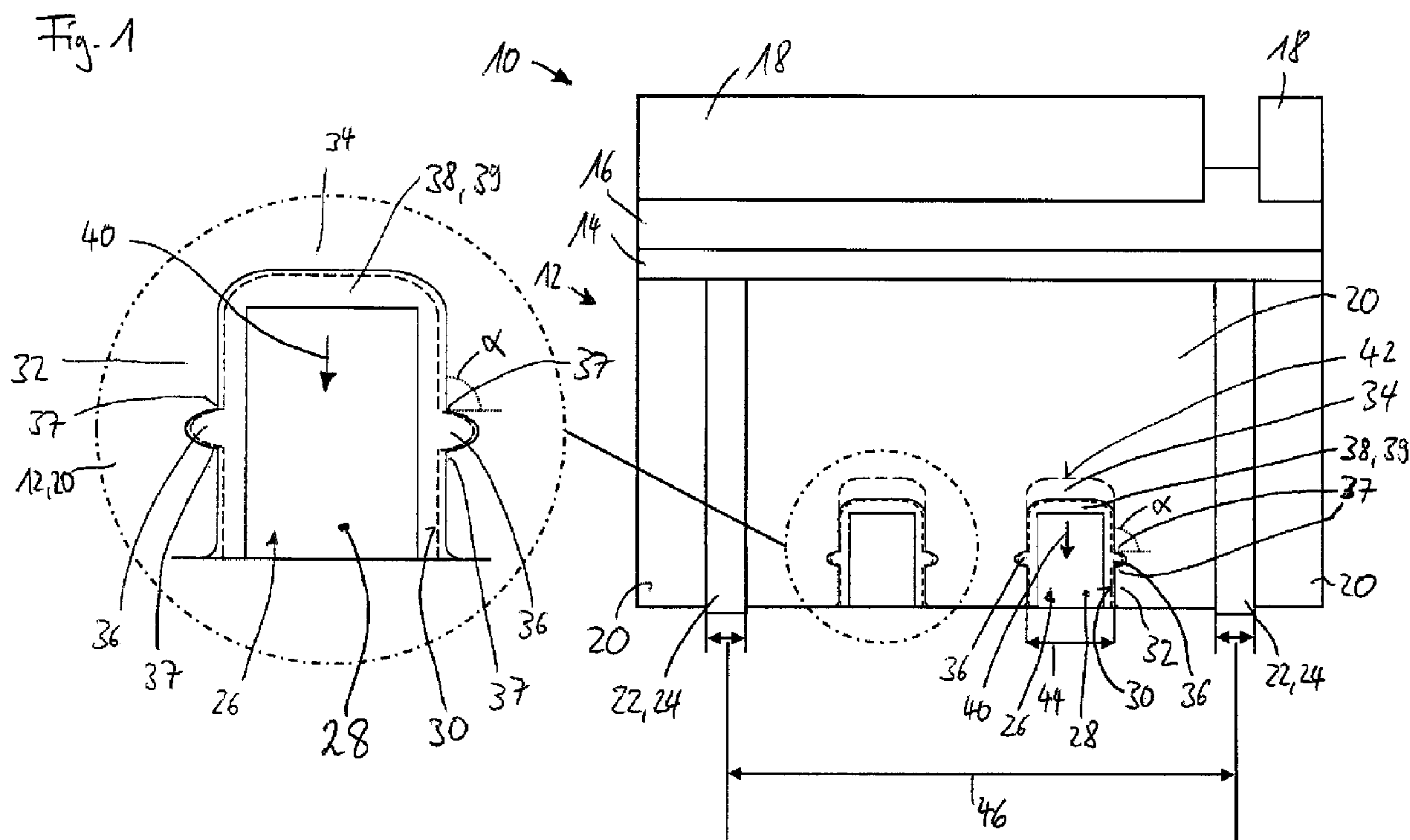




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(54) Title: CATHODE ARRANGEMENT AND CATHODE BLOCK WITH A GROOVE HAVING A GUIDE RECESS



(57) **Abrégé/Abstract:**

The present invention relates to a cathode assembly for an aluminum electrolytic cell, comprising at least one cathode block on the basis of carbon and/or graphite, which has a groove that is lined at least in some sections with a graphite film, wherein at least one busbar is provided in the at least one groove, said busbar having at least in some sections an envelope of cast iron. According to the invention, at least one recess is provided in the wall delimiting the at least one groove, and the envelope of cast iron engages in at least some sections into the at least one recess. The invention further relates to a cathode block for such a cathode assembly and to a method for producing such a cathode assembly for an aluminum electrolytic cell.



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**Cathode arrangement and cathode block with a
groove having a guide recess**

Abstract

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The present invention relates to a cathode arrangement for an aluminium electrolysis cell having at least one cathode block based on carbon and/or graphite, which has at least one groove lined with a graphite foil at least in certain regions, wherein at least one busbar is provided in the at least one groove and has an
10 encasement of cast iron at least in certain regions, wherein at least one recess is provided in the wall of the cathode block which delimits the at least one groove, and the encasement of cast iron engages into the at least one recess at least in certain portions. The invention also relates to a cathode block for such a cathode arrangement and to a process for producing such a cathode arrangement for an
15 aluminium electrolysis cell.

**Cathode arrangement and cathode block with a
groove having a guide recess**

The present invention relates to a cathode arrangement for an aluminium electrolysis cell, to a cathode block for such a cathode arrangement and to a process for producing such a cathode arrangement.

Such electrolysis cells are used for the electrolytic production of aluminium, which is customarily carried out in industry by the Hall-Héroult process. In the Hall-Héroult process, a melt composed of aluminium oxide and cryolite is electrolysed. Here, the cryolite, $\text{Na}_3[\text{AlF}_6]$, serves to lower the melting point of 2045°C for pure aluminium oxide to about 950°C for a mixture containing cryolite, aluminium oxide and additives, such as aluminium fluoride and calcium fluoride.

The electrolysis cell used in this process has a bottom, which is composed of a multiplicity of adjoining cathode blocks forming the cathode. In order to withstand the thermal and chemical conditions which prevail during operation of the cell, the cathode blocks are customarily composed of a carbon-containing material. The undersides of each of the cathode blocks are provided with grooves, in each of which there is arranged at least one busbar through which the current fed via the anodes is discharged. In this case, the interstices between the individual walls of the cathode blocks, which delimit the grooves, and the busbars are often sealed with cast iron, in order to electrically and mechanically connect the busbars to the cathode blocks by virtue of the resulting encasement of the busbars with cast iron. An anode formed from individual anode blocks is arranged about 3 to 5 cm above the layer of molten aluminium located on the top side of the cathode, and the electrolyte, i.e. the melt containing aluminium oxide and cryolite, is located between said anode and the surface of the aluminium. During the electrolysis carried out at about 1000°C , the aluminium which has formed settles beneath the electrolyte layer, i.e. as an intermediate layer between the top side of the cathode blocks and

the electrolyte layer, on account of the fact that its density is relatively large compared to that of the electrolyte. During the electrolysis, the aluminium oxide dissolved in the cryolite melt is cleaved to form aluminium and oxygen by a flow of electric current. In terms of electrochemistry, the layer of molten aluminium is the actual cathode, since aluminium ions are reduced to elemental aluminium on the surface thereof. Nevertheless, hereinbelow the term "cathode" will not be understood to mean the cathode from an electrochemical point of view, i.e. the layer of molten aluminium, but rather the component which forms the electrolysis cell bottom and is composed of one or more cathode blocks.

