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Brand et al.

(54) HEAT EXCHANGER FOR SMALL COMPONENTS

(76) Inventors: **Karine Brand**, Ulm (DE); **Florian Schopper**, Westerstetten (DE); **Oliver Woelflik**, Blaubeuren (DE)

Correspondence Address:
FLYNN THIEL BOUTELL & TANIS, P.C.
2026 RAMBLING ROAD
KALAMAZOO, MI 49008-1631 (US)

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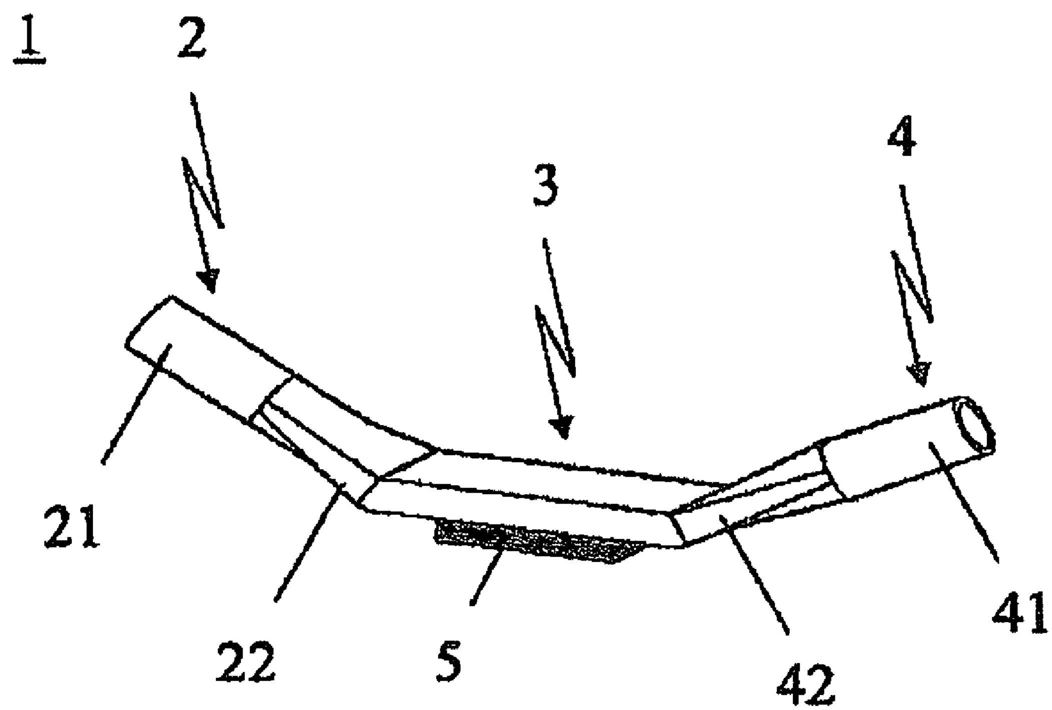
(57) ABSTRACT

The invention relates to a heat exchanger for small components through which a fluid may flow, made from several individual pieces, exclusively produced by forming and joined to each other, to an inlet channel, a planar heat exchange element and an outlet channel. The heat exchange element comprises an upper and lower side which may be connected to at least one heat source, characterized in that the inlet channel is made from a metal connector tube which continuously enlarges towards the heat exchange element on the inlet side up to the total cross-sectional flow area of the inlet side and face of the heat exchange element and the outlet channel continuously tapers away from the heat exchanger on the outlet side from the total cross-sectional flow area of the output side end face of the heat exchanger element to a metal connector tube. The heat exchange element comprises a channel-like inner structure running in the flow direction to increase the heat transfer, which runs within the element from the lower side to the upper side.



