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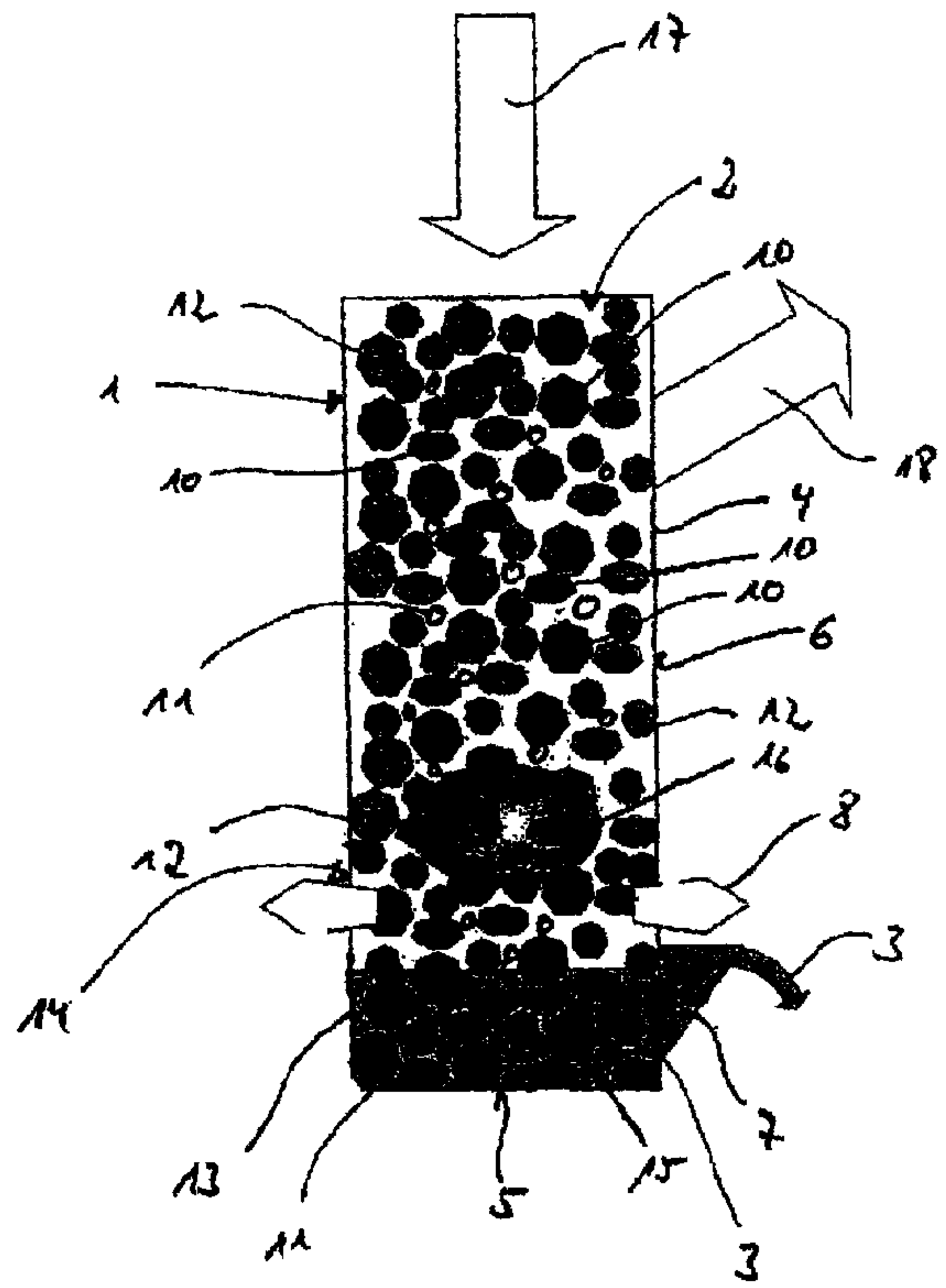
(54) Titre : PROCEDE POUR PRODUIRE DES MATIERES ISOLANTES A PARTIR DE FIBRES MINERALES, ET MATIERE DE CHARGE POUR AGREGAT DE FUSION DESTINE A LA PRODUCTION D'UNE MATIERE MINERALE EN FUSION

(54) Title: METHOD FOR THE PRODUCTION OF INSULATING MATERIALS MADE OF MINERAL FIBERSAND FILLING FOR A MELTING AGGREGATE FOR THE PRODUCTION OF A MINERAL MELT



(57) Abrégé/Abstract:
The invention relates to a method for the production of insulating materials made of mineral fibers, wherein a melting unit is filled with a meltable starting material for the production of a silicate melt and a combustible melt. The combustible comprises a primary

(57) Abrégé(suite)/Abstract(continued):
energy carrier and a substituent and the melt produced from the starting material is supplied to a defibrator wherein the melt is defibrated into preferably micro-fine fibers and the fibers are placed on a conveyor device as non-wovens. In order to further develop an inventive method in such a way that the implementation can be carried out in a more economical manner by a further development of raw material sources, also taking into account the usual procedural parameters for the production of a suitable melt such that good melt results without melt impurities can be obtained with the aid of said method, anodes used during the electrolysis of the melt, having a proportion of at least 15% in relation to the overall amount of the combustible, are used as a substituent and are added to the combustible.