A significant disadvantage of the cathode arrangements used in the Hall-Héroult process is their relatively low wear resistance, which manifests itself by erosion of the cathode block surfaces during electrolysis. In this case, on account of an inhomogeneous current distribution within the cathode blocks, the cathode block surfaces are not eroded uniformly over the length of the cathode blocks, but rather to an increased extent at the cathode block ends, and therefore the surfaces of the cathode blocks change to a V-shaped profile after certain electrolysis duration. As a result of the nonuniform erosion of the cathode block surfaces, the useful life of the cathode blocks is limited by the areas with the greatest erosion.

In order to counter this problem, WO 2007/118510 A2 discloses a cathode block with a groove which is intended for receiving a busbar and has a greater depth in the centre than at the cathode block ends, with respect to the cathode block length. This achieves a substantially homogeneous vertical current distribution over the cathode block length during operation of the electrolysis cell, as a result of which the increased wear on the cathode block ends is reduced and thus the service life of the cathode is increased.

A further disadvantage of the cathode arrangement used in the Hall-Héroult process is its comparatively high electrical resistance. One of several reasons for the

comparatively high electrical resistance is that the contact resistance between the busbars and the cathode blocks of the cathode is comparatively high and this contact resistance additionally increases as the operating time of the cathode increases. This is caused firstly by the fact that constituents of the melt undesirably diffuse into the cathode blocks during electrolysis, which leads to the formation of insulating layers of for example β -aluminium oxide, and secondly by the fact that the steel of the busbars, the cast iron and the carbon of the cathode blocks start to creep after relatively long loading, i.e. the steel of the busbars, the cast iron and the carbon of the cathode blocks deform irreversibly after relatively long loading.

In order to reduce the electrical contact resistance between the busbars and the cathode blocks, and therefore to increase the energy efficiency of the electrolysis process, it has been proposed in WO 2007/071392 A2 to line the groove of a carbon-based or graphite-based cathode block with a graphite foil at least in certain regions. Aside from the fact that the graphite foil reduces the electrical contact resistance between the busbar, or the layer of solidified cast iron encasing it, and the cathode block on account of its good positive fit on both sides, the elasticity of the graphite foil means that the latter also reduces in particular the increase in this contact resistance as the operating time of the cathode increases, because the graphite foil fills the gaps which form during creep of the steel of the busbar and of the carbon of the cathode block between the walls which delimit the groove of the cathode block and the busbar.

However, graphite foils have a smooth surface with very good sliding properties. In the case of a cathode block having a groove lined with a graphite foil, there is therefore the risk that the busbar accommodated therein, which usually has a length of several metres and a weight of several hundred kilograms, will subsequently be displaced in the groove in an uncontrolled manner in the depth direction of the groove opening, or will even fall out of the groove, if for example the cathode block is raised as it is being installed or is moved for another reason. This risk

is present in particular in the case of a groove having a rectangular cross section, which is virtually the only applicable form for the groove of a cathode block with a groove depth which varies over its length. In addition, the precisely fitting contact between the groove and the cast iron is lost as a result of the busbar slipping in the groove, and this leads to poorer current transfer from the busbar to the cathode block and therefore to a decrease in energy efficiency. Finally, graphite foil cannot be connected to cast iron or can be connected to cast iron only to a very small degree, and therefore the filling of the gap between the busbar and the graphite foil by pouring liquid cast iron into it and subsequent hardening or solidification of the cast iron do not result in a connection between the graphite foil and the cast iron, but rather only in the busbar being encased with cast iron.

It is therefore an object of the present invention to provide a cathode arrangement for an aluminium electrolysis cell of the type mentioned in the introduction, which has a low electrical resistance, which is also in particular permanently low over an extended electrolysis period, and in particular also a low contact resistance between the busbar and the cathode block, and in which undesirable subsequent displacement of the busbar in the groove of the cathode block perpendicularly to the longitudinal direction of the cathode block, i.e. in the depth direction of the groove, and in particular falling out of the busbar from the groove is reliably prevented, to be precise in particular even in the case of a groove with a rectangular cross section, as is conventionally used in cathode blocks with a groove depth which varies over the cathode block length.

According to the invention, this object is solved by a cathode arrangement for an aluminium electrolysis cell having at least one cathode block based on carbon and/or graphite, which has at least one groove lined with a graphite foil at least in certain regions, wherein at least one busbar is provided in the at least one groove and has an encasement of cast iron at least in certain regions, wherein at least one recess is provided in the wall of the cathode block which delimits the at least

one groove, and the encasement of cast iron engages into the at least one recess at least in certain portions.

This solution is based on the realization that a precisely fitting positively-locking connection which is resistant to displacement in the direction perpendicular to the longitudinal direction of the cathode block is achieved between a busbar and a cathode block having a groove lined with graphite foil if at least one recess is provided in at least one wall of the cathode block which delimits the groove and a busbar encased with cast iron at least in certain regions is introduced into the groove such that the encasement of cast iron engages into the recess at least in certain portions. According to the invention, it has been identified that, independently of the high sliding properties of the graphite foil used, this achieves a fixed mechanical connection between the busbar encased with cast iron and the cathode block perpendicular to the longitudinal direction of the cathode block, which counteracts undesirable displacement of the busbar in this direction and in particular falling out of the busbar from the groove lined with graphite foil, to be precise in particular even in the case of a groove having a rectangular cross section, as is preferred for cathode blocks with a groove depth which varies over the cathode block length. Therefore, the cathode arrangement according to the invention has the advantage, associated with the lining of the groove with graphite foil on account of the electrical and mechanical properties of graphite foil, of improved current transfer between the busbar and the cathode block and therefore improved energy efficiency, and at the same time avoids the disadvantage, associated with the high sliding properties of graphite, of uncontrolled mobility of the busbar in the groove in the direction perpendicular to the longitudinal direction of the cathode block and accompanying possible impairment of the electrical connection between the busbar and the cathode block in the event that the electrolysis cell is operated for a relatively long time.

