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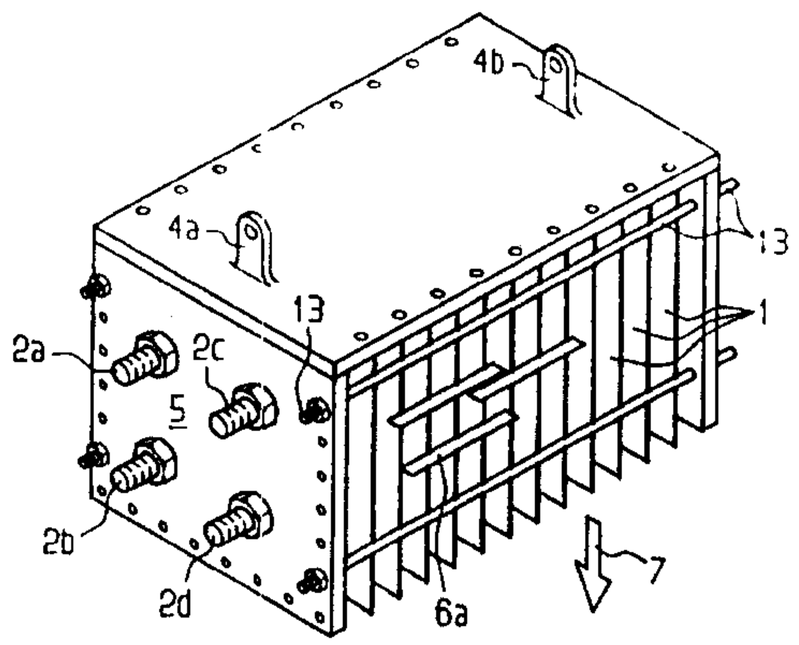
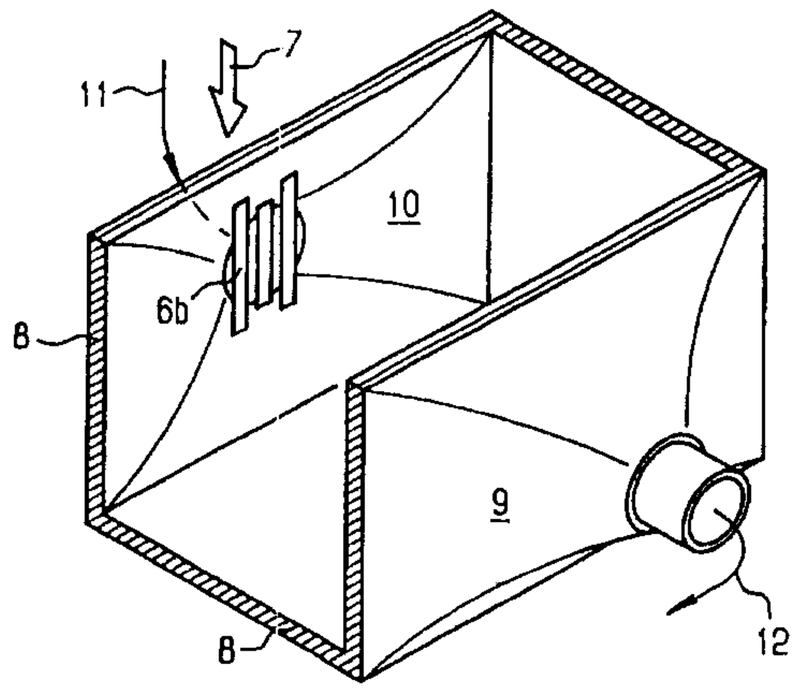
(54) **BATTERIE DE PILES A COMBUSTIBLE A REFROIDISSEMENT LIQUIDE**

(54) **LIQUID-COOLED FUEL CELL BATTERIES**





(57) Batterie, à refroidissement liquide, d'au moins deux piles à combustible (1), comprenant chacune une plaque polaire négative, une unité membrane-électrode et une plaque polaire positive qui sont connectées entre elles, de manière électroniquement isolée, étanche au gaz et mécaniquement rigide par un élément en forme de cadre, ladite batterie étant immergée dans un bain de liquide de refroidissement (9, 10).