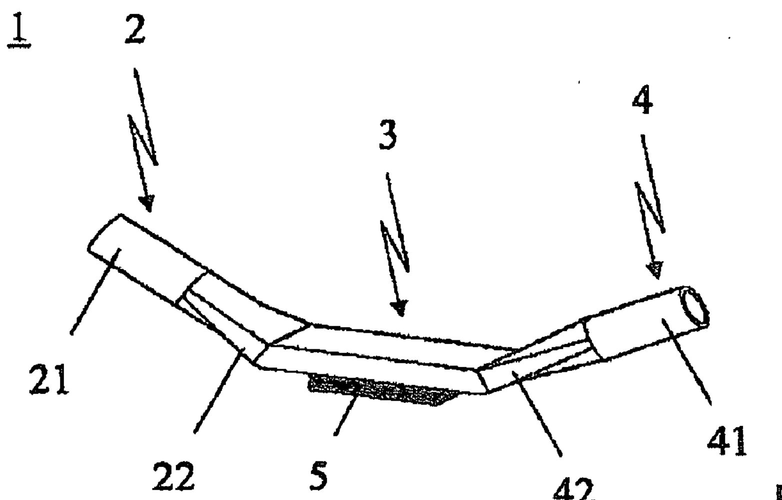


Fig. 1

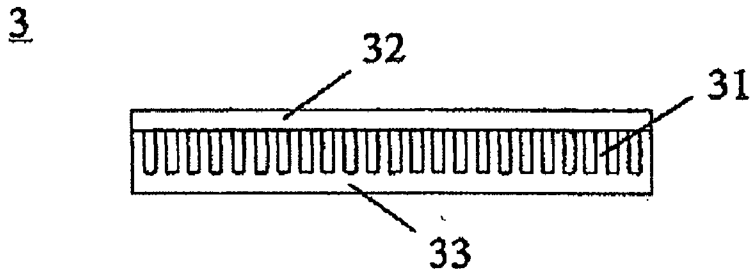


Fig. 2

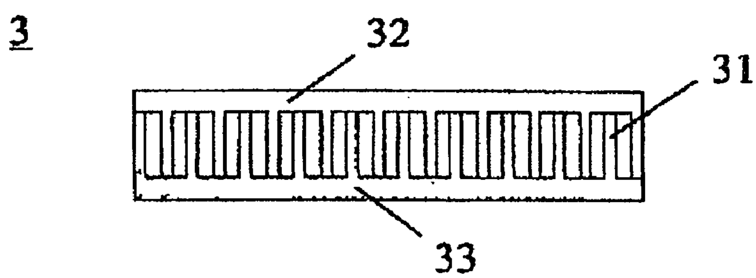


Fig. 3

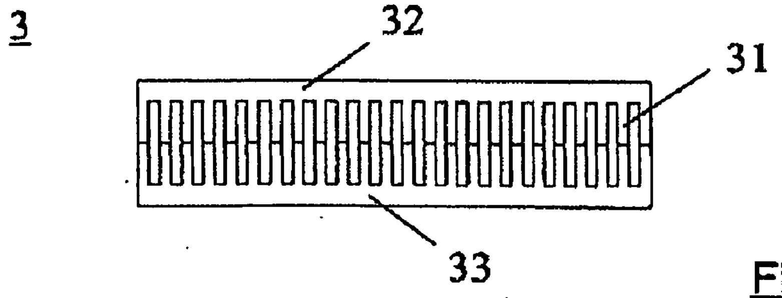


Fig. 4

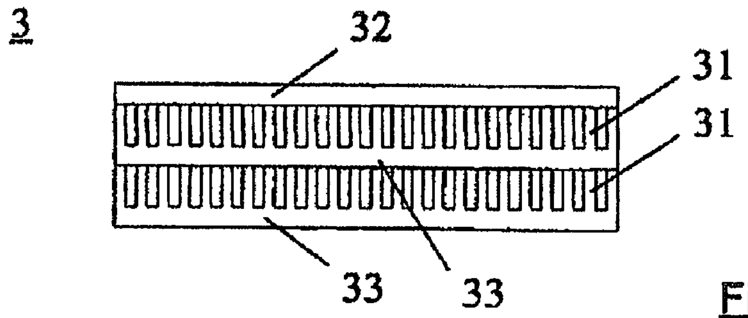


Fig. 5

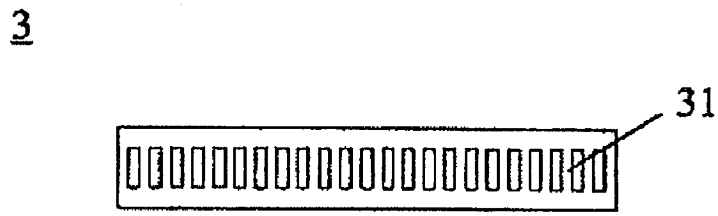


Fig. 6

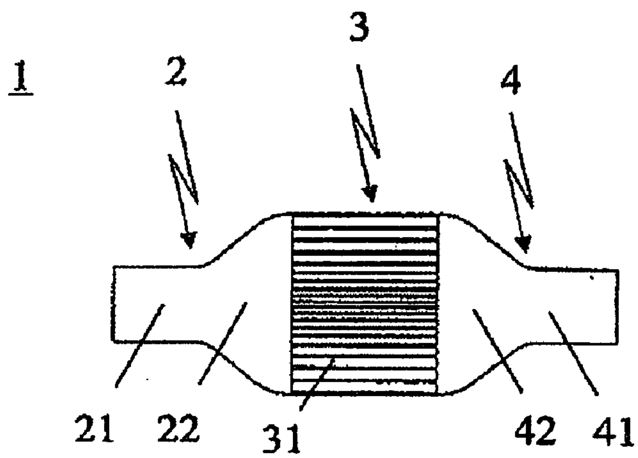


Fig. 7

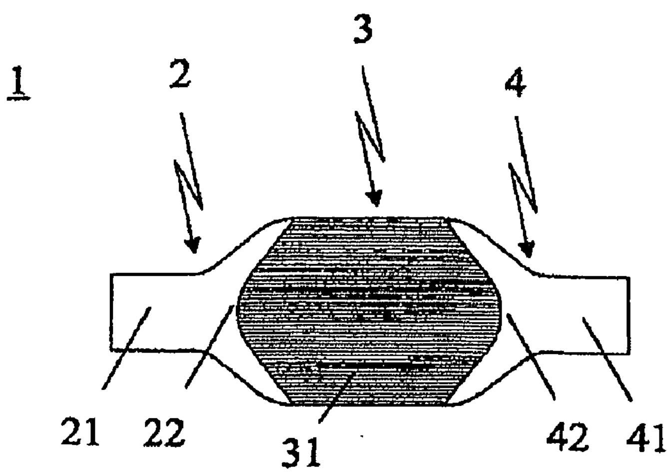


Fig. 8

HEAT EXCHANGER FOR SMALL COMPONENTS

[0001] The invention relates to a heat exchanger for small components, through which heat exchanger a fluid can flow, comprising a plurality of individual parts which are produced exclusively by forming and are firmly connected to one another by joints to form an inlet channel, a flat heat-exchanging element and an outlet channel with the heat-exchanging element having an upper face and lower face which can be connected to at least one heat source.

[0002] Heat exchangers such as these are already used in widely differing technical fields. Heat exchangers with liquid cooling or vaporization are becoming increasingly important, in particular because of the very large amount of heat emitted from microprocessors or from high-power electronic components.

[0003] Already-available heat exchangers in the form of water coolers for microprocessors are generally manufactured from a copper or aluminum block, by metal-cutting machining. Since solid material is used for the individual components, metal-cutting machining is correspondingly complex, and therefore expensive.

[0004] One further development which uses a manufacturing method that does not involve metal cutting is described in the document DE 103 15 225 A1. This document discloses a heat exchanger with an element in the form of a pot and an element in the form of a cover, the two of which can be connected to one another in order to form a sealed internal area with two