In addition, the present invention makes it possible to utilize the sliding properties of the graphite foil in a targeted manner to ensure that the busbar can be displaced longitudinally in the groove selectively, specifically in the case of movements caused by a change in temperature during start up.

In addition, the cathode arrangement according to the invention having the above-described advantages can be produced with extremely low expenditure and without complicated additional process steps. Thus, the mechanical connection which is provided between the busbar and the cathode block can be achieved simply by filling a recess of the cathode block at least partially with the cast iron during the already required casting of the busbar with the cast iron. This achieves very close contact between the busbar, the encasement of cast iron, the graphite foil and the cathode block, contributing to a particularly low electrical contact resistance between the busbar and the cathode block. In addition, the graphite foil absorbs the mechanical pressure which arises during operation of the cathode arrangement perpendicularly to the plane of the foil.

Within the context of the present invention, in demarcation relative to a mere surface roughness, a "recess" is understood to mean a cutout which, based on the surface of the wall which delimits the groove, has a depth of at least 0.05 mm and preferably of 0.5 mm.

In addition, within the context of the present invention, a "graphite foil" is understood to mean not only thin graphite sheet, but also in particular a partially compressed blank or a flexible plate of expanded graphite.

Within the context of the present invention, a "cathode arrangement" is understood to mean a cathode block having at least one groove, wherein at least one busbar, possibly encased by cast iron, is received in each of the at least one groove. Similarly, this term denotes an arrangement of a plurality of cathode blocks each hav-

ing at least one groove, wherein at least one busbar, possibly encased by cast iron, is received in each of the at least one groove.

In principle, the encasement of cast iron can be in direct contact with the graphite foil or with the cathode block itself at least in the region of the recess. Although this is preferred according to the present invention, it is not absolutely necessary. What in fact matters primarily for producing the desired mechanical connection between the busbar and the cathode block is the fact that the encasement of cast iron engages into the at least one recess at least in certain portions, i.e. fills the hollow space formed by the at least one recess at least in certain regions.

According to a preferred embodiment of the present invention, that portion of the encasement of cast iron which engages into the at least one recess is configured complementarily to the recess. This makes it possible to achieve a particularly good positively-locking engagement of the encasement of cast iron into the recess and therefore particularly effective mechanical fastening of the cast iron encasement and the busbar connected thereto to the cathode block.

In order to achieve a particularly good positive fit between the cast iron encasement and the cathode block, it is proposed in a development of the concept of the invention that that portion of the encasement which engages into the at least one recess and, if appropriate, the busbar encased thereby fill at least 70%, preferably at least 80%, particularly preferably at least 90%, very particularly preferably at least 95% and most preferably 100% of the recess. It is thereby possible to particularly reliably avoid undesirable displacement of the busbar in the direction perpendicular to the longitudinal direction of the cathode block and in particular falling out of the busbar from the groove.

It is advantageous that each of the at least one recess extends continuously over at least 20%, preferably over at least 40%, particularly preferably over at least

60%, very particularly preferably over at least 80% and most preferably at least approximately over the entire length of the groove. This can prevent the busbar from possibly slipping out of the groove during assembly. In addition, if the recess extends over a considerable part of the groove length, as described above, it is possible to ensure good displaceability of the busbar in the longitudinal direction of the groove, in which case undesirable displacement of the busbar parallel to the depth direction of the groove is still reliably prevented.

In principle, the cathode block can also have a multiplicity of recesses which follow one another in the longitudinal direction of the groove and are separated from one another by recess-free portions of the groove. This embodiment is particularly advantageous when longitudinal displaceability of the busbar in the cathode block is not desirable.

In order to ensure that the cast iron encasement and the busbar are anchored reliably in the cathode block, the at least one recess preferably has a depth of 2 mm to 40 mm, particularly preferably of 5 mm to 30 mm and very particularly preferably of 10 mm to 20 mm.

For the same reason, the at least one recess preferably has an opening width, based on the height of the cathode block, of 2 mm to 40 mm, particularly preferably of 5 mm to 30 mm and very particularly preferably of 10 mm to 20 mm.

As a consequence, the at least one recess preferably has a cross-sectional area of 1.5 mm^2 to 1600 mm^2 , particularly preferably of 10 mm^2 to 900 mm^2 and very particularly preferably of 40 mm^2 to 400 mm^2 . These values are preferred in particular for recesses having a polygonal cross section and particularly having a rectangular cross section. If the at least one recess has a curved cross section, such as for example a substantially semicircular cross section, the at least one recess preferably has a cross-sectional area of 1.5 mm^2 to 630 mm^2 , particularly

preferably of 10 mm^2 to 350 mm^2 and very particularly preferably of 40 mm^2 to 160 mm^2 .

In principle, the at least one recess can have any polygonal or bent cross section. Good results in terms of a good positively-locking engagement of the cast iron encasement into the at least one recess and at the same time in terms of reliable and unproblematic fillability of the recess with cast iron during casting are achieved in particular if the at least one recess has an at least substantially semi-circular, triangular, rectangular or trapezoidal cross section.

In a development of the concept of the invention, it is proposed that the at least one recess extends substantially perpendicularly into the wall of the cathode block which delimits the groove. This brings about a particularly reliable fixing action in the depth direction of the groove.

According to the present invention - as considered in the depth direction of the groove - the at least one recess is delimited at each of its ends by a transition region between the recess and an adjoining portion of the groove wall. If this transition region has an angled configuration, the angle between the adjoining portion of the groove wall and the wall of the recess, as seen from the inside of the cathode block, is preferably 90 degrees to 160 degrees, particularly preferably 90 degrees to 135 degrees and very particularly preferably 100 degrees to 120 degrees. If this transition region has a curved configuration, possibly but not necessarily ideally a configuration curved like a circle, the radius of curvature of the transition region is preferably at most 50 mm, particularly preferably at most 20 mm and most preferably at most 5 mm.

According to a further preferred embodiment of the present invention, the wall which delimits the groove comprises a bottom wall and two side walls, each side wall having at least one recess, preferably a recess which extends perpendicularly

to the surface of the respective side wall. In this way, the busbar is held on both sides in the groove, as a result of which the busbar can be fixed particularly effectively in the desired position. In principle, it is also possible for a plurality of recesses to be provided in one or in both of the side walls, for example at least 1, at least 2, at least 3 or at least 4 recesses per side wall, into each of which the encasement of the busbar of cast iron engages at least in certain portions. A particularly strong connection between the busbar and the cathode block is achieved as a result. It is preferable for the depth and/or the volume of the individual recesses to be all the more lower as more recesses are provided in the groove.

It is preferable for the at least one recess to be at an at least substantially constant distance from the bottom wall of the groove over its length and to run parallel thereto. In such a configuration, displaceability of the busbar parallel to the groove bottom is ensured.