(57) A liquid-cooled battery with at least two fuel cells (1) which both contain a negative pole flange, a membrane-electrode unit and a positive pole flange, which are interconnected by a frame element in a mechanically rigid, gastight and electronically insulating way. The battery is submerged in a cooling bath (9, 10).

PCT

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(54) Title: LIQUID–COOLED FUEL CELL BATTERIES

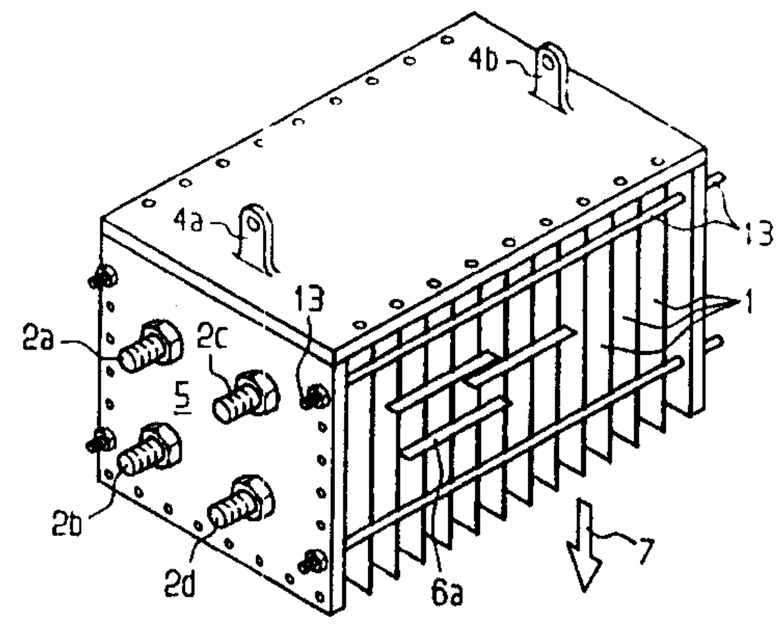
(54) Bezeichnung: FLÜSSIGKEITSGEKÜHLTE BRENNSTOFFZELLENBATTERIE

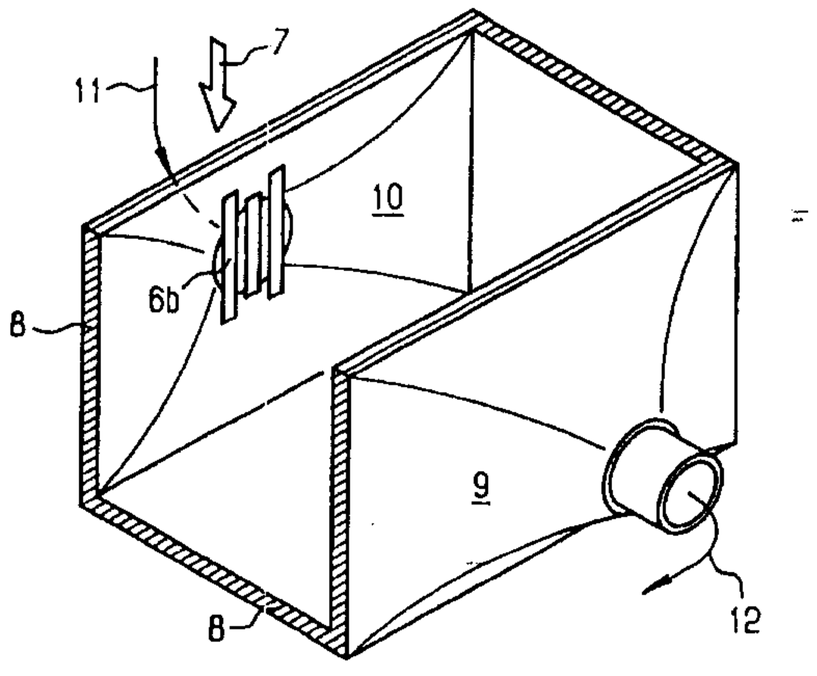
(57) Abstract

A liquid–cooled battery with at least two fuel cells (1) which both contain a negative pole flange, a membrane–electrode unit and a positive pole flange, which are interconnected by a frame element in a mechanically rigid, gastight and electronically insulating way. The battery is submerged in a cooling bath (9, 10).