Abstract

The invention relates to a method for the production of insulating materials made of mineral fibers, wherein a melting unit is filled with a meltable starting material for the production of a silicate melt and a combustible melt. The combustible comprises a primary energy carrier and a substituent and the melt produced from the starting material is supplied to a defibrator wherein the melt is defibrated into preferably micro-fine fibers and the fibers are placed on a conveyor device as non-wovens. In order to further develop an inventive method in such a way that the implementation can be carried out in a more economical manner by a further development of raw material sources, also taking into account the usual procedural parameters for the production of a suitable melt such that good melt results without melt impurities can be obtained with the aid of said method, anodes used during the electrolysis of the melt, having a proportion of at least 15% in relation to the overall amount of the combustible, are used as a substituent and are added to the combustible.

Method for the production of insulating materials made of mineral fibers and filling for a melting aggregate for the production of a mineral melt

The invention relates to a method for the production of insulating materials made of mineral fibers, particularly from glass and/or rock wool, in which a melting aggregate, especially a cupola furnace, is filled with a meltable starting material for the production of a silicate melt and a combustible. The combustible comprises a primary energy carrier, especially foundry coke, and a substituent and the melt produced from the starting material is supplied to a defibrator wherein the melt is defibrated into preferably micro-fine fibers and the fibers are placed on a conveyor belt as a non-woven. The invention further relates to a filling for a melting aggregate, especially a cupola furnace for the production of a mineral melt which is supplied to a defibrator for the production of mineral fibers, particularly rock wool or glass wool fibers, wherein the mineral fibers are placed on a collection belt for the formation of a fibrous web consisting of a meltable starting material and a combustible which is formed by a primary energy carrier, especially foundry coke, and a substituent.

Insulating materials made of mineral fibers are produced from silicate melts. For this purpose, a silicate starting material, for instance glasses, natural stone or artificial stone are supplied to melting aggregate, for instance a cupola furnace or a shaft furnace. The silicate melt which is obtained there from is then fed to a defibration unit, in which micro-fine mineral fibers are produced from this silicate melt. The mineral fibers which are immediately fed to a collecting chamber are normally wetted with binding and/or impregnating agents and are deposited on a conveying device, usually a conveyor belt, arranged below the collecting chamber. On said conveyor belt the mineral fibers which have been wetted with binding and/or impregnating agents form a fibrous web which is processed in a manner known per se in downstream thermal and/or mechanical installations, in order to produce insulating materials in the form of webs, boards, molded bodies or the like. Accordingly, mineral fiber insulating materials consist of glassily solidified fibers which are connected to each other pointwise by small amounts of binding agents.

In the case of insulating materials made of mineral fibers a difference is made between those from glass wool and those from rock wool. Mineral fiber insulating materials from rock wool are produced from silicate melts having relatively high fractions of network transformers, especially alkalis and borons. The raw materials are melted in oil or gas-fired tank furnaces. The fiber-making takes places for instance with the aid of the so-called TEL process in which the melt is passed through openings in the walls of a rotating body under the influence of centrifugal forces. By this method relatively long and smooth fibers are produced.

Rock wool insulating materials have usually been melted from rock like diabase, basalt and limestone, dolomite. In the meantime, these natural stones are increasingly replaced by artificial stones or are subject to the melting process together with artificial stones. In these artificial stones particularly production wastes are processed, which may consist of solidified melts that occur at the regular emptying of the melting aggregate. In addition to these production wastes also defective production batches are processed. The wastes are comminuted in a first step, thereafter mixed with Portland cement as a binding agent and with crushed stones and finally pressed into artificial blocks, so-called shaped blocks.

The coarse-grained stones and/or the correspondingly formed shaped blocks are filled into the melting aggregate, usually the cupola furnace, together with coarse pieces of coke as a primary energy source. Further, additives are supplied which have a grain size spectrum of approx 80 to 200 mm. By charging the raw material-coke column from the bottom, i.e. according to the counter flow principle, with the air that is required for combustion, the coke is burnt above the bottom of the furnace. In the region where the air is introduced, the furnace temperature reaches a level at which the stones and the additives are melted. During this process, the fraction of already glassily solidified wastes increases the melting speed. The temperature inside the furnace decreases towards the upside, since the heat energy is delivered to the stones and to the primary energy source. At the same time, the oxygen content in the furnace decreases.