According to a further preferred embodiment of the present invention, each of the at least one recess is lined at least in certain regions and preferably over its full extent with the graphite foil, in which case it goes without saying that the remaining regions of the groove are also preferably lined over their full extent with the graphite foil. As a consequence, a particularly low electrical contact resistance between the cast iron and the cathode block is produced even in the region of the recesses. In addition, the sliding properties of the graphite foil mean that it is possible to ensure displaceability of the busbar, as described above, in the longitudinal direction of the at least one recess and therefore in the longitudinal direction of the cathode block, if the majority of the surface and preferably at least approximately the entire surface of the wall which delimits the groove is lined with graphite foil. In this case, the graphite foil can be pressed against the boundary of the recess by the encasement of the busbar of cast iron, in order to bring about both particularly good electrical contact and also a particularly effective positive fit. This effect becomes important especially during heating of the electrolysis cell for start up, since

the specific thermal expansion of steel or iron is approximately three times the specific thermal expansion of conventional cathode materials.

The at least one recess of the groove can be lined with the graphite foil during the production of the cathode arrangement simply by inserting the graphite foil into the groove such that it fills the recess, and then pouring the cast iron into the groove in such a manner that the graphite foil is pressed into the recess, where it is pressed in particular directly against the cathode block material which delimits the recess.

In order to achieve a vertical current density distribution which is uniform over the cathode block length, it is proposed in a development of the concept of the invention that the at least one groove has a depth which varies over its length or the length of the cathode block, it being particularly preferable for the centre of the groove, with respect to the longitudinal direction, to have a greater depth than the two longitudinal-side ends thereof. This achieves a uniform distribution of the electric current fed via the cathode arrangement over the entire length of the cathode block, as a result of which an excessive electric current density at the longitudinal-side ends of the cathode block and thus premature wear at the ends of the cathode block is avoided. In this embodiment, virtually the only applicable cross-sectional form for the groove is rectangular, and therefore the effect of the present invention, specifically that of reliably avoiding falling out of the busbar from the groove opening, is particularly pronounced here.

Such a uniform current density distribution over the length of the cathode block avoids movements in the aluminium melt which are caused by the interaction of electromagnetic fields, and it is thereby possible to arrange the anode at a smaller height above the surface of the aluminium melt. This reduces the electrical resistance between the anode and the aluminium melt and increases the energy efficiency of the fused-salt electrolysis which is carried out.

In the above-described embodiment, too, in which the cathode block has a groove of variable depth, the at least one recess of the cathode block is preferably configured such that it is at a substantially constant distance from the bottom of the groove over the length of the groove, in order to thereby make it possible to displace the busbar as required along the longitudinal direction of the cathode block.

The cathode arrangement according to the invention is also suitable without any problems in particular for the use of conventional groove and/or busbar geometries. By way of example, the groove and/or the busbar can conventionally have a substantially rectangular cross section. This is preferable in particular if the groove has a depth which varies in the longitudinal direction. The busbar, in particular, can also conventionally consist of steel.

In a development of the concept of the invention, it is proposed that the graphite foil lining the groove at least in certain regions contains expanded graphite and particularly preferably compressed expanded graphite, which is particularly preferably free of binders. It is very particularly preferable for the graphite foil lining the groove at least in certain regions to consist of expanded graphite and particularly preferably of compressed expanded graphite free of binders. As set forth above, the foil in principle can also be formed by a substantially plate-shaped blank, which contains expanded graphite and in this case has a sufficient elasticity to be deformed elastically such that it permits the above-described filling of the recess by the cast iron encasement and in the process can be inserted into the recess between the cast iron and the wall which delimits the groove.

The graphite content of the graphite foil is preferably at least 60%, further preferably at least 70%, particularly preferably at least 80%, especially preferably at least 90% and very particularly preferably at least approximately 100%.

Good results in terms of optimum exploitation of the mechanical and electrical properties of the graphite are achieved in particular if the graphite foil has a thickness of between 0.2 mm and 3 mm, preferably between 0.2 mm and 1 mm and particularly preferably between 0.3 mm and 0.5 mm.

Depending on the desired properties, the graphite foil can be inserted or adhesively bonded into the groove. Adhesive bonding of the graphite foil into the groove is preferable in particular if the graphite foil is pressed to only a relatively small degree against the surface of the recess, or if displacement of the graphite foil, no matter how small, in the longitudinal direction of the cathode block is to be avoided.

According to a further preferred embodiment of the present invention, the cathode block has one or two grooves for receiving in each case at least one busbar. In principle, it is possible within the context of the invention for one groove of the cathode block to receive exactly one busbar, but in particular also two busbars, which are inserted into various portions of the length of the groove. In this case, the busbars can be arranged so that they lie opposite one another on their faces.

The present invention also relates to a cathode block for a cathode arrangement of an aluminium electrolysis cell based on carbon and/or graphite, which has at least one groove for receiving a busbar, wherein at least one recess is provided in the wall of the cathode block which delimits the at least one groove. Such a cathode block can advantageously be used as a component part of the cathode arrangement described above. Here, the cathode block can be constructed on the basis of amorphous carbon, graphitic carbon, graphitized carbon or any desired mixture of the above carbons.

The present invention also relates to a process for producing a cathode arrangement for an aluminium electrolysis cell, comprising the following steps:

- providing a cathode block based on carbon and/or graphite, which has at least one groove for receiving a busbar, wherein at least one recess is provided in the wall of the cathode block which delimits the at least one groove,
- lining at least a region of the at least one groove with a graphite foil,
- inserting a busbar into the at least one groove,
- pouring liquid cast iron into at least a portion of the at least one recess between the graphite foil and the busbar, and
- allowing the cast iron to solidify.

The static pressure of the cast iron column thrusts the graphite foil located in the groove into the at least one recess, where it is pressed in particular against the cathode block which delimits the at least one recess. It is thereby possible with particular ease to produce a cathode arrangement having a recess lined partially or completely by the graphite foil which has a particularly low electrical contact resistance between the busbar and the cathode block. During heating of the electrolysis cell for start up, particularly close contact is achieved by the different thermal expansions of steel or iron and the cathode material.

The graphite foil can be inserted and/or adhesively bonded into the groove before the busbar is inserted. A loose insertion of the graphite foil in the groove can be sufficient as a prefixing, since the graphite foil is preferably pressed by the cast iron against the at least one wall of the cathode block which delimits the groove during casting.

For producing the cathode block, a carbon-containing or graphite-containing starting material or a mixture of a plurality of such materials can be brought into a mould and then compacted to form a green body. The starting materials in this case are preferably present in particulate or granular form. Then, the green body can be heated and thus carbonized and, if appropriate, graphitized. Within the

context of the present invention, it is possible to use both carbonized cathode blocks, which are understood to mean those cathode blocks which, during their production, have been subjected to heat treatment of up to at most 1500°C and preferably between 800 and 1200°C and have a high content of amorphous carbon, and also graphitized cathode blocks, which are understood to mean those cathode blocks which, during their production, have been subjected to heat treatment of more than 2000°C and preferably between 2300 and 2700°C and have a high content of graphite-like carbon. Finally, it is possible to use cathode blocks based on graphitic carbon, i.e. those which have not been graphitized but to which graphite has been added as starting material.