(57) Zusammenfassung

Batterie mit Flüssigkeitskühlung aus zumindest zwei Brennstoffzellen (1), die jeweils eine negative Polplatte, eine Membran–Elektroden–Einheit und eine positive Polplatte, die durch ein Rahmenelement mechanisch fest, gasdicht und elektronisch isolierend miteinander verbunden sind, umfassen, wobei die Batterie in ein Kühlflüssigkeitsbad (9, 10) eingetaucht ist.





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TEXT ~~TRANSLATION~~

LIQUID-COOLED FUEL CELL BATTERY

The invention is directed to a battery composed of at least two fuel cells that respectively comprises [sic] a negative pole plate, a membrane electrode unit and a positive pole plate that are connected to one another mechanically rigidly, gas-tight and electronically insulating by a frame element.

Up to now, such batteries wherein every fuel cell of the battery respectively has a negative and a positive pole plate are disclosed, for example, by German Letters Patent 44 42 285; however, the problem of liquid cooling of such fuel batteries has not yet been solved. A liquid coolant is desirable for stationary applications wherein the waste heat is to be utilized in order to keep the required heat exchanger and the distribution of the heat compact.

Liquid-cooled fuel cell batteries are known that, however, respectively contain only individual contact or pole plates at the positive and at the negative end of the battery. Within the battery, these individual contact or pole plates are replaced by what are referred to as bipolar plates, which are often fashioned hollow. The liquid coolant of the known liquid-cooled batteries is located in the cavities of the bipolar plates. Previously known bipolar plates adjoin, on the one hand, the anode space and, on the other hand, the cathode space of the individual fuel cells to be connected to one another. When a traditional battery is assembled, the bipolar plates are stacked on top of one another with the membrane electrode units of the individual fuel cells and are mechanically joined to one another by screw bolts, tie rods or other clamp devices. A single pole or contact plate is then respectively located at the end. This system is also referred to as filter press technique (see, for example, W. Vielstich from "Brennstoffelemente", Verlag Chemie GmbH, pages 171 and 201/202).

A significant disadvantage of filter press technique is that very high demands must be made of the edge seals of the fuel cell battery because the respective reaction agents, i.e. oxidant, fuel and coolant, must be reliably sealed from one another. Up to now, for example, an especially ticklish, direct sealing without buffer area that must assure that oxidant and fuel cannot overflow into

one another is required at the edges of the bipolar plates. It is self-evident that such demands made of the edge seals are reflected in the manufacturing costs of the batteries. There is therefore a need to overcome the previously known filter press technique, not only given air-cooled fuel cells as in the above-cited German Letters Patent 44 42 285, but also given liquid-cooled fuel cell batteries.

It is therefore an object of the present invention to make a liquid-cooled battery of fuel cells available that is designed without direct edge sealing between cathode and anode space.

The general perception of the invention is that this is possible given employment of individual sealing of the fuel cell units of a battery disclosed by German Letters Patent 44 42 285 when a battery manufactured therefrom is immersed into a coolant bath.

The subject matter of the invention is a battery with liquid cooling composed of at least two fuel cells that respectively comprise a negative pole plate, a membrane electrode unit and a positive pole plate that are connected to one another mechanically rigidly, gas-tight and electronically insulating by a frame element, whereby the battery is immersed into a coolant bath.

A further subject matter of the present invention is a method for cooling a fuel cell battery, whereby the battery is cooled by immersion into a coolant bath.

