microwave radiation, in which by electric or high-frequency heating the temperature of the melt stabilizes at a temperature corresponding to the required viscosity suitable for drawing (in basalts in the area of liquidus, in basalts modified with glass at temperatures around 100 °C and more higher than the liquidus of the mixture). In the bottom of the fiberizing tank 8 there are nozzles 9 of cylindrical shape with a length of about 2 cm and an inner diameter of approximately 4 mm, the length of the nozzles being governed by their diameter and the wetting property of the melt in question. They are made of a refractory ceramic material or ceramic metal selected from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al and are cemented to the vessel of the fiberizing tank 8. The melt is extruded through the nozzles 9 into the outer space by means of hydrostatic pressure proportional to the overall depth of the melt above the bottom of the fiberizing tank 8 (the large area of the surface of the melt in the superheating chamber 4 connected to the fiberizing tank 8 makes it possible to eliminate differences in the hydrostatic pressure on the bottom of the fiberizing tank 8). After the extrusion of the melt into the outer space, it is caught up and individual fibres, formed by drawing, immediately cool and harden in the air, whereupon they are wound up. By drawing the caught up drop of basalt a fibre is formed which is wound up on a rotating drum. The area of the openings in the bottom of the column-shaped space in the fiberizing tank 8 is heated to a temperature in the range of 1250 to 1700°C. The original viscosity of the basalt is thus preserved and the basalt flows better through the nozzles 9 (in the bottom of the fiberizing tank 8 there can be approximately 200 nozzles 9 or more). The speed of drawing of the fibres and the productivity of the whole production process is increased. The lower part of the stabilizing fiberizing tank 8 (where the nozzles 9 are situated) is a so-called “hot” area which is under the “cold” area arranged above it.

These two parts can be separated by insulation, for example of alumina, Al and Zr oxides, and the cold area moreover can be actively cooled (by water cooling, water vapour).

The nozzles 9 are formed of ceramic elements or elements made of ceramic metals, passing through and projecting from the bottom of the fiberizing tank 8. They can be made of a refractory ceramic material or metal selected, for example, from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al. This solution is significantly cheaper than the nozzles used to date, made from a material based on platinum – rhodium (for example the alloys Pt 90% Rh 10% or Pt 80% Rh 20%). The durability of ceramic compared to platinum nozzles is shorter, however the price of aluminium oxide and other ceramic metals compared to the price of platinum is substantially lower. Ceramic nozzles thus become a “consumable” material. Moreover, during use of alumina nozzles (Al_2O_3) a reaction of MgO , Cr_2O_3 and FeO with alumina occurs in the nozzles to form a new mineral phase - a mineral from the spinel group. The refractory nature of the spinel prevents further reaction of the molten basalt with the alumina and a protective layer of spinel forms in the nozzle, which significantly prolongs the life of the nozzle (such a reaction is not possible with glass fibres because no glass contains the components which create spinel in reaction with alumina). The fiberizing tank 8 can be made of the same material as the nozzles 9, that is from refractory ceramic material selected from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al.

An apparatus for the production, for example, of 5 kg of fibre of a thickness of 10 μm an hour (that is 120 kg a day and 40 tons a year) requires in the meting chamber two or more vessels with a capacity of approximately 2 to 3 litres (5 kg of melt), 200 nozzles and a drawing speed of 2000 m/min., with consumption of 10 to 12 kWh/hour (preferably with two magnetrons with an output of 6 kWh).

In Figure 2, in a different arrangement the melting chamber 3 and the superheating chamber 4 are separated. A connecting pipe 15 positioned above leads into the melting chamber 3 from a material storage tank 14. The melting chamber 3 is positioned on the upper part of the preheating chamber 4, both these chambers being exposed to microwave radiation from sources 11 in a microwave oven with casing 16. Above the bottom of the melting chamber 3 there is the rim of the discharge outlet 5 into the superheating chamber 4 in which there is the melt 13. This melt flows out across the raised overflow rim 7 through the outlet 6 in the bottom of the superheating chamber into the fiberizing tank 8 and from there it passes through the nozzles 9. After extrusion of the melt into the outer space, it is caught up here and individual fibres are formed by drawing.

