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[54] **HEAT EXCHANGER AND METHOD OF MANUFACTURING THE SAME**

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Related U.S. Application Data

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[52] **U.S. Cl.** ..... **165/164,** 165/180, 29/157.3 R, 62/6, 138/38

[51] **Int. Cl.** **F28f 1/40**

[58] **Field of Search** 165/164, 165, 10, 180, 179; 29/157.3; 62/6; 138/38

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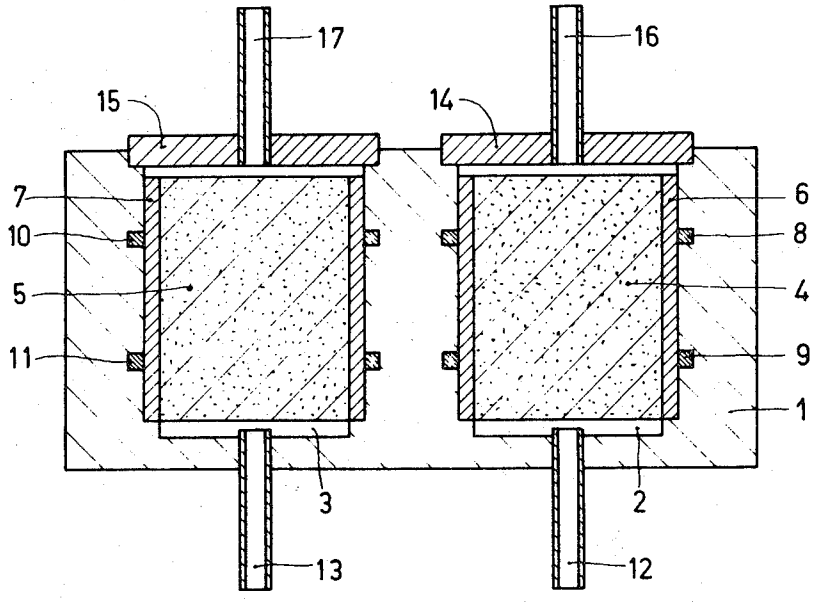
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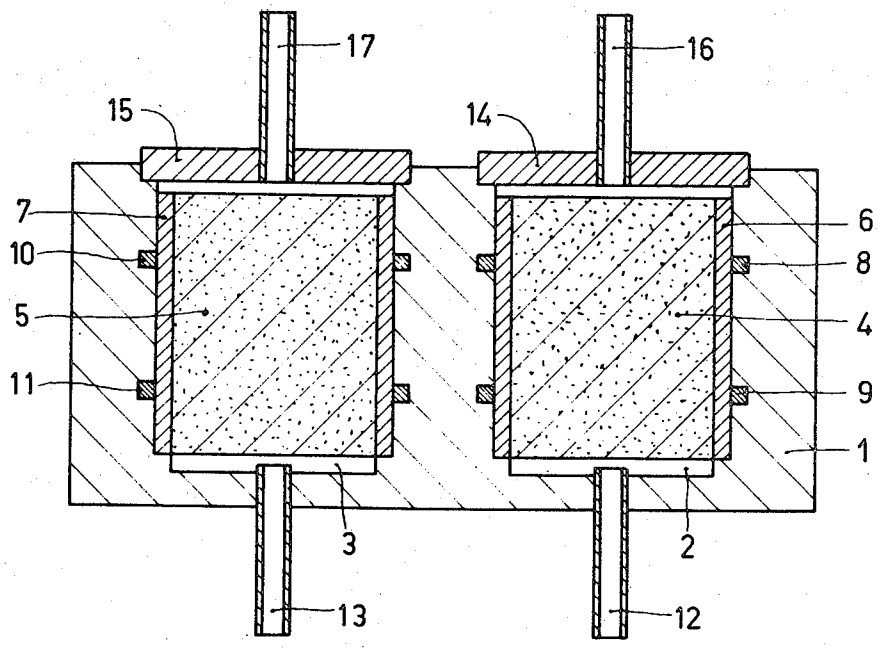
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[57] **ABSTRACT**

A heat exchanger comprising a readily heat-conducting block of material having at least one chamber, a gas-permeable filling mass in said chamber, the mass consisting of particles of readily heat-conducting material sintered together with a layer of a readily heat-conducting material provided on an outer circumferential surface of the mass, and a soldered joint provided between the layer and the inner wall of the chamber in at least one zone extending throughout the circumference of the filling mass.