openings, through which a heat-exchanging medium can be passed into the internal area and out of it. The heat exchanger has a multiplicity of projections which protrude into the internal area. The elements which are in the form of pots or covers are formed by a cold-forming process, and preferably by an extrusion-molding process. The projections which protrude into the internal area result in the area along which the cooling medium flows being appropriately large to achieve as good a heat-exchanging performance as possible. One major aim in this case, however, is low-cost production of large quantities.

[0005] The document JP 2005019905 A discloses a cooling device having a heat exchanger which is used as a heat sink for semiconductor components. The heat exchanger has an internal area which is structured towards the heat source, in order to increase the heat dissipation. These structures, which extend over little height, have no significant influence on the fluid flowing in the internal area.

[0006] In addition, the document U.S. Pat. No. 5,473,508 discloses a heat exchanger for cooling electronic components by means of an air flow. The heat exchanger comprises a plurality of individual parts, which are connected firmly to one another by joints to form an inlet channel, a flat heat-exchanging element and an outlet channel. The closed heat-exchanging element, which comprises a covered element and a base element, in this case makes contact with the heat source.

[0007] The invention is based on the object of developing a heat exchanger of the type described above and of optimizing its heat-exchanging capability, subject to the requirement for a low-cost production method.

[0008] The invention is reflected by the features of claim **1**. The other claims, which refer back to claim **1**, relate to advantageous embodiments and developments of the invention.