Further advantageous developments of the invention derive from the subclaims, the specification, the Figures and the explanations thereof.

In one embodiment of the invention and of the inventive method, the battery is completely immersed into a coolant bath.

In an advantageous development of the invention, the container for the coolant bath is integrated such in the battery housing that the battery housing itself is no longer surrounded by liquid coolant.

The electrolyte membrane, which is the heart of the membrane electrode unit of the fuel cell, extends up to the edge of the cell and could be washed out given employment of water as coolant. It is therefore provided in an advantageous development of the invention that it is not water but a

hydrophobic, i.e. water-repellant coolant (for example, oil or transformer oil) that does not wet the membrane that is employed. Alternatively to this advantageous embodiment, the electrolyte membrane can be prevented from being washed out by water as coolant in that a seal as offered, for example, by the Gore company in conjunction with the membrane electrolyte unit and that precludes this washing effect is employed in the individual sealing of the membrane electrode unit by the frame element. The costs of a battery constructed in this way nonetheless still lie below the costs for the seals of the known bipolar plates.

It is advantageous when the coolant flows through the coolant bath. The flow can thereby be effected solely by convection. As needed, the flow can also be generated by a pump or the convection can be intensified by a pump.

It is advantageous when the flow existing in the coolant bath is regulated such that it is uniformly distributed over the entire fuel cell battery. This can occur via a coolant distributor.

In an advantageous development of the method, the flow velocities and/or the flow distribution of the coolant in the coolant bath can be regulated. This is especially practical when the battery is intended to meet different power demands and has a differing cooling need over time as a result thereof.

What is referred to here as "battery" is an aggregate or stack of at least two series-connected, individual fuel cells. One possible application of such a battery is, for example, decentralized power generating wherein aggregates having a far higher plurality of individual fuel cells are employed. For example, a battery must produce a power of approximately 10 kW for employment in a household energy supply system for a single-family house. Given an assumed cell area of approximately 300 cm^2 and a power of approximately 100 Watts per individual fuel cell , a battery employable therein comes out to about 100 individual cells.

The fuel cells that are disclosed in the above-cited German Letters Patent 44 42 285 are preferably referred to here as "individual fuel cell" or "fuel cell unit". The full content of this Letters Patent is herewith referenced and the

entire disclosure thereof is included in the subject matter of the present specification. Said fuel cells are units that can be individually handled and that respectively comprise a negative pole plate, a membrane electrode unit and a positive pole plate, whereby the aforementioned component parts are connected to one another mechanically firmly, gas-tight and electronically insulating by a respective frame element.

What is referred to here as "membrane electrode unit" is a membrane respectively having a negative and a positive electrode. All such units that are standard in this technology are included under the term "membrane electrode unit". The electrodes preferably do not extend up to the edge of the membrane but leave an edge area of the membrane free, so that a frame element of the fuel cell embraces only the positive and negative pole plate of the fuel cell as well as the membrane itself.

What is fundamentally referred to as "frame element" is that part that is suitable for connecting at least negative pole plate, membrane and positive pole plate and, potentially, the electrodes or other component parts of the fuel cell as well to one another mechanically firmly, gas-tight and electronically insulating. The frame element can be composed of one piece; however, it can also be composed, for example, of a plurality of parts. The frame element preferably has a U-profile crossection, whereby the two U-legs press the two pole plates together with the membrane and thus close off the inside of this unit gas-tight from the penetration of gasses. The frame element corresponds to the frame element that was disclosed in the afore-mentioned German Letters Patent 44 42 285.

Each of the fuel cells preferably has at least four through supply and waste disposal openings that are respectively connected to one another within a battery.

When stacking at least two inventive fuel cells to form a battery, a direct mechanical and electronic contact of the negative pole plate of the one fuel cell with the positive pole plate of the next fuel cell preferably derives. The two cells are thus electrically connected in series. When present, the direct

mechanical and electronic contact occurs along the four supply and waste disposal openings. The negative and positive pole plates of the two fuel cells adjoining one another are thereby shaped such that an interspace or cavity through which coolant can flow remains between the completely stacked fuel cells that are in direct mechanical and electronic contact.