By a subsequent heating of the exhaust air harmful carbon compounds are transformed into less harmful compounds. The energy contained in the exhaust air is thereafter delivered to the combustion air with the aid of heat exchangers.

The molten constituents of the raw materials which are introduced into the melting aggregate sink to the bottom of the melting aggregate. During this process a segregation takes place in which the iron which is predominantly reduced from the stones accumulates at the bottom and the melt which has a lower specific weight and which is required for fiber making is discharged through a discharge which is arranged above the bottom. The melt which is discharged here is thereafter fed to the defibration unit and is defibrated. From the melt which is fed to the defibration unit only a fraction of 50% is transformed into fibers. The coarser non-fibrous constituents are separated from the fibrous constituents by wind sieving.

The iron which accumulates in the bottom area must be regularly discharged. During this discharging of the iron the fiber production is interrupted. The melt which is contained in the melting aggregate at this point of time is not suitable for direct insulating material production after re-starting the melting aggregate and is therefore processed as a waste material during the recycling and is supplied to the production.

During the melting process which is mostly carried out in cupola furnaces a strong dependency exists between the viscosity and the temperature. Further, the germination number and hence the crystallization tendency are relatively high. At the fiber making on so-called cascade spinning machines these properties result in mineral fibers which are relatively short and which are swirled in themselves. The individual mineral fibers itself are glassily solidified. Due to their composition the temperature resistance of the mineral fibers made of a stone melt is higher than in insulating materials which are made of glass wool.

An important factor at the production and rating of mineral fibers is the bio-solubility, i.e. the residence time of the mineral fibers in the human organism. The bio-solubility of insulating materials made of rock wool is decisively influenced by the content of Al_2O_3. With increasing fractions of Al_2O_3 the temperature resistance of the fibers increases on one side and, surprisingly, also the bio-solubility on the other side.

A typical composition of bio-soluble mineral fibers made of rock wool includes a fraction of SiO_2 of between 35 and 43 percent by weight, a fraction of Al_2O_3 of between 17.5 to 23.5 percent by weight, a fraction of TiO_2 of 0.1 to 3 percent by weight, a fraction of FeO of 1.7 to 9.3 percent by weight, a fraction of CaO + MgO of 23.5 to 32 percent by weight and a fraction of K_2O + Na_2O of 1.3 to 7 percent by weight.

For the economy of these rock wool insulating materials which are used as a mass product the use of raw materials which include a high fraction of Al_2O_3 is important. Although natural stones contain in many cases alumo-silicates, the same are frequently not present in the required concentration or only together with undesired minerals. On the other hand, calcinated bauxites are comparatively expensive. For this reason residues are often exploited which up to present could only be dumped and which include a considerable risk for the environment because of the content of soluble matter. At the same time, these residues, which occur for instance at the production of rock wool, in the form of melt remainders, separated non-fibrous particles, filtering dusts, defective productions or the like are almost completely recycled in a primary waste material cycle. These residues are prepared prior to their recycling so as to correspond to the requirements of the machine equipment, particularly the melting aggregates. For their recycling the residues are for instance comminuted and mixed together in different grain sizes or are mixed with other splintery raw materials and are spiked with binders like cement for instance and pressed into sufficiently large shaped bodies before the same are supplied to a shaft furnace or a cupola furnace as coarse-piece raw materials. From the document EP 0 765 295 C1 it is known for instance to bind suitable shaped bodies from fine-grained raw materials also with the aid of lignin. In the document WO 94/12007 corresponding shaped bodies with molasses-containing binders are described.

As it has already been mentioned above, coke is used as a primary energy carrier. The energy which is required for melting the raw materials amounts to approximately 2 megawatts per ton of melt. Depending on the origin of the coal which is used for coking, the content of inorganic constituents of the coke (ash content) is between 6 and 10 percent by weight.

Foundry coke as a primary energy carrier turned out as a particularly suited combustible. Foundry coke has a high calorific value which approximately amounts to 30,000 kJ/kg at a water content lower than 5 percent by weight. In addition to that, foundry coke is characterized by a low ash content of less than 10 per cent by weight, a low sulfur content of less than 1 percent by weight as well as a low content of volatile constituents of less than 1 percent by weight and at the same time a high drum strength M80 of more than 75%. It must be taken into consideration here that the non-combustible constituents of the coke are embedded in the silicate melt. For this reason, combustibles are required, of which the non-combustible constituents are low and do not have any impact on the final product.

From the document US 4 822 388 it is known to replace the coke predominantly by a furnace cladding of furnaces for the production of aluminum. In this case it is described as desirable to completely replace the coke, but at least 60% of the primary energy carrier shall consist of the residues of the furnace cladding.