[0009] The invention includes a heat exchanger for small components through which heat exchanger a fluid can flow, comprising a plurality of individual parts which are produced exclusively by forming and are firmly connected to one another by joints to form an inlet channel, a flat heat-exchanging element and an outlet channel with the heat-exchanging element having an upper face and lower face which can be connected to at least one heat source, in which the inlet channel is composed of a metal connecting tube which widens continuously on the input side towards the heat-exchanging element, in which the outlet channel, starting from the heat-exchanging part, tapers on the output side continuously to a metal connecting tube, and in which the heat-exchanging element has a channel-like internal structure in order to increase the heat transfer, which internal structure runs in the flow direction and extends from the lower face to the upper face in the interior.

[0010] The invention is in this case based on the idea of the heat exchanger being composed of a plurality of individual parts which are produced exclusively by forming. The geometries of the individual parts are designed such that they can be produced by a cold forming process. In particular, in this case, it is possible, starting from an essentially round tube cross section, to create a widened area in the inlet channel into a conical transition, and to create the taper for the outlet channel. In this case, the end surface of the conically widened inlet channel is then connected by joints to the input-side end face of the flat heat-exchanging element, and the end face of the conically tapering outlet channel is connected to the output-side end face of the heat exchanger. The design options of the molding technology accordingly determine, up to a certain extent, the geometry of the upper face and lower face of the heat-exchanging element.

[0011] In principle, the metal connecting tube of the inlet channel or outlet channel may have any cross-sectional shape, although it is preferably round or oval for reasons relating to the forming process and the flow characteristics.

[0012] The channel-like internal structure which runs in the heat-exchanging element has an important function. This structure extends in the internal area from the lower face to the upper face, thus resulting in increased heat transfer.

[0013] The channel structure has also been found to be extremely robust in response to the influence of external forces. These can occur when a heat source is being connected to and fixed on the heat-exchanger which, in the case of hollow internal structures, would result in the pressure forces that are used causing the common contact surface of the heat exchanger to be deformed by the heat source, or even to be forced in. This would be the case in particular if thin walls were to be considered for material saving reasons, which are no longer designed to withstand such high mechanical loads. In comparison to the previously used metal-cutting processes, the forming methods in their own right already result in a material saving, thus achieving a cost reduction. The design configuration of the internal area, as described above, with corresponding channel structures also makes a further contribution to this.

[0014] In this context, the channel-like internal structures running in the flow direction are not necessarily continuous side walls. Pins or cuboids arranged at relatively short intervals in the flow direction, may likewise also form an appropriate channel structure. Overall, however, this results in an advantageous design configuration, from the flow point of view.

[0015] Soldering processes, adhesive bonding or welding, which are already widely used in engineering, are particularly suitable as joining processes. The mutually abutting surfaces on the end faces of the heat-exchanging element with the inlet channel or outlet channel may, however, also be designed so that they can be plugged into one another by means of grooves formed on the end faces.

[0016] Another two-part embodiment of the individual parts produced by forming may comprise two half elements which are formed in the longitudinal direction and need be connected to one another by joints only in the longitudinal direction.

[0017] The particular advantage is that a heat exchanger with correspondingly thin walls can be appropriately robust with regard to deformation. The channels which run in the internal area in this case carry the single-phase or two-phase fluid in a specific manner through the heat exchanger, so that the heat-exchanging performance is optimized for mechanical robustness. In particular, the conical inlet and outlet channels ensure a smooth transition for uniform fluid distribution, with very little pressure drop in the flow.

[0018] In one preferred refinement of the invention, the internal structure can be designed such that the fluid flow is constant over the cross section. By way of example, this can be achieved by the channel-like internal structure having a different width, also referred to in the following text as channels, with smaller channel cross sections being provided in the center of the heat exchanger, and becoming larger towards the outside, in both directions. This results in the main flow from the inlet channel being distributed more uniformly throughout the heat exchanger.

[0019] The physical design of the internal volume of the heat-exchanging element is particularly important in terms of advantageous flow conditions. For example, the internal structure of the heat-exchanging element can advantageously be continued in the inlet channel and/or outlet channel. This results in the fluid being distributed appropriately into the individual channels in order to achieve advantageous flow conditions, immediately after passing out of the metal connecting tube into the widening part of the heat-exchanging element. In this case, structures such as these are preferably used in the inlet channel. On the outlet side however, channels in the tapering part of the heat-exchanging element can also carry the fluid flow in a specific manner and advantageously from the flow point of view.

[0020] In a further advantageous refinement to the invention, the internal structure may comprise continuous ribs which form channels. Continuous ribs can be produced particularly reliably by forming processes when the intervals between the ribs are short. The ribs run as partition walls in the internal area from the lower face to the upper face and form the individual longitudinally running channels in which the fluid is carried during operation.