As the starting substances for carbonized cathode blocks, use is made for example of a mixture of calcined anthracite, graphite and coal tar pitch and/or petroleum pitch, whereas graphitic cathode blocks are produced for example from a mixture containing graphite and coal tar pitch and/or petroleum pitch. Here, graphite denotes both natural and synthetic graphite.

According to an advantageous development of the process, during the production of the cathode block, the starting material containing carbon and/or graphite is introduced into a mould, which has a protrusion formed complementarily to the at least one recess.

Similarly, the at least one recess can be produced by subsequently removing and/or eliminating cathode block material of the at least one wall of the cathode block which delimits the groove. It is possible in particular for the recess to be introduced subsequently by a milling process, in which case a milling head used for introducing the recess preferably has a cross section corresponding to the recess.

The present invention also relates to a cathode arrangement obtainable by a process as described above.

Hereinbelow, the present invention is described purely by way of example on the basis of advantageous embodiments and with reference to the attached drawings.

In the drawings:

Figure 1 shows a cross section of a detail of an aluminium electrolysis cell having a cathode arrangement according to an exemplary embodiment of the present invention,

Figure 2 shows a longitudinal section of the cathode arrangement of the aluminium electrolysis cell shown in Figure 1, and

Figures 3a-d show exemplary cross sections of recesses which are provided in a groove of a cathode block according to the invention.

Figure 1 shows a cross section of a detail of an aluminium electrolysis cell 10 having a cathode arrangement 12, which at the same time forms the bottom of a tank for an aluminium melt 14 produced during operation of the electrolysis cell 10 and for a cryolite-aluminium oxide melt 16 located above the aluminium melt 14. An anode 18 is in contact with the cryolite-aluminium oxide melt 16. At the side, the tank formed by the lower part of the aluminium electrolysis cell 10 is delimited by a carbon and/or graphite lining (not shown in Figure 1).

The cathode arrangement 12 comprises a plurality of cathode blocks 20, which are each connected to one another via a ramming mass 24 which has been inserted into a ramming mass joint 22 arranged between the cathode blocks 20. A cathode block 20 in this case comprises two grooves 26 arranged on the underside thereof,

having a rectangular, specifically a substantially rectangular cross section, wherein a busbar 28 of steel likewise having a rectangular cross section is received in each groove 26. Here, each wall 32, 34 delimiting the groove 26 is lined by a graphite foil 30, which is indicated by dashed lines in Figure 1.

The grooves 26 are each delimited by two side walls 32 and a bottom wall 34 of the cathode block 20, with a recess 36 extending substantially perpendicularly into the side wall 32 and having an approximately semicircular cross section being provided in each of the side walls 32. Each recess 36 is delimited by an upper and a lower transition region 37 of the cathode block 20. In the present exemplary embodiment, the transition regions 37 have an angled configuration, with an angle α between the adjoining portion of the groove wall and the wall of the recess of 90 degrees. In this case, the interstice between the busbar 28 and the groove 26 lined with the graphite foil 30 is poured out in each case with cast iron 38, and therefore the graphite foil 30 is fixed between the cast iron 38 and the cathode block 20. In this case, the graphite foil 30 is pressed against the walls 32, 34 which delimit the respective groove 26 by the cast iron 38. In the present exemplary embodiment, the recesses 36 are also each lined by the graphite foil 30, in which case the cast iron 38 positively fills the lined recesses 36 and presses the graphite foil 30 against the cathode block 20 which delimits the recess 36. In this way, a low electrical contact resistance between the busbar 28 and the cathode block 20 is ensured over the entire cross section of the groove 26. The cast iron 38 forms an encasement 39 for the busbar 28 and is integrally connected to the busbar 28.

In addition, the cast iron 38 received in the recesses 36 in each case forms a positively-locking connection with the material of the cathode block 20 which delimits the recess 36, and this prevents movement of the busbar 28 connected to the cast iron 38 in the direction of the arrow 40. This prevents undesirable movement of the busbar 28 in the depth direction of the groove 26 or prevents even the busbar 28 from falling out of the groove 26.

Figure 1 specifically shows the cross section of the cathode arrangement 10 at a longitudinal-side end of the cathode block 20. In this case, the depth of the grooves 26 of the cathode block 20 varies over the length of the grooves 26. The groove cross section in the region of the centre of the groove 26 is indicated by a dashed line 42 in Figure 1. In the present exemplary embodiment, the difference between the groove depth at the longitudinal-side ends of the groove 26 and in the centre of the groove 26 is approximately 10 cm. The width 44 of each groove 26 is substantially constant over the entire groove length and is approximately 15 cm, whereas the width 46 of each of the cathode blocks 20 is approximately 65 cm.

In the present exemplary embodiment, a plurality of anodes 18 and a plurality of cathode blocks 20 are arranged above one another in such a way that each anode 18 covers two cathode blocks 20 arranged alongside one another in width and covers half a cathode block 20 in length, in each case two anodes 18 arranged alongside one another covering the length of a cathode block 20.

Figure 2 is a longitudinal section showing the cathode block 20 shown in Figure 1. As can be seen from Figure 2, the groove 26, considered in its longitudinal section, tapers towards the centre of the cathode block 20 in the form of a triangle, as a result of which a substantially uniform vertical electric current density is ensured over the entire cathode length. As indicated by a dashed line in Figure 2, the recesses 36 here run parallel to the groove bottom 34 and are at a constant distance from the groove bottom 34 over the length of the groove 26. In the present exemplary embodiment, the busbar 28, which is not shown in Figure 2 for the sake of greater clarity, has a bar-like form and has a rectangular longitudinal section, such as to form an interstice between the busbar and the groove bottom 34, which interstice increases in size towards the centre of the groove 26 and can be filled either by cast iron 38 or by additional metal plates connected to the busbar 28.

Similarly, it would also be possible to use a busbar 28 which is matched in its longitudinal section to the triangular profile of the groove 26.