Upon immersion of the battery or of the fuel cell stack into a coolant bath, for example, the coolant flows through these cavities. The flow of the liquid coolant then proceeds analogous to the air stream in the mainly air-cooled version of a fuel cell battery that is known from the above-cited Letters Patent.

The flow velocity in the coolant bath can be regulated via a pump. Given fluids with high heat capacity, a slight flow velocity already suffices in order to achieve a good cooling effect. Turbulences that are generated in the stream of the coolant are advantageous because the heat capacity of the coolant, which is not substrate-specific, is thus increased. In this context, the application having Serial Number 19635901.5 is referenced, the technical teaching thereof being suitable for employment in the scope of the present invention.

The flow distribution can be regulated by a coolant distributor that is attached to the admission of the liquid coolant and that divides the uniform stream of coolant at the admission. The coolant distributor serves the purpose of uniformly supplying the fuel cell battery with coolant.

The flow velocity of the coolant within the liquid and coolant bath can be regulated by the pump and the flow distribution.

What is meant by "hydrophobic" is the property of a medium to have a water-repellant effect. All the coolants that do not dissolve in water, i.e. are not suitable for wetting the water-saturated membrane and thereby washing it out, are understood by a hydrophobic coolant.

The pump with which the flow of the coolant is potentially intensified can be an arbitrary pump with which the liquid can be suctioned in, placed under pressure or compressed such that a flow arises. The arrangement of the

pump in the overall system is arbitrary and can both precede as well as follow the actual coolant bath.

The coolant bath is situated in a liquid-tight container. This is preferably provided with at least two permanent openings, one at the admission and one at the discharge of the coolant. However, it can comprise many openings; a coolant distributor is then usually superfluous.

The invention is described in greater detail below with reference to two Figures.

Figure 1 shows the embodiment of the inventive battery wherein the container for the coolant bath is integrated into the battery housing.

Figure 2 shows the embodiment of the inventive battery wherein the flow in the coolant bath is distributed via a coolant distributor.

Figure 1 shows the illustration of an inventive battery composed of a stack of individual fuel cells 1 respectively forming a unit that can be handled, this having four through supply or waste disposal openings 2a, 2b, 2c and 2d. The battery is surrounded by a six-sided, cuboid-shaped battery housing. The Figure shows the battery before assembly, the direction thereof being indicated by the arrows 7. The assembly can ensue with any fluid-tight connection of the two parts.

The upper side 3 of the battery housing with the two current taps 4a and 4b as well as the side 5 of the battery housing with the end [sic] and supply openings 2a through 2d can be seen in the upper half of Figure 1. The stack of fuel cells 1 is held together, for example, by screw closures or tie rods 13 that, again by way of example, are adjusted via a screw thread at the upper side 3 and the underside (not shown). The end [sic] and supply openings 2a through 2d are connected to axial channels that extend over the entire cell stack.

During operation of the battery, the oxidant, for example, is delivered via the supply opening 2b and is then conducted through the adjoining axial channel through the entire fuel cell stack of the battery, having respective openings to the individual cathode spaces. The oxidant consumed in the

individual cathode spaces of the battery can in turn leave the cell stack through the waste disposal opening 2C via the likewise through waste disposal channel. In the aforementioned example, the fuel is then correspondingly supplied via the supply opening 2a and eliminated via the waste disposal opening 2d.

The diffusors 6a with whose assistance the coolant can be distributed in the coolant bath are shown transverse to the cell stack. The attachment of the diffusors is not absolutely required but can be contained in the battery or not respectively as needed and dependent on the embodiment of the invention.

Upon assembly of the battery, the upper half of Figure 1 is plugged into the lower half of Figure 1, as indicated by the arrows 7, whereby the edges of sides 3 and 5 of the battery housing meet the seal surface 8 along the adjoining edges of the battery housing that is shown in the lower half of Figure 1. The seal surface 8 assures that the container is liquid-tight.