The mineral fibre can be used with a bonding agent for the creation of composite material for the surface finish of objects, for example plastic or metal pipes. The mineral fibre can advantageously be basalt fibre in a layer 2 to 20 mm. thick, formed by a continuous wound-up fibre with binding agent on the surface of the object, for example with an epoxy resin or polyurethane resin. In plastic pipes for

conducting pressurized water, their strength is significantly increased. The layer of basalt fibre with resin reinforces the pipe against surface damage, but also against increases in internal pressure of the liquid in the pipe. In metal pipes their resistance against corrosion, the surrounding soil, water and weather is increased. The fibres can be wound directly onto the pipe from the nozzles during drawing of the fibres. It is not necessary to lubricate the surface of the fibre when an organic substance is applied to the surface, for example silanes, modified starches or oil. Alternatively, the fibre can be wound around the pipe by means of drums, by use of the "roving" technique, that is with a bundle of fibres with minimal twisting, about two or three twists to a standard metre of fibre.

Industrial Use

The invention is intended for the preparation of a homogeneous silicate melt, particularly uninterrupted production of continuous basalt or glass fibre. Because of the easy access to the raw materials and particularly because of their qualities, which in several applications are superior to those of glass fibres, continuous basalt fibres are in wide use as basalt composites, reinforcement in concrete, insulating panels, filters – screens for molten aluminium, carriers for catalysers in chemical processes etc. The properties of basalt melts, and thus the properties of basalt fibres can be easily modified, both chemically and by heat conditions. It is thus possible to a significant degree to adapt the properties of the fibre to the user's needs, for example refractory fibres for automobile exhausts. Moreover, basalt fibres provide a screen against electro-magnetic radiation.

PATENT CLAIMS

1. An apparatus for preparing a homogeneous silicate melt, intended for placing in a microwave oven, characterised in that it comprises a melting chamber (3) with an outlet (5) for the outflow of the melt into the superheating chamber (4), where the superheating chamber (4) consists of a vessel whose outlet (6) is arranged at the bottom of the vessel and is furnished with a raised overflow rim (7) situated with an offset below the lowest point of the outlet (5) of the melting chamber (3), while the outlet (6) from the superheating chamber (4) leads into a fiberizing tank (8) furnished with its own heating, in the bottom of which there is an outlet.
2. An apparatus according to claim 1, characterised in that an independent melting chamber (3) is positioned at least in part on an independent superheating chamber (4).
3. An apparatus according to claim 1, characterised in that an independent melting chamber (3) is joined by a pipe to an independent superheating chamber (4).
4. An apparatus according to any of claims 1 to 3, characterised in that the melting chamber (3) and/or the superheating chamber (4) are open above, at least in part.
5. An apparatus according to claim 1, characterised in that the melting chamber (3) and the superheating chamber (4) are formed altogether as one vessel, furnished with an inner partition (2) with at least one outlet (5).
6. An apparatus according to any of claims 1 to 5, characterised in that the fiberizing tank (8) consists of a pipe of suitable diameter and is formed as an integral whole together with the vessel of the superheating chamber (4).
7. An apparatus according to any of claims 1 to 6, characterised in that the outlet (6) of the superheating chamber (4) in the direction of the fiberizing tank (8) has an offset outlet rim (10).
8. An apparatus according to any of claims 1 to 7, characterised in that the outlet of the fiberizing tank (8) consists of a set of nozzles (9) for drawing the continuous mineral or glass fibres.
9. An apparatus according to any of claims 1 to 8, characterised in that the outlet (5) from the melting chamber (3) has a diameter in the range of 1 to 5 cm and is arranged above the bottom of the vessel of this chamber (3) at a distance of about one quarter of its interior height, the