From the document EP 1 241 395 A2 it is further known to form the primary energy carrier at the production of insulation materials from mineral fibers of at least 50 percent by weight of coke and a mixture of a carbon carrier and refractory bricks, wherein said mixture is obtained from furnace clearing, especially the cathodic cladding of furnaces for the production of aluminum. This pre-known method turned out worthwhile in the practice, since it taps new energy sources for the production of insulation materials from mineral fibers which are much cheaper than coke.

In view of this prior art, the invention is based on the p r o b l e m of further developing a method in accordance with the invention in such a way that a method in accordance with the invention can be carried out in a more economical way by tapping new raw material sources, while taking into account the usual procedural parameters for the production of a suitable melt, so that good melt results without impurities of the melt are achieved. The invention is further based on the p r o b l e m of providing an inexpensive filling for a melting aggregate which allows preparing an inexpensive melt for fiber making of mineral fibers for insulation materials, so that the production of insulation materials is possible with an increased economy and constant product quality.

In a method of the above-mentioned kind, the s o l u t i o n of this problem provides that the combustible has admixed to it as a substituent anodes which are used in a melting electrolysis in a proportion of at least 15% in relation to the total amount of the combustible. For the s o l u t i o n of the problem it is further provided that in a filling for a melting aggregate said substituent consists of used-up anodes that are employed in the melting electrolysis and of which a fraction of at least 15% in relation to the total amount of the combustible is contained in the combustible.

In accordance with the invention it is hence provided that in a method for producing insulating materials from mineral fibers, particularly from glass and/or rock wool, in which a melting aggregate, especially a cupola furnace, is filled with a meltable starting material for the preparation of a silicate melt and with a combustible, said combustible includes in addition to a primary energy carrier, e.g. foundry coke, a substituent which has admixed to it as used-up electrodes which are employed in a melting electrolysis especially the remainders thereof in a proportion of at least 15% in relation to the total amount of the combustible. According to a further feature it is provided that a fraction of the substituent of up to 70% in relation to the total amount of the combustible is added to the combustible. The anodes are especially anode remainders from the melting electrolysis. The anodes re mostly produced in a so-called prebake method and they consist of coal blocks which are pressed from highly viscous c calcinated petrol coke, coal tar pitch and anode remainders and are prebaked. Here, petrol coke is a product from petro-chemistry which is produced during crude oil refining. Coal tar pitch is a side product of black coal coking in coking plants of the steel industry. Accordingly, such anodes can be formed essentially from recyclable residues from other branches of industry.

More particularly, this disclosure relates to a method for the production of insulating materials made of mineral fibers from glass or rock wool or both, wherein a melting aggregate comprising a fill of meltable starting material is supplied for the production of a silicate melt with a combustible comprising a primary energy carrier and a substituent, and the melt produced is supplied to a defibrator and the melt is defibrated into micro-fine fibers and the fibers are placed on a conveyor device as a non-woven, wherein a substituent comprising used-up anodes is admixed with the combustible, in a proportion of at least 15% in relation to the total amount of the combustible and, before being admixed with the melting aggregate, the used-up anodes are comminuted to a grain size of at least 50 mm, in order to achieve optimum mixing and combustion behavior of the filling, to form a loose bulk with sufficient open pores, so that gases produced in the lower part of the melting aggregate during combustion can be diffused at a high temperature through the fill and can heat the fill.

The anodes are formed in a block-shape and are used in the melting electrolysis for instance for the production of aluminum. During this process, aluminum is produced at the cathode, e.g. the cathodic cladding of a melting furnace. Oxygen is produced at the anode of the melting furnace. The anode is therefore subject to a process of wear in which it becomes oxidized into CO At the end of the process of wear a remainder of the used-up anode is left which can be recycled up to present exclusively at the production of corresponding anodes. Corresponding anodes constitute a very hard carbon product having a calorific value of approximately 33,000 kJ/kg at an ash content of max 4% by weight, a carbon content of max 99% by weight, a sodium content of max 0.8% by weight, a sulfur content of max 1.5% by weight, an aluminum content of max 1% by weight, and a fluorine content of max 1.8% by weight.

Surprisingly it has shown that due to their chemical composition and especially due to the high carbon content the anode remainders can be used as primary energy carriers in connection with the usually employed constituents of the combustible, namely foundry coke for instance for the production of insulating materials from mineral fibers, especially glass and/or rock wool in a melting aggregate.

According to a further feature of the invention it is provided that the anodes or the remainders of the anodes are cleaned before they are admixed to the combustible. In particular, a mechanical cleaning process is carried out in which adhering residues of the melt on the surfaces of the anodes or remainders of the anodes are removed, so that an anode remainder having a carbon content which is a high as possible is admixed to the combustible as a substituent of a fraction of the primary energy carrier.