[0021] The internal structure may advantageously be composed of rods or pyramids projecting from the inner wall. However, these are always arranged such that channel-like internal structures are formed in the flow direction. This produces advantageous structures from the flow point of view, which still allow a certain amount of fluid to be exchanged with adjacent channels.

[0022] In a further preferred refinement, the heat-exchanging element may be formed integrally. However, this is possible only subject to specific preconditions when using the forming process on which this is based. With an integral configuration, the channel structure is preferably produced with continuous longitudinally pointing ribs in the internal area. This reduces the complexity of the joints for the heat-exchanging element. Integral heat-exchanging elements are now just connected to the inlet channel and to the outlet channel.

[0023] The inlet channel, the heat-exchanging element and the outlet channel can advantageously be arranged aligned. In other words, the elongated shape has no further bends with tight radii and therefore assists the fluid to flow uniformly through the entire heat exchanger.

[0024] Alternatively, however, it is also necessary to consider designs when only a small amount of physical space is available for the heat exchanger, for example as a heat sink for microprocessors or other components that generate heat in a computer. The inlet channel and/or the outlet channel can then advantageously run pointed away from heat source. However, in general, this is feasible only with bending radii that are as large as possible and assist the fluid to flow with as little disturbance as possible.

[0025] When using copper and copper alloys, it is not possible to preclude corrosion with some of the fluids that are used. The inner surface of the heat exchanger can then advantageously be coated.

[0026] Further advantages and refinements of the invention will be explained in more detail with reference to the schematic drawings, in which:

[0027] FIG. **1** shows a view of a heat exchanger with a heat source,

[0028] FIG. **2** shows a cross section through a heat-exchanging element with a cover and base,

[0029] FIG. **3** shows a cross section through a heat-exchanging element with an identically designed cover and base, and an internal structure in which items engage in one another,

[0030] FIG. **4** shows a cross section through a heat-exchanging element with an identically designed cover and base, and an internal structure in which items are placed on one another,

[0031] FIG. **5** shows a cross section through a heat-exchanging element which is formed from bases stacked one on top of the other, with a closing cover,

[0032] FIG. **6** shows a cross section through an integral heat-exchanging element,

[0033] FIG. **7** shows a plan view of a heat exchanger with channel-like structures of different width,

[0034] FIG. **8** shows a plan view of a heat exchanger with channel-like structures which continue into the inlet channel and outlet channel.

[0035] Mutually corresponding parts are provided with the same reference symbols in all the figures.

[0036] FIG. **1** shows a schematic view of a heat exchanger **1** with a heat source **5**. The heat exchanger **1** comprises an inlet channel **2**, a flat heat-exchanging element **3** and an outlet channel **4**, which are firmly connected to one another by joints. The heat source **5** is arranged on the lower face of the heat-exchanging element **3**. The inlet channel **2** comprises a metal connecting tube **21** which widens continuously on the input side towards the heat-exchanging element **3**. The shape of the inlet channel illustrated in the figure can be produced integrally by means of a forming process, for example by extrusion molding. In this case, the joint is located on the common touching surface between the inlet channel **2** and the heat-exchanging element **3**. The outlet channel **4**, which may also be integral, likewise comprises a collecting zone **42** and a metal connecting tube **41**. The collecting zone **42** tapers continuously to the metal connecting tube **41**. The joint is in this case located on the common touching surface between the outlet channel **4** and the heat-exchanging element **3**.

[0037] The heat source **5** is an electronic component, for example a microprocessor. The heat source **5** is often held by brackets or by adhesive bonding, with intermediate layers which conduct the heat well also being used. When intermediate layers are used, the heat source **5** is connected to the heat exchanger **1** with a contact pressure. In the illustrated embodiment, the inlet channel **2** and the outlet channel **4** run pointed away from the heat source **5**.

[0038] FIG. **2** shows a cross section through a two-part heat-exchanging element **3** with a cover **32** and a base **33**. The internal structure is formed together with the base **33**, and the cover **32** is firmly joined to the base. The joints for connecting the cover **32** and the base **33** may be in the form of welded, soldered or adhesive joints, or else force fits. Joining processes which do not lead to thermal or mechanical deformation of the component are preferred.