- offset overflow rim (7) of the outlet (6) from the superheating chamber (4) is about 1 cm above the bottom of its vessel. the diameter of the outlet (6) is in the range of 3 to 10 cm and the inner diameter of the fiberizing tank (8) in the shape of a pipe is in the range of 10 to 20 cm.
10. An apparatus according to any of claims 1 to 9, characterised in that the melting chamber (3), superheating chamber (4) and fiberizing tank (8) are made of ceramic material, for example sintered alumina, or sintered alumina in combination with SiO₂.
 11. An apparatus according to claim 8, characterised in that the nozzles (9) are formed of ceramic elements or elements made of ceramic metals, passing through and projecting from the bottom of the fiberizing tank (8).
 12. An apparatus according to claim 8 or 11, characterised in that the nozzles (9) are made of a refractory ceramic material selected, for example, from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al.
 13. An apparatus according to any of claims 8, 11 or 12, characterised in that the nozzles (9) are formed from tubes with an inner diameter of about 4 mm.
 14. An apparatus according to any of claims 8, 11, 12 or 13, characterised in that the nozzles (9) are furnished with a means for heating them.
 15. An apparatus for uninterrupted production of continuous mineral or glass fibre which comprises a melting chamber (3) and a superheating chamber (4), positioned in a microwave oven, characterised in that both these chambers (3, 4) according to any of claims 1 to 14 are positioned in the oven in the area of the microwave radiation, while the fiberizing tank (8) with its own heating is arranged outside this area.
 16. Use of a refractory ceramic material or of a metal, selected from the group comprising the oxides Al, Mg, Cr, Zr, the silicides Mo and the nitrides Si, W, Ti and Al for the body of the melting chamber (3) and/or the superheating chamber (4) and/or the fiberizing tank (8) and/or the bodies of the nozzles (9) for uninterrupted production of continuous mineral or glass fibre.
 17. Use according to claim 16, characterised in that the refractory ceramic material is sintered alumina, or sintered alumina in combination with SiO₂.

18. A method of uninterrupted production of continuous mineral or glass fibre characterised in that the crushed input raw material, for example basalt, is exposed to microwave radiation preferably at a frequency of 2450 MHz, whereby it is melted, the molten material, above the area of sedimentation of unmelted remains, continuously passes through into a separate space in which it is heated again by microwave radiation to a temperature of at least 200°C higher than the temperature of the liquidus of the melt, and from that space it flows continuously across the overflow rim into the space beneath it, outside the area of operation of the microwave radiation, in which by electric or high-frequency heating the melt stabilizes at a temperature corresponding to the required viscosity, whereupon the melt is extruded into the outer space through at least one opening in the bottom, by means of hydrostatic pressure proportional to the overall depth of the melt above this bottom.
19. A method according to claim 18, characterised in that, after the extrusion of the melt into the outer space, it is caught up and individual fibres, formed by drawing, immediately cool and harden in the air, whereupon they are wound up.
20. A method according to claim 18 or 19, characterised in that the area of the openings in the bottom of the column-shaped space is heated to a temperature in the range of 1250 to 1700°C.
21. A charge for the melting chamber (3) for preparing a silicate melt for the production of continuous mineral or glass fibre comprising crushed basalt of loose gravelly consistency, characterised in that it further includes crushed recycled glass in quantities of 10 to 80 % wgt. and/or phonolite.
22. A charge according to claim 21, characterised in that the crushed glass is in a quantity of 25 to 35 % wgt.
23. A charge according to claim 21 or 22, characterised in that the crushed glass has granules of 2 to 15 mm. in size.
24. A charge according to claims 21 to 23, characterised in that the crushed glass is made from ordinary recycled bottle glass.
25. Use of mineral fibre with a bonding agent for the creation of composite material for the surface finish of objects, for example plastic or metal pipes.

26. Use according to claim 25, characterised in that the mineral fibre is basalt fibre in a layer 2 to 20 mm. thick, formed by a continuous wound-up fibre with binding agent on the surface of the object, for example with an epoxy resin or polyurethane resin.