Finally, Figures 3a to d show exemplary recesses 36, which are provided in a groove of a cathode block 20 according to the invention, in cross section. Here, the recesses 36 each have a substantially semicircular cross section (Figure 3a), a substantially trapezoidal cross section (Figure 3b) or a substantially triangular cross section (Figure 3c). The angle α of the transition regions 37 between the wall of the recess 36 and the adjoining portion of the groove wall 32, as seen from the inside of the cathode block 20, is in this case about 90 degrees in Figure 3a, about 120 degrees in Figure 3b and about 125 degrees in Figure 3c. Figure 3d shows a configuration in which a plurality of recesses 36 with a triangular cross section, as shown in Figure 3c, are arranged in succession in the depth direction of the groove 26, in order to particularly reliably hold an inserted busbar 28. In this case, the transition regions 48 between two adjoining recesses 36 have an angle β of about 70 degrees between the walls of two adjoining recesses 36, as seen from the inside of the cathode block 20. The recesses 36 shown in Figures 3a to d each extend perpendicularly into the side wall 32 of the cathode block 20 which delimits the groove 26, such that they form a fixing with cast iron received in the recesses 36, which is effective in the depth direction of the groove 26 and prevents undesirable movement of the busbar 28 parallel to the depth direction of the groove 26 after the busbar 28 has been cast with cast iron 38.

List of reference symbols

10	Aluminium electrolysis cell
12	Cathode arrangement
14	Aluminium melt
16	Cryolite-aluminium oxide melt
18	Anode

20	Cathode block
22	Ramming mass joint
24	Ramming mass
26	Groove
28	Busbar
30	Graphite foil
32	Side wall
34	Bottom wall
36	Recess
37	Transition region between the wall of the recess and the adjoining portion of the groove wall
38	Cast iron
39	Encasement
40	Arrow
42	Dashed line
44	Width of the groove 26
46	Width of the cathode block 20
48	Transition region between two adjoining recesses
α	Angle between the wall of the recess and the adjoining portion of the groove wall
β	Angle between the walls of two adjoining recesses

Patent Claims

1. Cathode arrangement for an aluminium electrolysis cell (10) having at least one cathode block (20) based on carbon and/or graphite, which has at least one groove (26) lined with a graphite foil (30) at least in certain regions, wherein at least one busbar (28) is provided in the at least one groove (26) and has an encasement (39) of cast iron (38) at least in certain regions, characterized in that
at least one recess (36) is provided in the wall (32, 34) of the cathode block (20) which delimits the at least one groove (26), and the encasement (39) of cast iron (38) engages into the at least one recess (36) at least in certain portions.
2. Cathode arrangement according to Claim 1, characterized in that
that portion of the encasement (39) of cast iron (38) which engages into the at least one recess (36) is configured complementarily to the recess (36).
3. Cathode arrangement according to Claim 1 or 2, characterized in that
that portion of the encasement (39) which engages into the at least one recess (36) and, if appropriate, the busbar (28) encased thereby fill at least 70%, preferably at least 80%, particularly preferably at least 90%, very particularly preferably at least 95% and most preferably at least 100% of the recess (36).
4. Cathode arrangement according to at least one of the preceding claims, characterized in that

each of the at least one recess (36) extends continuously over at least 20%, preferably over at least 40%, particularly preferably over at least 60%, very particularly preferably over at least 80% and most preferably at least approximately over the entire length of the groove (26).

5. Cathode arrangement according to at least one of the preceding claims, characterized in that
each of the at least one recess (36) has a depth of 2 mm to 40 mm, preferably of 5 mm to 30 mm and particularly preferably of 10 mm to 20 mm.
6. Cathode arrangement according to at least one of the preceding claims, characterized in that
each of the at least one recess (36) has an opening width, based on the height of the cathode block, of 2 mm to 40 mm, preferably of 5 mm to 30 mm and particularly preferably of 10 mm to 20 mm.
7. Cathode arrangement according to at least one of the preceding claims, characterized in that
each of the at least one recess (36) preferably has a cross-sectional area of 1.5 mm^2 to 1600 mm^2 , preferably of 10 mm^2 to 900 mm^2 and particularly preferably of 40 mm^2 to 400 mm^2 .
8. Cathode arrangement according to at least one of the preceding claims, characterized in that
the at least one recess (36) has an at least substantially semicircular, triangular, rectangular or trapezoidal cross section.
9. Cathode arrangement according to at least one of the preceding claims, characterized in that

the recess (36) extends substantially perpendicularly into the wall (32, 34) of the cathode block (20) which delimits the groove (26).

10. Cathode arrangement according to at least one of the preceding claims, characterized in that,
as considered in the depth direction of the groove (26), the at least one recess (36) is delimited at each of its ends by a transition region (37) between the recess (36) and an adjoining portion of the groove wall (32, 34), wherein each of the transition regions (37) has an angled configuration, wherein the angle (α) between the wall of the recess (36) and the adjoining portion of the groove wall (32, 34), as seen from the inside of the cathode block, is 90 degrees to 160 degrees, preferably 90 degrees to 135 degrees and particularly preferably 100 degrees to 120 degrees.
11. Cathode arrangement according to at least one of Claims 1 to 9, characterized in that,
as considered in the depth direction of the groove (26), the at least one recess (36) is delimited at each of its ends by a transition region (37) between the recess (36) and an adjoining portion of the groove wall (32, 34), wherein each of the transition regions (37) has a curved configuration, wherein the radius of curvature of the transition region is at most 50 mm, preferably at most 20 mm and particularly preferably at most 5 mm.
12. Cathode arrangement according to at least one of the preceding claims, characterized in that
the wall (32, 34) which delimits the groove (26) comprises a bottom wall (34) and two side walls (32), each side wall (32) having at least one recess (36).
13. Cathode arrangement according to at least one of the preceding claims,

characterized in that

the at least one recess (36) is at a substantially constant distance from the bottom wall (34) of the groove (26) over its length.

14. Cathode arrangement according to at least one of the preceding claims, characterized in that each of the at least one recess (36) is lined at least in certain regions and preferably over its full extent with the graphite foil (30), and each of the at least one groove (26) is preferably lined over its full extent with the graphite foil (30).
15. Cathode arrangement according to Claim 14, characterized in that the graphite foil (30) is pressed against the boundary of the recess (36) by the encasement (39) of the busbar (28) of cast iron (38).
16. Cathode arrangement according to at least one of the preceding claims, characterized in that the groove (26) has a depth which varies over its length.
17. Cathode arrangement according to Claim 16, characterized in that the longitudinal-side ends of the groove (26) have a smaller depth than the centre thereof.
18. Cathode arrangement according to at least one of the preceding claims, characterized in that each of the at least one groove (26) has an at least substantially rectangular cross section.