[0039] FIG. **3** shows a cross section through a heat-exchanging element **3** with identically designed cover **32** and base **33**, and with an internal structure **31** with parts which engage in one another. The internal structure is in this case formed in two halves together with the cover **32** and the base **33**. For forming purposes, this offers the advantage, for example when there are continuous ribs of in the cover **32** and the base **33**, providing coarser structures which engage in one another after being joined together such that correspondingly small channels are produced.

[0040] In a further refinement, FIG. **4** shows a cross section through a heat-exchanging element **3** with an identically designed cover **32** and base **33**. When fitted to one another, the two form the channel-like internal structure.

[0041] FIG. **5** shows a cross section through a heat-exchanging element **3**, which is formed from two bases **33** stacked one on top of the other, with a closing cover **32**. Structures such as these are used, for example, when a heat source is arranged not only on the upper face but also on the lower face.

[0042] FIG. **6** shows a further refinement of the heat-exchanging element **3**, which can be produced integrally by means of extrusion molding. The integral components are preferably used for relatively large channel structures, for manufacturing reasons. These can also be manufactured continuously and can be cut to the appropriate length.

[0043] FIG. **7** shows a plan view of a heat exchanger **1**, cut open in the area of the heat-exchanging element **3**, with channel-like structures of different widths. The channels of the internal structure **31** are in this case designed such that the fluid flow is constant over the cross section of the heat-exchanging element **3**, resulting in a uniform pressure drop in the flow direction of the fluid.

[0044] FIG. **8** shows a plan view of a partially cut-open heat exchanger **1** with channel-like structures which continue into the inlet channel **2** and outlet channel **4**. In this refinement, the fluid is distributed advantageously from the flow point of view into the individual channels of the internal structure **31** immediately after passing out of the metal connecting tube **21** into the widening part of the distributor zone **22** or from the tapering parts of the collecting zone **42** of the heat exchanger **1**, and is collected again towards the metal connecting tube **41**.

LIST OF REFERENCE SYMBOLS

[0045] **1** Heat exchanger
[0046] **2** Inlet channel
[0047] **21** Metal connecting tube
[0048] **22** Distributor zone
[0049] **3** Heat-exchanging element
[0050] **31** Internal structure
[0051] **32** Cover
[0052] **33** Base
[0053] **4** Outlet channel
[0054] **41** Metal connecting tube
[0055] **42** Collecting zone
[0056] **5** Heat source

1. A heat exchanger (**1**) for small components, through which heat exchanger (**1**) a fluid can flow, comprising a plurality of individual parts which are produced exclusively by forming and are firmly connected to one another by joints to form an inlet channel (**2**), a flat heat-exchanging element (**3**) and an outlet channel (**4**) with the heat-exchanging element (**3**) having an upper face and lower face which can be connected to at least one heat source,
characterized,
in that the inlet channel (**2**) comprises a metal connecting tube (**21**) which on the input side widens continuously towards the heat-exchanging element (**3**) up to the entire cross-sectional area through which flow can pass of the input-side end face of the heat-exchanging element (**3**),
in that the outlet channel (**4**), starting from the heat-exchanging element (**3**) tapers on the output side continuously from the entire cross-sectional area through which flow can pass of the output-side end face of the heat-exchanging element (**3**) to a metal connecting tube (**41**), and
in that the heat-exchanging element (**3**) has a channel-like internal structure (**31**) in order to increase the heat transfer, which internal structure (**31**) runs in the flow direction and extends from the lower face to the upper face in the interior.

2. The heat exchanger as claimed in claim **1**, characterized in that the internal structure (**31**) is designed such that the fluid flow is constant over the cross section.

3. The heat exchanger as claimed in claim **1**, characterized in that the internal structure (**31**) of the heat-exchanging element (**3**) continues in the inlet channel (**2**) and/or in the outlet channel (**4**).

4. The heat exchanger as claimed in claim **1**, characterized in that the internal structure (**31**) is composed of continuous ribs which form channels.

5. The heat exchanger as claimed in claim **1**, characterized in that the internal structure (**31**) is composed of rods or pyramids projecting from the inner wall.

6. The heat exchanger as claimed in claim **1**, characterized in that the heat-exchanging element (**3**) is formed integrally.

7. The heat exchanger as claimed in claim **1**, characterized in that the inlet channel (**2**) the heat-exchanging element (**3**) and the outlet channel (**4**) are arranged aligned.

8. The heat exchanger as claimed in claim **1**, characterized in that the inlet channel (**2**) and/or the outlet channel (**4**) run pointed away from the heat source (**5**).

9. The heat exchanger as claimed in claim **1**, characterized in that the inner surface is coated.

* * * * *