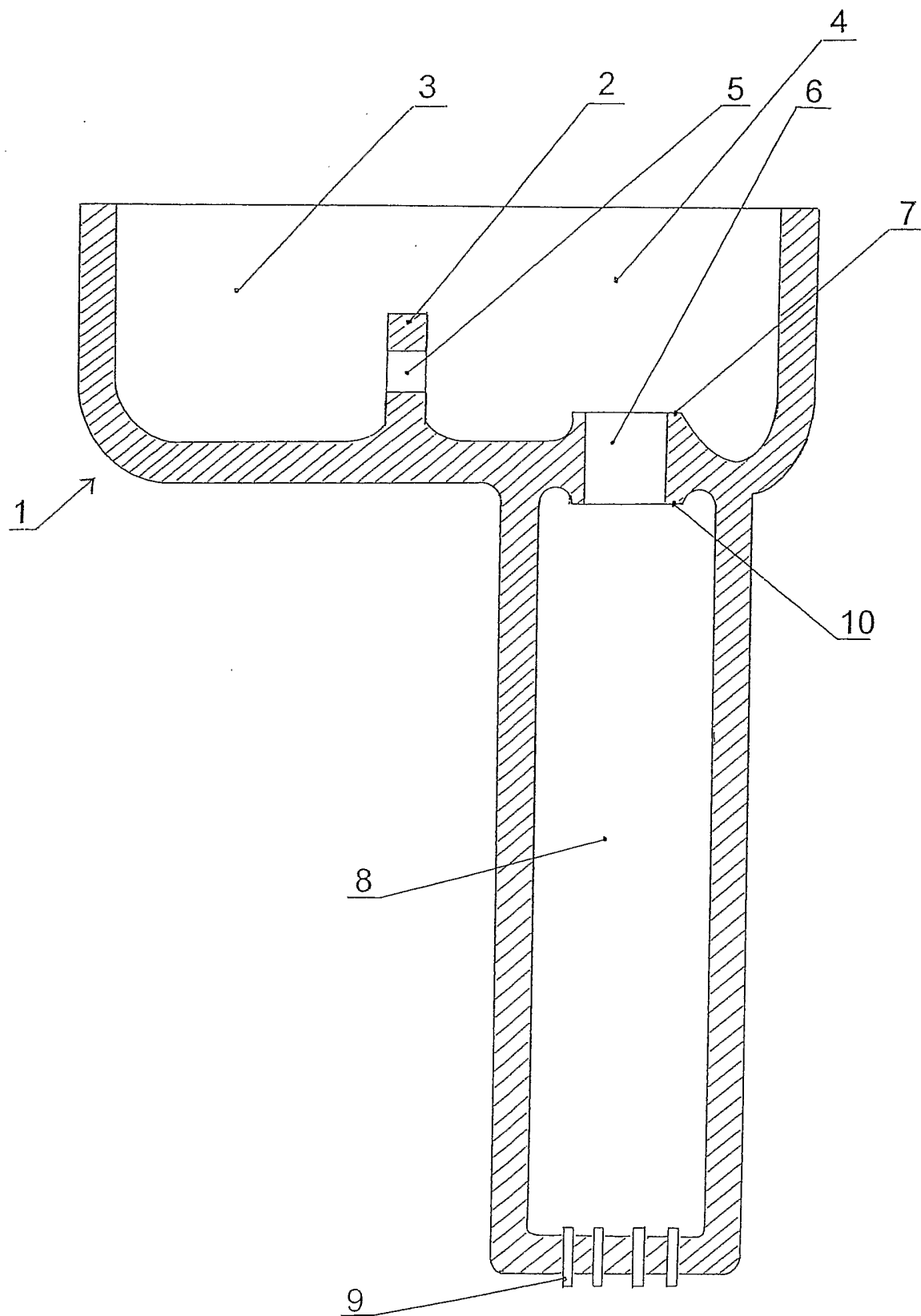


FIG. 1