For employing the anodes in a cupola furnace that is provided as a preferred melting aggregate in the present invention, the anodes must exhibit a particular grain size, depending on the dimensions of the cupola furnace, in order to achieve an optimum mixing and combustion behavior of the filling of the cupola furnace. In this connection, the components of the filling shall form a loose bulk with sufficient open pores, so that the gases which are produced in the lower part of the cupola furnace during the combustion can be diffused at a high temperature through the fill and can heat the fill. Therefore, it turned out advantageous in usual cupola furnaces to comminute the anodes to a medium grain size of between 50 and 200 mm prior to filling the melting aggregate.

According to a further feature of the invention it is provided that the starting material and the combustible including the substituent form a filling for the melting aggregate which is composed up to 30% of combustible including the substituent and of the meltable starting material for the rest of it. Hence, the meltable starting material comprises up to 70% of the filling.

According to a further feature of the invention the meltable starting material consists up to 50% of natural stones, especially diabase and/or basalt and of a rest of artificial shaped blocks, wherein the shaped blocks particularly consist up to 70% of recyclable mineral fiber material from the production and a rest of recovered mineral fiber insulation materials. The recycled mineral material from the production consists for instance of segments or minor-quality products which are removed from the production process. The shaped blocks are pressed into lumpy bodies from fine-grained material and the solids which are required for the shaped blocks together with stones with latent-hydraulic substances used as a supporting grain. As latent-hydraulic substances there may be used for instance Portland cement or other similarly effective binders, while crushed stones may be used as a supporting grain.

In the melting aggregate, especially in the cupola furnace, a filling which is prepared in this way is arranged in a column-like fashion, wherein the filling contains the raw material, i.e. the meltable starting material and the combustible in the form of the primary energy carrier and the substituent. The required combustion air is supplied to the filling according to the counter flow principle, so that the primary energy carrier burns down above a shaft floor of the melting aggregate. In the zone of the introduction of the combustion air the atmosphere in the melting aggregate reaches a temperature which is sufficient for melting the meltable starting material. The meltable starting material is discharged as a melt through a drain and is forwarded to a fiber making device which usually comprises several discs which are driven for rotation, wherein the melt impinges on the outer shell of said discs and is defibrated by the rotary movement into single mineral fibers which thereafter are charged with a binding and/or impregnating agent and are placed on a collection belt.

In the production of aluminum, aluminum oxide is melted in electrolysis furnaces under the use of a flux like for instance cryolite (Na_3AlF_6) and is reduced to metallic aluminum. For this purpose, electrolytic cells are employed which consist of a steel tub which is lined with refractory bricks, for instance firebrick and/or aluminum oxide bricks. On this ceramic layer a layer of electrically conducting carbon or graphite stones and/or masses is arranged which forms the cathodic part.

In the same way as the anodes which have been described above and which are used according to the invention, also this cathodic cladding of the electrolytic cells is subject to wear which necessitates a revision every five years on average. During this revision the furnaces must be shut off and the cathodic cladding must be renewed. The worn-out cladding is comprised of a mixture which consists for one half of graphite and for the other half of refractory bricks. It is not possible to completely separate these components from each other during removal, but the components can be screened in a technically expedient way.

In an advantageous embodiment of the invention it is provided that in addition to the anodes high-carbon residues, especially recovered cathodic claddings of melting aggregates for the production of aluminum, are admixed as further substituents to the combustible. It is provided in particular that the fractions of the different substituents are equal in relation to the amount or the carbon content of the individual fractions of the different substituents. Consequently, at least two substituents are admixed to the combustible in equal amounts or, according to their carbon content, in different amounts. This technique therefore requires to first determine the carbon content of the substituent and thereafter to compute a mixing ratio, so that the substituents to be admixed have a predetermined carbon content. In this connection, a larger amount of a substituent having a low carbon content is mixed with a smaller amount of a substituent having a higher carbon content. In this connection, it turned out advantageous that the used-up cathodic cladding of an electrolysis furnace in conjunction with the anodes can be used in a highly economical way as a primary energy carrier in mineral wool production.

Normally the high-carbon fraction of the cathodic cladding which is preferably used in accordance with the invention contains 40 to 60% by weight of carbon as well as 4 to 12% by weight of SiO_2, 26 to 56% by weight of Al_2O_3, 6 to 14% by weight of FeO/Fe_2O_3, 21 to 41% by weight of Na_2O and 1.8 to 3.6% by weight of SO_3.

When using the cathodic cladding in connection with the anodes as a part of the primary energy carrier the cyanogen compounds contained in the cladding are destroyed during the melting process and are converted into less harmful, at least non-toxic nitrogen compounds. Therefore, residues which are produced here can be disposed and dumped much easier and hence cheaper and environmentally friendlier.

Further features of the method according to the invention or the melt according to the invention will become apparent from the subclaims and the subsequent description of the attached drawing showing a schematic structure of a filling in a cupola furnace. Further features will also become apparent from the following description of one embodiment.