The admission opening 11 and the discharge opening 12 of the coolant can be seen at the two sides 9 and 10 of the liquid container and battery housing. Immediately adjoining the admission opening 11, the battery housing has more diffusors 6b that reside transverse to the diffusors 6a that are shown in the upper half of Figure 1. As already mentioned, the diffusors help for uniform distribution of the coolant in the coolant bath. The attitude of the diffusors is thereby arbitrary and Figure 1 shows an exemplary arrangement.

The fat that the battery is shown as cuboid and, thus, six-sided in both Figures merely serves for simplification and illustration of the inventive battery. This development is in fact a preferred embodiment, but the invention is definitely not limited to this shape of the battery; on the contrary, it can also cover all types of batteries in different geometrical shapes.

Figure 2 shows a development of the invention with a coolant distributor. The coolant distributor is thereby integrated such in the battery housing that a more compact structure is achieved. The middle of Figure 2 again shows the stack of individual fuel cells 1 with which the battery is constructed. One can likewise see the front surface 5 of the battery housing with the four waste disposal and supply openings 2a, 2b, 2c and 2d through

which the reaction gasses are conducted through the fuel cell stack and through which the consumed reaction gasses are eliminated from the battery cell stack. The current tap 4 is likewise situated at the side 5 of the cuboid and, therefore, six-sided battery.

At its edge directed toward the front, the side 10 of the battery shows the coolant admission opening 11. A coolant distributor is integrated such into this side 10 of the battery shown in Figure 2 that the coolant flows into the fuel cell stack 1 through the various openings 1a that are located at the inside at this side. The openings 11a of the distributor are designed such that the coolant experiences an optimally uniform distribution along the entire fuel cell stack. At its outwardly directed edge, side 9 of the battery shown in Figure 2 again exhibits the coolant discharge opening 12 through which the used coolant in turn leaves the coolant bath in which the battery is immersed. The inside of the side 9 of the inventive battery housing that is shown in Figure 2 cannot be seen and this, by way of example and not necessarily, has the same distribution of openings 11a, which serve as outlet, as the side 10. Finally, how the battery is assembled is also indicated in Figure 2 by the four arrows 7.

It should be reëmphasized that the Figures merely describe preferred embodiments of the inventive battery and are definitely not intended to limit the scope of the application, particularly with respect to their geometrical illustration, which is highly simplified. On the contrary, the present invention is not bound to any kind of geometrical fashioning but is quite generally applicable to batteries composed of fuel cells wherein the individual fuel cells represent units that can be individually handled and that can be adequately cooled by immersion into a coolant bath, potentially with appertaining flow of the liquid located in the coolant bath. In particular, the inventive battery can forego the especially problematical seals between cathode and anode space, as already mentioned above.

Inventively, the battery housing or the coolant bath into which the battery is partly or completely immersed for cooling is fashioned such that a testing of the fuel cell stack as well as a testing of the individual gas conduits is

possible during operation, i.e. given ongoing cooling, so that, for example, faulty cells or leaks can be found and the faults can be eliminated while the battery is in the coolant bath. Since all seals of the reaction gas spaces in the above-cited German Letters Patent 44 42 285 lead into the exterior space, which represents the coolant bath in this case, namely, all gas leaks can be easily detected on the basis of the emerging gas bubbles. Since the cells can be made individually easily accessible in the disclosed battery design, there is also a possibility of detecting faulty cells on the basis of a simple voltage measurement.

Patent Claims

1. Battery with liquid cooling composed of at least two fuel cells that respectively comprise a negative pole plate, a membrane electrode unit and a positive pole plate that are connected to one another mechanically rigidly, gas-tight and electronically insulating by a frame element, and are immersed into a coolant bath, whereby a flow is generated in the coolant bath with a pump and/or with a liquid distributor.