6 Claims, 1 Drawing Figure





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HEAT EXCHANGER AND METHOD OF MANUFACTURING THE SAME

This is a continuation of application Ser. No. 14,555, filed Feb. 26, 1970, now abandoned.

The invention relates to a heat exchanger which is particularly suitable for use in the temperature range below 2° K and comprises a readily heat-conducting block of material having at least one chamber containing at least one gas-permeable filler of particles of a likewise readily heat-conducting material which are sintered together, preferably the same material as that of the block, each of the chambers comprising at their oppositely located ends, connections with which they can be incorporated in ducts through which flows of helium can be conducted which exchange heat with each other.

Heat exchangers of the type described are known. They are used, for example, in cooling devices in which ^4He or a mixture of ^3He and ^4He circulates as a working medium between a cooled place (cooler) and a place to be cooled. Such cooling devices are described in Dutch Pat. application No. 6,807,902 and in U.S. Pat. No. 3,376,712. In these cooling devices the temperature of the place to be cooled lies below 1° K. In these devices it is desirable to cool the flow of medium flowing to the place to be cooled in the counter-current heat exchange with medium flowing away from the place to be cooled. For this purpose heat exchangers are used having a construction as described above, in which the filling mass is formed by sintered copper balls having a diameter of approximately 40 μm and the surrounding block of material also consists of copper.

The very fine copper balls give a very large heat-exchanging surface area with the circulating helium so that a good heat transfer is ensured between helium and the filling mass. For a satisfactory operation of the heat exchanger it is furthermore necessary that a good heat transfer is ensured from the filling mass to the block of material. In order to achieve this it is known to sinter the pre-sintered filling mass, after placing in the chamber, to the block under a compression pressure. In this case large difficulties occur. First of all, as a result of the sintering together of the copper balls, cracks nearly always occur in the filling mass after sintering in the chamber, and furthermore the resistance to flow increases which disturbs the satisfactory operation. Secondly, as a result of the compression the end face of the filling mass is more or less squeezed so that the resistance to flow of the filling mass increases considerably. Since a low resistance to flow of the heat exchangers is essential for a satisfactory operation of the cooling device, it will be obvious that increase of the resistance to flow is not acceptable.

It is the object of the invention to provide a heat exchanger of the above described type in which the said drawbacks are fully obviated.

For that purpose, the heat exchanger according to the invention is characterized in that the filling mass comprises at its circumferential surface a layer of a readily heat-conducting material provided thereon, preferably the same material as that of the filling mass and the block of material, and is incorporated so as to fit in the relative chamber, a soldered joint being provided between the layer of material and the wall of the relative chamber in at least one zone extending throughout the circumference of the filling mass.

Due to the atomic contact between the provided layer of material and the filling mass, a good heat contact is ensured. As a result of the soldered joint between the layer of material and the block of material, a good heat contact is obtained in this case also.

Since the filling mass, after placing in the chamber, is no longer sintered, cracking of the filling mass does not occur either, and the helium can nevertheless not flow between the block and the filling mass, since this is prevented on the one hand by the soldered joint and on the other hand by the layer of material. So this layer has both a heat transmitting function and a sealing function. The end faces of the filling masses remain readily open (no increase of the resistance to flow) since this is no longer sintered in the chamber.

According to the invention, all the components of the heat exchanger are preferably manufactured from the same material. The advantage of this is that the thermal expansion and the shrinkage, respectively, is the same for all the components so that few thermal stresses occur. Copper is a very suitable material for this purpose. In a further favorable embodiment the layer of material is provided on the filling mass electrolytically.

The invention furthermore relates to a method of manufacturing the above-described heat exchanger. It is characterized in that a rod of sintered material is turned down to a diameter which is smaller by approximately 1 mm than that of a chamber in a block of a readily heat-conducting material, after which the rod is provided electrolytically with a layer of readily conducting material, the ends of the rod being then liberated from the deposited layer of material, the rod being then rinsed to remote acid and salt, the rod being turned down to such a diameter that the filling mass sawn at the desirable length fits in the chamber, at least one annular groove being provided in the wall of the chamber prior to placing the filling mass, a soldering ring being provided in said groove the assembly being heated to above the melting temperature of the solder after placing the filling mass, the open side of the chamber being then sealed by soldering a cover.