In the drawing there is schematically represented a cupola furnace 1 in which a filling 2 for the production of a mineral melt 3 is arranged which can be supplied to a fiber making device (not further illustrated) for the production of mineral fibers which are deposited on a collection belt for forming a fibrous web.

The cupola furnace 1 consists of a cylindrical housing having a bottom 5 and a side wall 6 including in the lower part thereof, namely in the part facing the bottom 5, a discharge opening 7 through which the melt 3 leaves the cupola furnace 1. Above the discharge opening 7 a closed circular pipeline 8 is arranged which includes inlet nozzles which are equally spaced over the circumference of the side wall 6 and through which primary wind is blown into the cupola furnace 1.

The filling 2 consists of a combustible which includes a primary energy carrier in the form of foundry coke 10 and a substituent 11 which consists of anodes from the melting electrolysis.

The combustible contains 70% by weight of foundry coke 10 and 30% by weight of substituent 11. In addition to the combustible a meltable starting material 12 is a constituent of the filling. The meltable starting material 12 consists for 40% by weight of natural stones, namely diabase and basalt, and for 60% by weight of artificial shaped blocks which in turn consist for 60% by weight of recycling material originating from the production process and for 40% by weight of recovered mineral fiber insulation materials. Additionally, these shaped blocks include latent-hydraulic substances, namely Portland cement and crushed stones as a supporting grain, which components permit or facilitate the pressing of the artificial shaped blocks.

In the cupola furnace 1, in the lower part thereof above the bottom 5, the sump 13 is distinguished from the coke bed 14, which coke bed 14 comprises the sump 13 and the bottom area with a layer 15 of reduced iron. The sump 13 is the area in the cupola furnace in which the melt 3 is contained in addition to the combustible. Above the sump 13 in the area of the closed circular pipeline 8 there is a section of the coke bed 14 in which exclusively combustible is present which is burnt in this area and which provides the melting temperature which required for melting the starting material 12. Above the coke bed a melting zone

16 is arranged in which the meltable starting material 12 is melted which is then immediately discharged to the sump and is drained through the discharge opening 7 upon reaching a certain level which is predetermined by the discharge opening 7.

The filling 2 is charged into the housing 4 of the cupola furnace 1 in accordance with arrow 17, wherein the constituents of the filling are usually heaped up alternating according to a predetermined pattern. But it may also be provided that the constituents of the filling 2, namely the starting material 12 and the combustible consisting of the foundry coke 10 and the substituent 11 are mixed before being charged into the cupola furnace 1.

Smoke gases which are produced during the combustion of the combustible are discharged in the upper area of the cupola furnace 1 in accordance with arrow 18 and are used for heating the cupola furnace 1, where appropriate.

What is claimed is:

1. A method for the production of insulating materials made of mineral fibers selected from glass or rock wool or both, wherein a melting unit is filled with a meltable starting material comprising natural stone and shaped blocks of recyclable waste mineral fiber and recovered fiber insulation material and a combustible material, the combustible material comprising a primary energy carrier and a substituent, supplying the melt produced from the melting unit to a defibrator, wherein the melt is defibrated into fibers, which fibers are placed on a conveyor to form a non-woven insulating material,

wherein the substituent comprises used-up anodes from a melting electrolysis and is present in a proportion of at least 15% by weight of the total amount by weight of the combustible material and, before being admixed into the melting unit, the used-up anodes are comminuted to a grain size of at least 50 mm in order to achieve optimum mixing and combustion of the materials in the melting unit,

the meltable starting material and the combustible material forming a loose bulk in the melting unit, whereby gases produced in the lower part of the melting unit during combustion diffuse at a high temperature through the materials to heat them.

2. The method according to claim 1, wherein the melting unit is a cupola furnace and foundry coke is used as the primary energy carrier.

3. The method according to claim 1, wherein the substituent comprises up to 70% by weight of the total amount by weight of the combustible material.

4. The method according to claim 1, wherein the used-up anodes are cleaned before they are admixed with the combustible material.

5. The method according to claim 4, wherein the cleaning of the used-up anodes is carried out mechanically.

6. The method according to claim 1, wherein up to 30% by weight of the combustible material is present and the remainder comprises the meltable starting material.

7. The method according to claim 1, wherein the meltable starting material is composed up to 50% by weight of natural stones and the remainder comprises the shaped blocks.

8. The method according to claim 7, wherein the shaped blocks consist of up to 70% by weight of recyclable waste mineral fiber material and the remainder comprises recovered mineral fiber insulating materials.

9. The method according to claim 7, wherein the shaped blocks are made from fine-grained material, at least one latent-hydraulic substance as a binder, and stones as a supporting grain.

10. The method according to claim 1, wherein the combustible material further comprises a high-carbon waste material.

11. The method according to claim 10, wherein recovered cathodic claddings of melting aggregates for the production of aluminum are used as the high-carbon waste material.