19. Cathode arrangement according to at least one of the preceding claims, characterized in that
each of the at least one busbar (28) has a substantially rectangular cross section.
20. Cathode arrangement according to at least one of the preceding claims, characterized in that
the graphite foil (30) contains or consists of expanded graphite, preferably at least partially compressed expanded graphite.
21. Cathode arrangement according to at least one of the preceding claims, characterized in that
the graphite foil (30) has a thickness of between 0.2 mm and 3 mm, preferably between 0.2 mm and 1 mm and particularly preferably between 0.3 mm and 0.5 mm.
22. Cathode arrangement according to at least one of the preceding claims, characterized in that
the graphite foil (30) is inserted and/or adhesively bonded into the groove (26).
23. Cathode arrangement according to at least one of the preceding claims, characterized in that
the cathode block (20) has one or two grooves (26) for receiving in each case at least one busbar (28).
24. Cathode block for a cathode arrangement (12) of an aluminium electrolysis cell (10) based on carbon and/or graphite having at least one groove (26) for receiving a busbar (28),
characterized in that

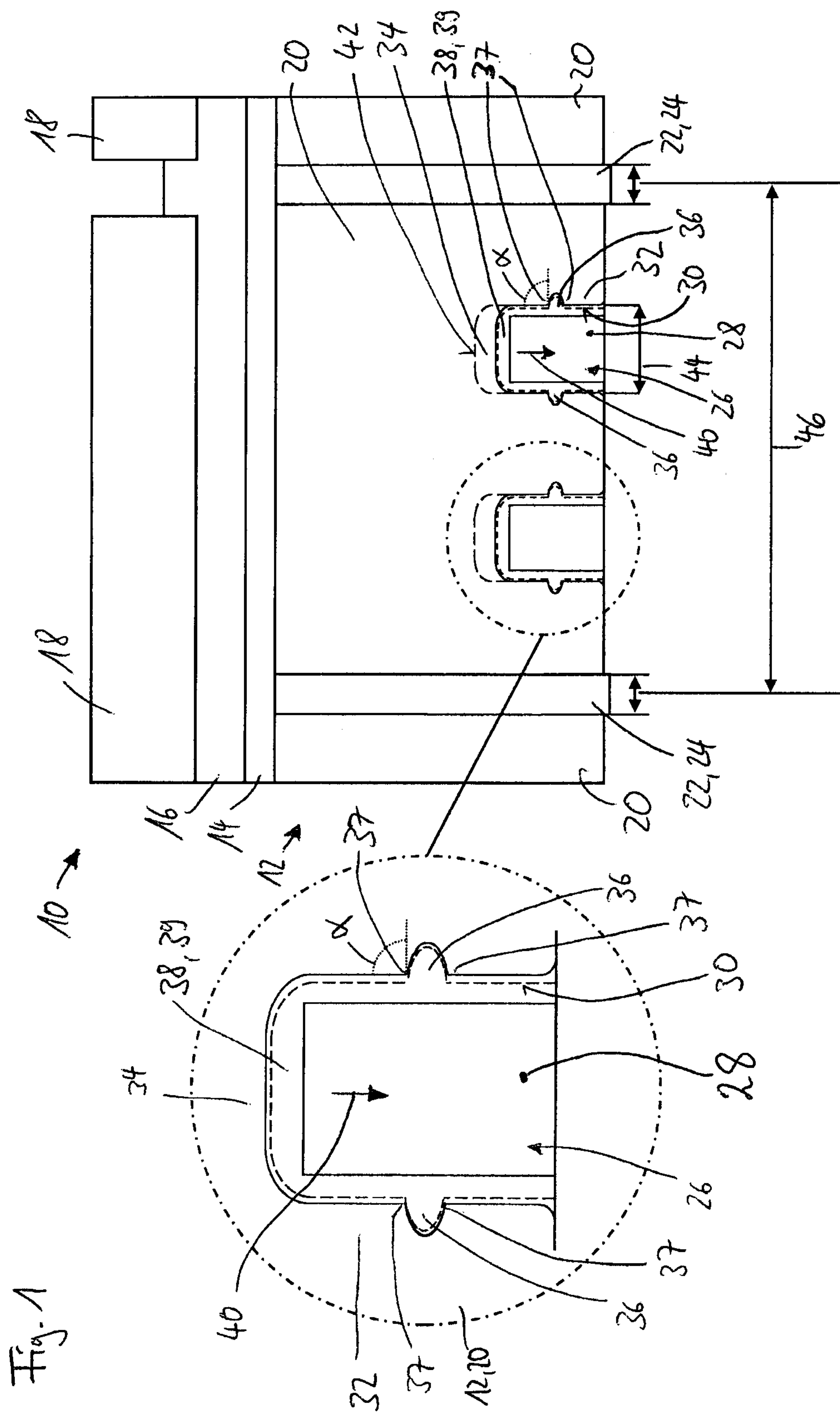
at least one recess (36) is provided in the wall (32, 34) of the cathode block (20) which delimits the at least one groove (26).

25. Process for producing a cathode arrangement (12) for an aluminium electrolysis cell (10), comprising the following steps:
 - providing a cathode block (20) based on carbon and/or graphite, which has at least one groove (26) for receiving a busbar (28), wherein at least one recess (36) is provided in the wall (32, 34) of the cathode block (20) which delimits the at least one groove (26),
 - lining at least a region of the at least one groove (26) with a graphite foil (30),
 - inserting a busbar (28) into the at least one groove (26),
 - pouring liquid cast iron into at least a portion of the at least one recess (36) between the graphite foil (36) and the busbar (28), and
 - allowing the cast iron (38) to solidify.
26. Process according to Claim 25, characterized in that the graphite foil (30) is inserted and/or adhesively bonded into the groove (26).
27. Process according to Claim 25 or 26, characterized in that, during the production of the cathode block (20), material containing carbon and/or graphite is introduced into a mould, which has a protrusion formed complementarily to the at least one recess (36).
28. Process according to at least one of Claims 25 to 27, characterized in that

the at least one recess (36) is produced by removing and/or eliminating material of the wall (32, 34) of the cathode block (20) which delimits the groove (26).