2. Battery according to claim 1, whereby the container for the coolant bath is integrated in the battery housing.

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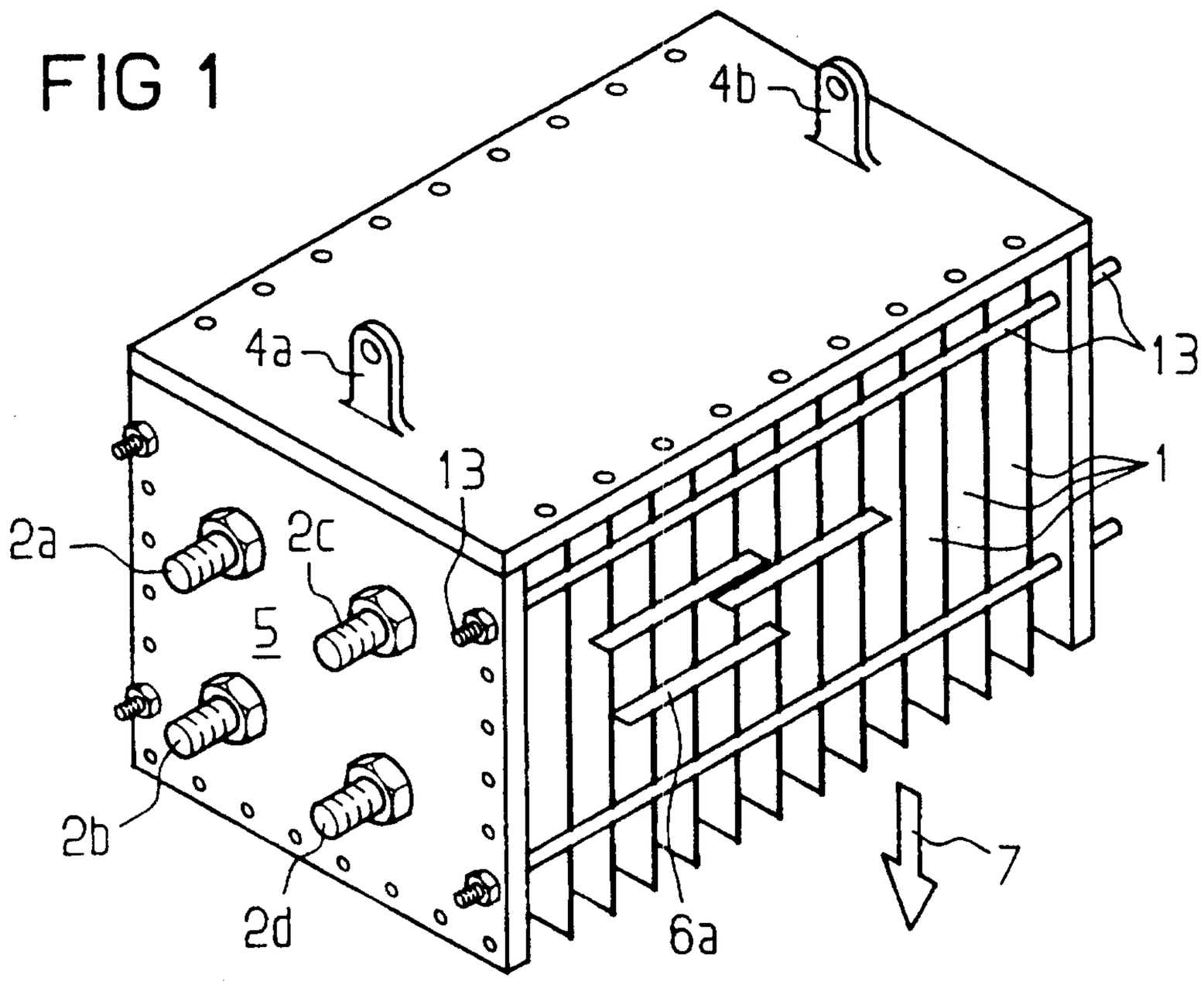
FIG 1