12. The method according to any one of claims 1 to 11, wherein the fibres are micro fibres.

13. A filling for a melting unit for the production of a mineral melt which is supplied to a defibrator for making rock wool fibres or glass wool fibers or both, wherein the fibers are placed on a conveyor belt for forming a fibrous web, said filling consisting of a meltable starting material comprising natural stone and shaped blocks of recyclable waste mineral fiber and recovered fiber insulation and a combustible material comprising a primary energy carrier and a substituent, wherein the substituent comprises used-up anodes from a melting electrolysis, and the combustible material contains at least 15% by weight of the substituent in relation to the total amount by weight of the combustible material and the used-up anodes have an average grain size of at least 50 mm in order to

achieve optimum mixing and combustion of the filling, which forms a loose bulk, so that gases produced in the lower part of the melting unit during the combustion are diffused at a high temperature through the filling to heat it.

14. The filling according to claim 13, wherein the amount of the substituent comprises up to 70% by weight in relation to the total amount by weight of the combustible material.

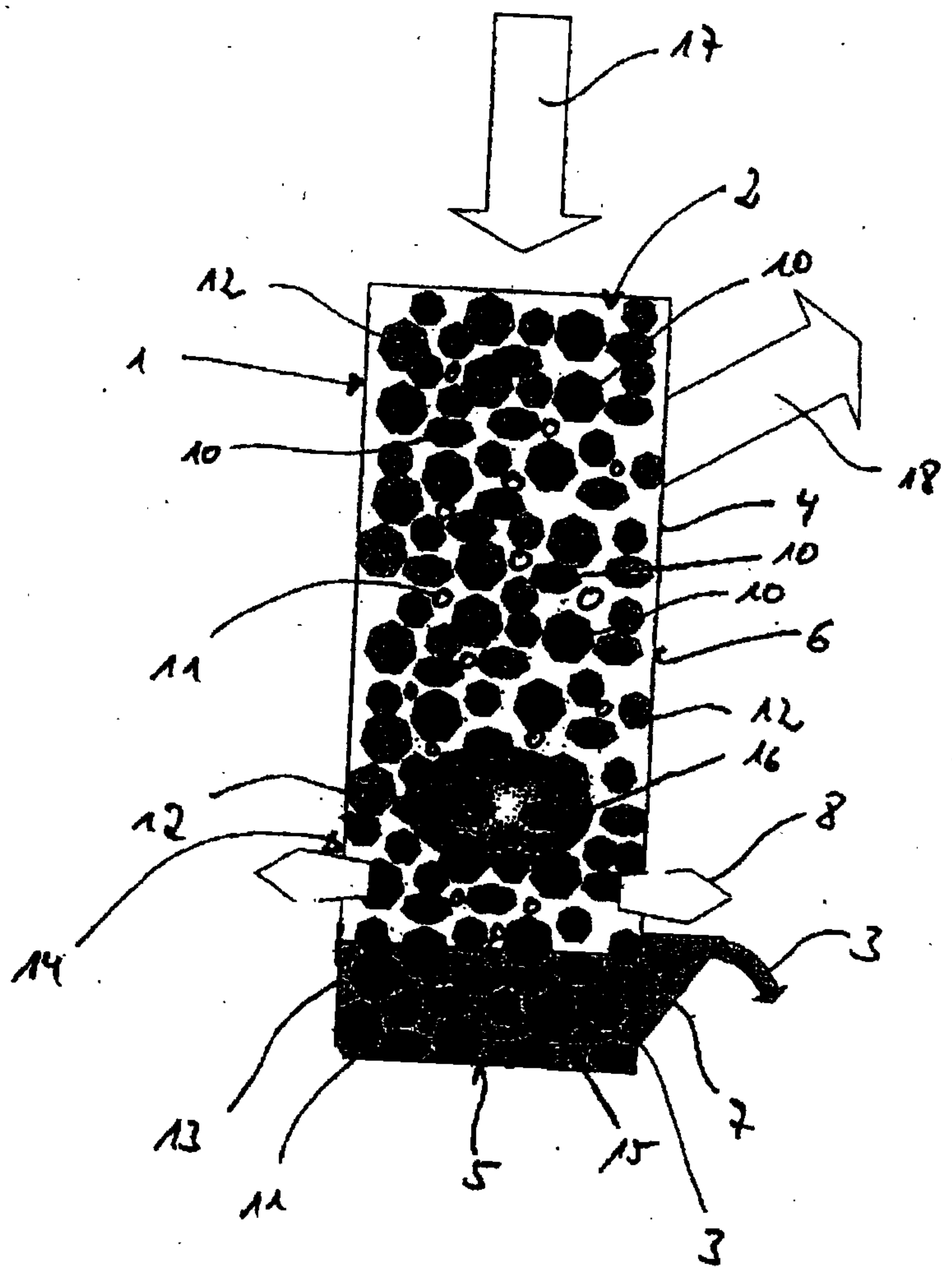
15. The filling according to claim 13, wherein up to 30% by weight of the combustible material is present in the filling and the remainder comprises the meltable starting material.