29. Cathode arrangement obtainable by a process according to at least one of Claims 25 to 28.

1/2



2/2

Fig. 2

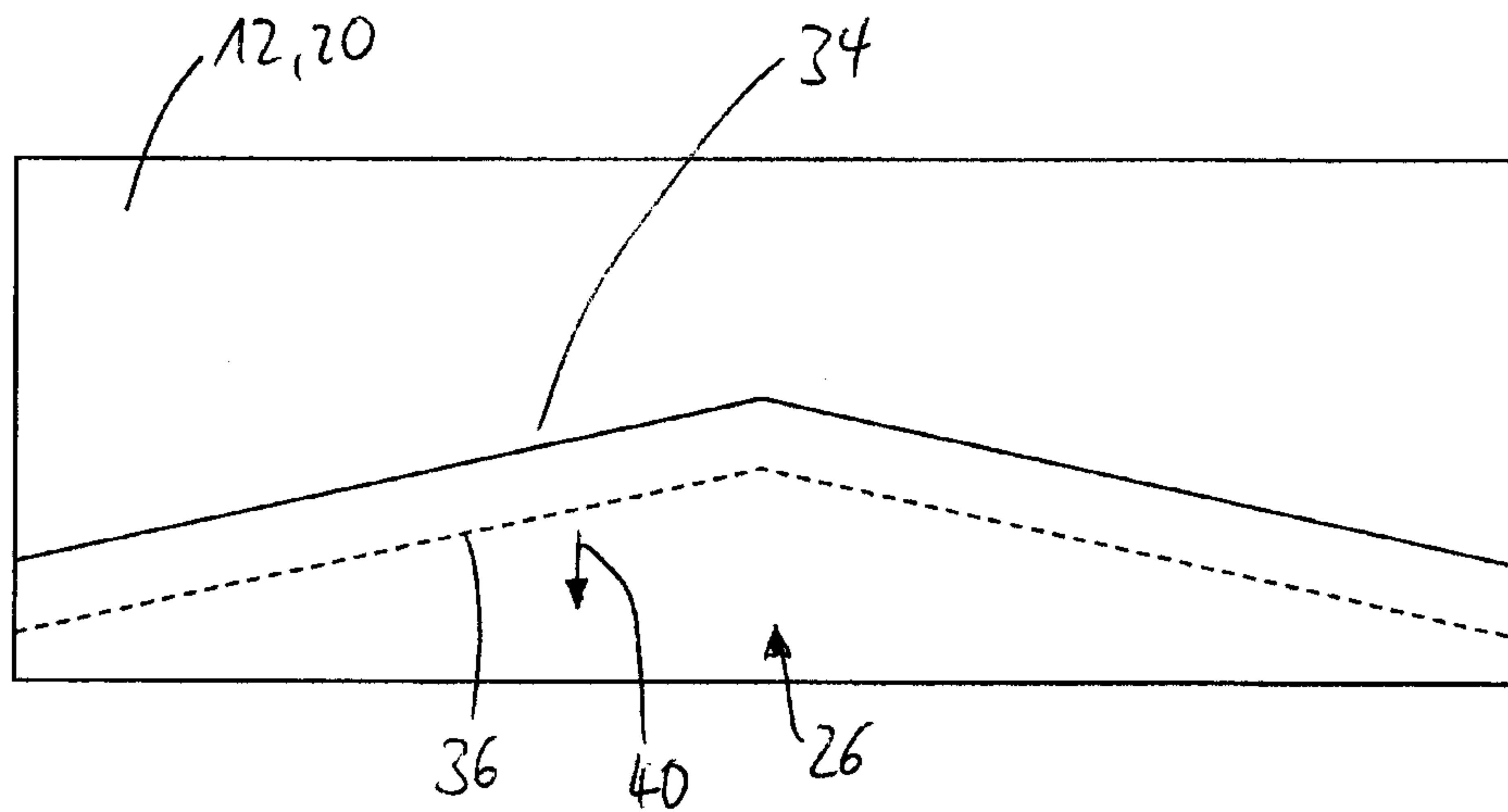


Fig. 3

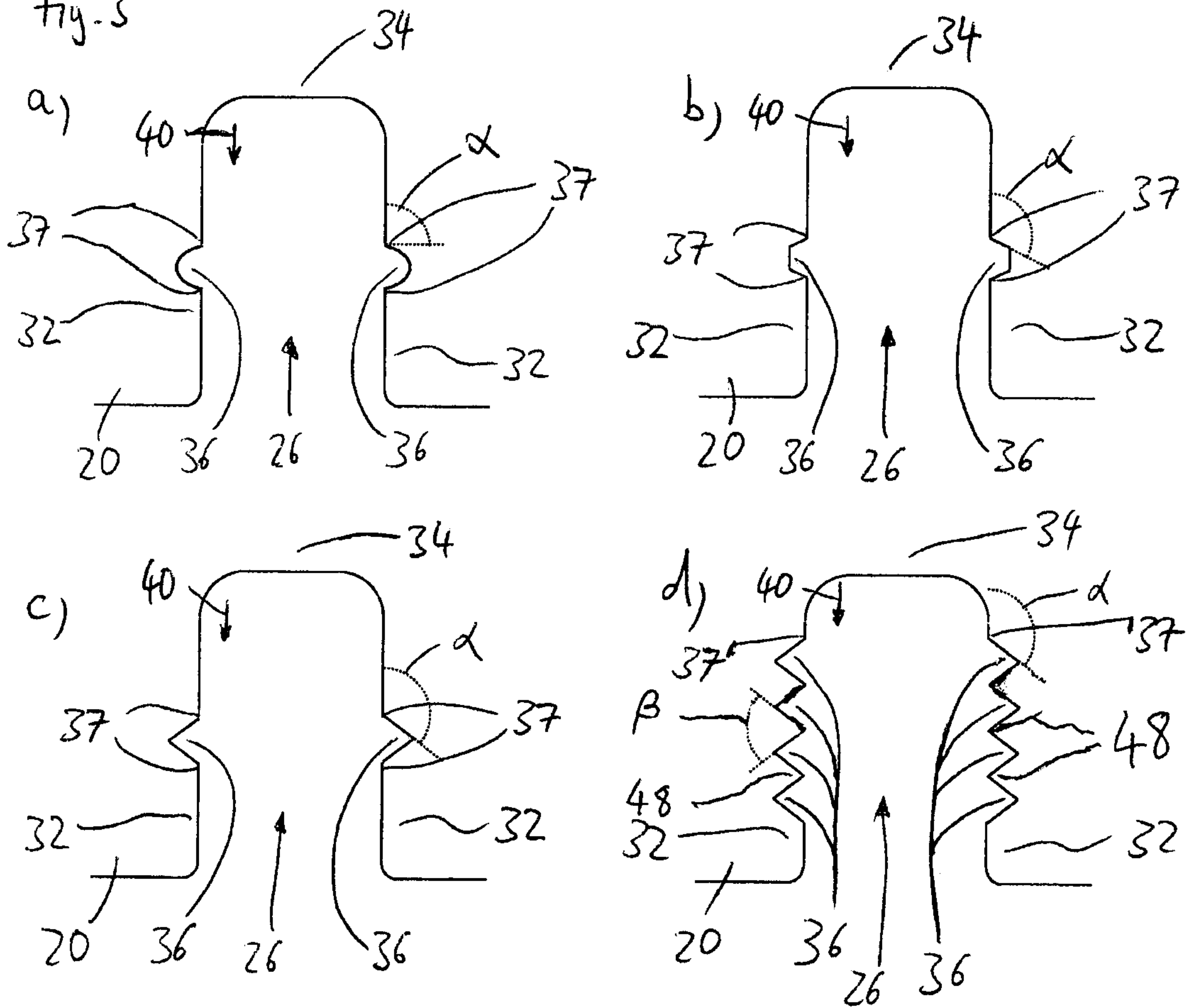


Fig. 1