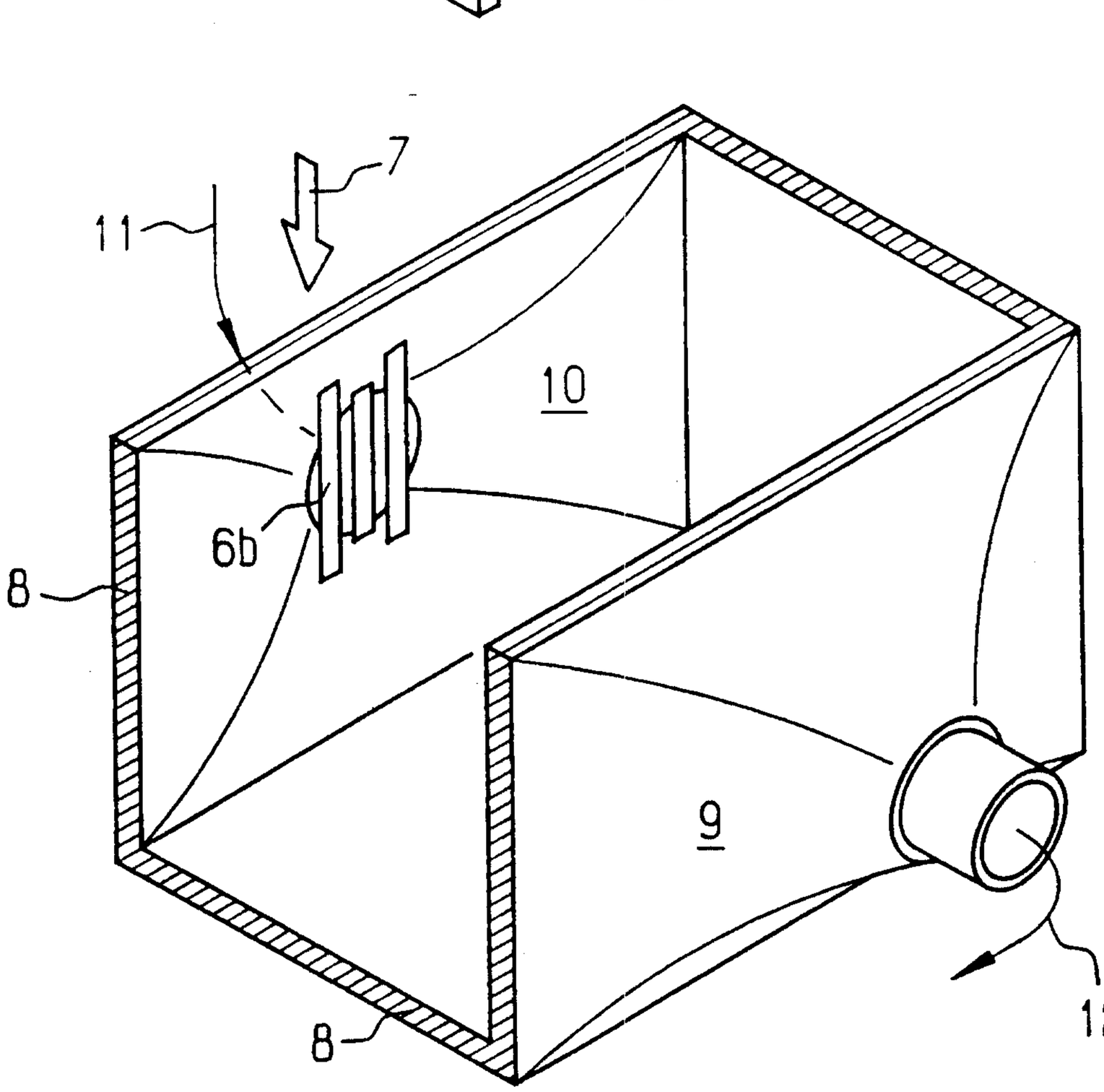


FIG 2