16. The filling according to claim 13, wherein the meltable starting material includes up to 50% by weight of natural stones, and the remainder comprises artificially shaped blocks, wherein the artificially shaped blocks consist of up to 70% by weight of recycled waste mineral fiber material and the remainder comprises recovered mineral fiber insulating materials.

17. The filling according to claim 16, wherein the artificially shaped blocks are pressed from fine-grained material having an average grain size of between 0.2 and 3 mm; with at least one binder of latent-hydraulic substances; and stones as a supporting grain.

18. The filling according to claim 13, wherein the combustible material further contains high-carbon waste materials.

19. The filling according to claim 18, wherein the high-carbon waste materials are recovered cathodic claddings of melting aggregates for the production of aluminum.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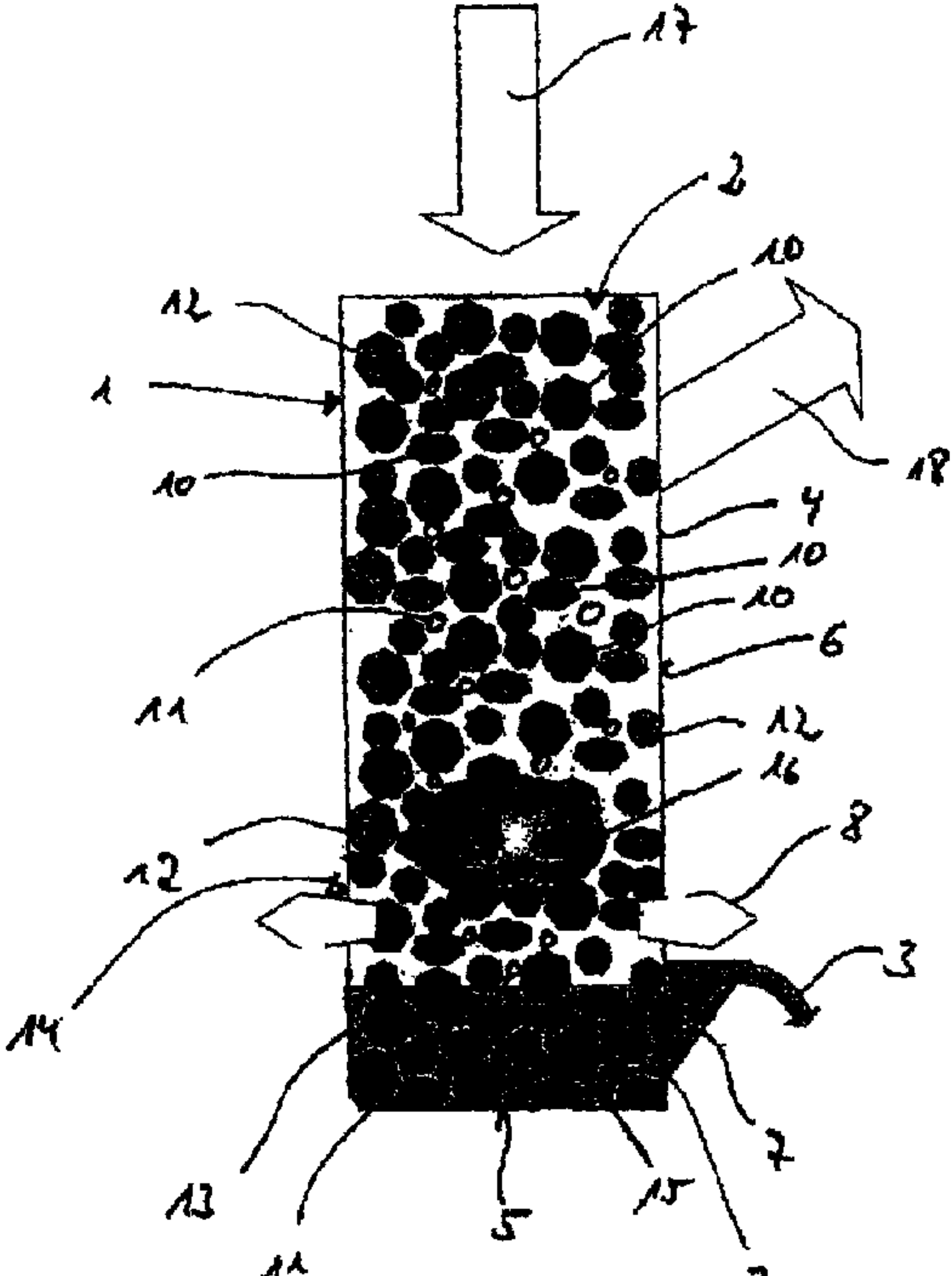
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