In order that the invention may be readily carried into effect, one embodiment of a heat exchanger will now be described in greater detail, by way of example, with reference to the accompanying drawing which is diagrammatic and not drawn to scale.

This heat exchanger comprises a copper block **1** in which two chambers **2** and **3** are recessed. In each of these chambers, filling masses **4** and **5**, respectively, of sintered copper balls are accommodated, said filling masses comprising at their circumferential surface electrolytically grown layers **6** and **7**, respectively, of copper. The layers **6** and **7**, respectively, are soldered to the copper block **1**, at the points **8,9** and **10,11**, respectively. Pipes **12** and **13** soldered in an aperture in the block **1**, communicate with the lower side of the chambers **2, 3** while the upper side of the chambers **2** and **3** is sealed by soldered covers **14** and **15**, respectively, in each of which a pipe **16** and **17**, respectively is soldered. Thus pipes **12** and **16** (and also pipes **13** and **17**) each constitute a pair of inlet-outlet means with a flow path defined between them.

This heat exchanger is manufactured as follows:
A rod of sintered copper balls is first turned down to a diameter which is smaller by approximately 1 mm than

that of the chambers **2** and **3**. A layer of copper, slightly more than 0.5 mm thick, is deposited electrolytically on said rod. At the ends of the rod, the deposited layer is removed and the rod is then rinsed with alkali so as to remove the acid residues. Then it is rinsed with warm water so as to remove the formed salts, after which it is fired in a vacuum. Pieces which correspond to the dimensions of the filling masses **4** and **5** are then cut from said rod. Said filling masses are turned down to such a diameter as to fit in the chambers **2** and **3**. At the points **8,9** and **10,11**, respectively, annular grooves are provided in the wall of the chambers **2** and **3**, in which grooves, rings of soldering material are laid, these rings as shown having thickness, *t*, substantially less than the length, L, of the filling mass in the direction of the flow path between the inlet and outlet pipes. The filling masses **4** and **5** are then placed in the chambers. Heating to above the melting temperature of the solder is then carried out so that the soldered joints are obtained at the points **8, 9** and **10, 11** respectively. Simultaneously with this soldering operation the pipes **12** and **13** can be soldered in the block **1**. The covers **14** and **15** with the pipes **16** and **17** are then soldered on the block **1**.

In this manner a heat exchanger is obtained having a good thermal contact between the filling mass **4, 5** and the layer **6,7**; as well as a good thermal contact between the layer **6,7** and the block **1**. Leakage between the filling mass and the block is not possible. The filling masses **4** and **5** have a low resistance to flow, since no sintering takes place after the arrangement of the filling masses in their chambers.

What is claimed is:

1. A heat exchanger for use in a temperature range below 2° K, comprising, a block of readily-heat-conducting material, the block having at least one internal chamber defining inner walls, the chamber further having inlet and outlet means thus defining a flow path through said chamber, a gas-permeable filling mass having an outer surface and formed of sintered particles of a readily-heat-conducting material, a layer of readily-heat-conducting material deposited on said outer surface of the filling mass, said mass disposed within said flow path and constituting a partition of predetermined length between the inlet and the outlet, with said layer on said mass being in direct heat exchange contact with said inner walls of the chamber, and a soldered junction between said chamber walls and said layer on said filling mass, the junction defining a circumferential zone of smaller thickness in the flow path direction than said length of the mass, sealing said mass to said chamber walls such that the inlet and outlet can communicate only through said mass.

2. A heat exchanger comprising a copper block having at least one internal chamber defining inner walls, and spaced apart inlet and outlet ducts thus defining a flow path through the chamber, a gas-permeable filling mass defining an outer surface, the mass formed of sintered copper particles, a layer of electrolytically deposited copper on said outer surface of said filling mass, said mass disposed within said flow path and constituting a partition between the inlet and the outlet with said layer on said mass being in direct heat exchange contact with said inner walls of the chamber, and a copper solder junction between said chamber walls and said layer on said filling mass the junction defining a circumferential annular zone sealing said mass to said chamber walls such that the inlet and outlet can communicate only through said mass.

3. Apparatus according to claim **1** wherein said block has a second chamber spaced from and similar to the first chamber.

4. Apparatus according to claim **1** wherein said layer is an electrolytically deposited layer.

5. Apparatus according to claim **1** wherein said block, the filling mass, and said layer are all copper.

6. Apparatus according to claim **1** wherein said solder junction defines an annular ring defining a plane generally transverse to said flow path.

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