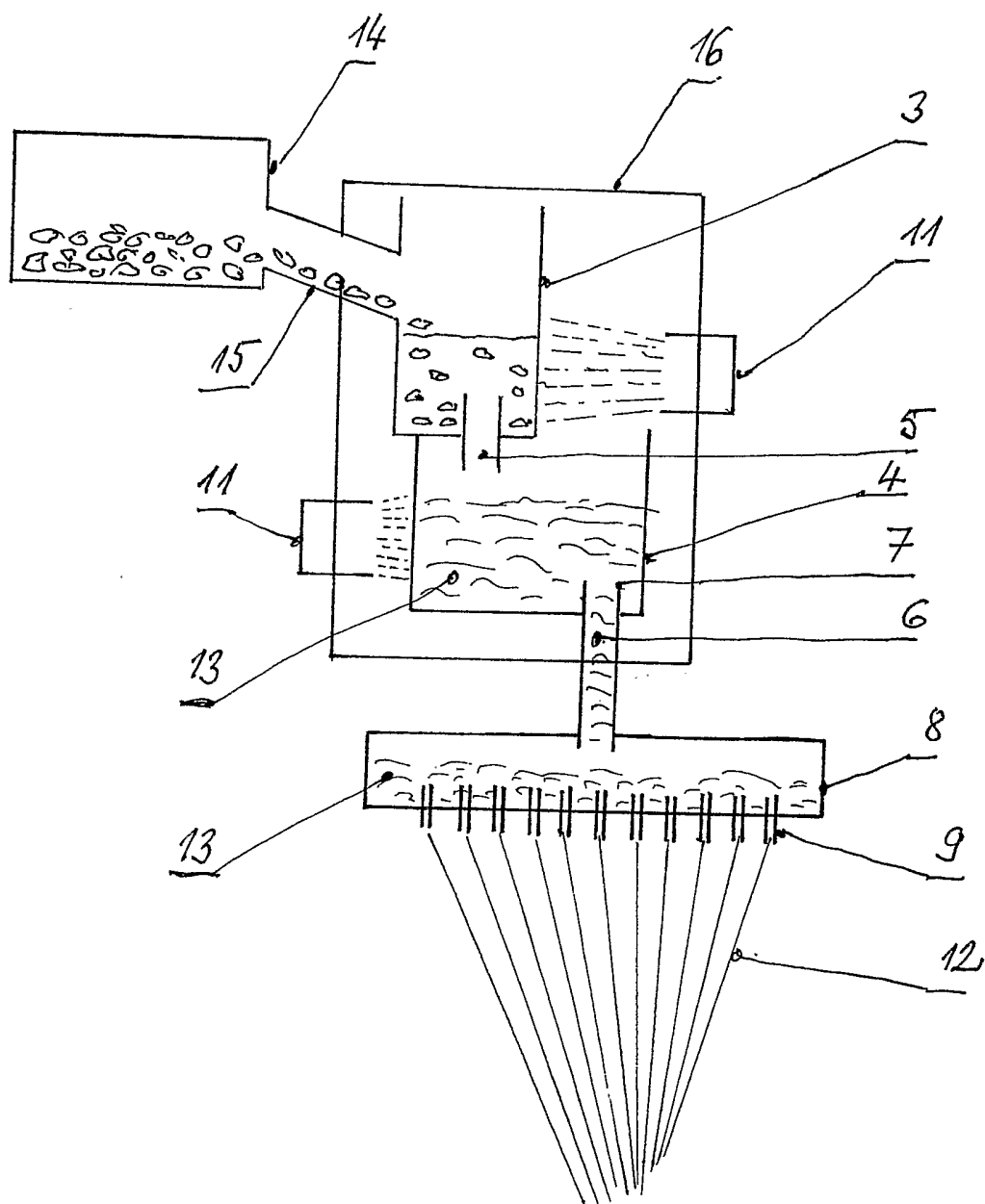


FIG. 2