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(54) **COLD PIECE OF A CRYOGENIC COOLER WITH IMPROVED HEAT TRANSFER**

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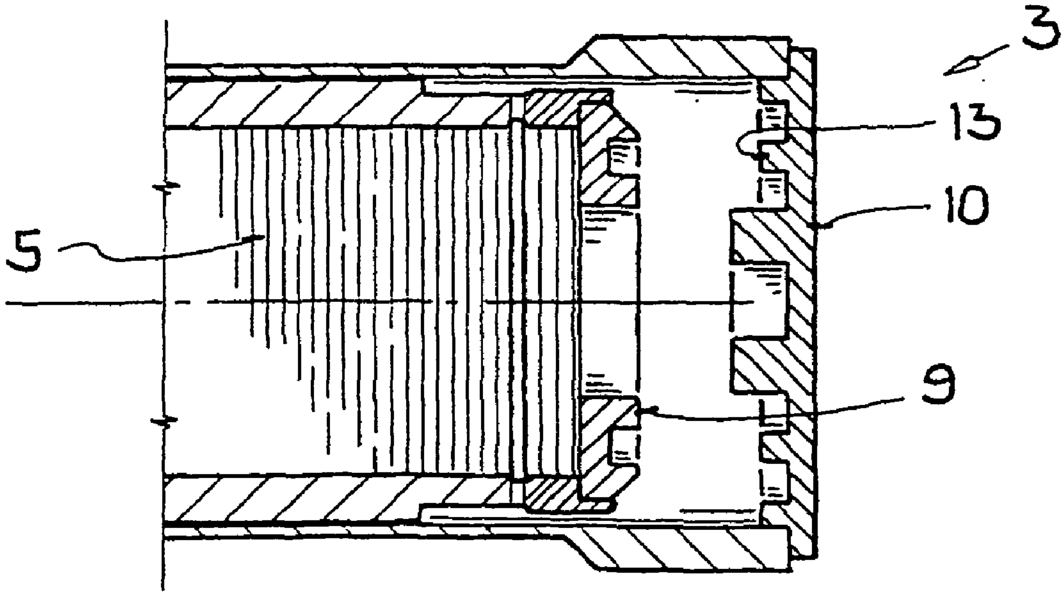
(57) **ABSTRACT**

The invention relates to a cold component of a cryogenic cooler, in particular, for cooling electronic components. It is necessary to minimize the thermal resistance between the cooling medium (**11**) and the external wall surface on the front face of the cold end of the cold finger (**3**), in order to achieve an effective cooling of the electronic component. One possibility is the physical enlargement of the outer wall surface of the front face. The surfaces involved in heat transfer may be effectively increased in size with an almost unchanged volume of the expansion chamber, whereby the inner side of the heat transmitter (**10**) and the end of the regenerator (**5**) facing the heat transmitter (**10**) are ribbed such that the ribs (**9, 13**) intermesh with each other in the end position of the regenerator (**5**).



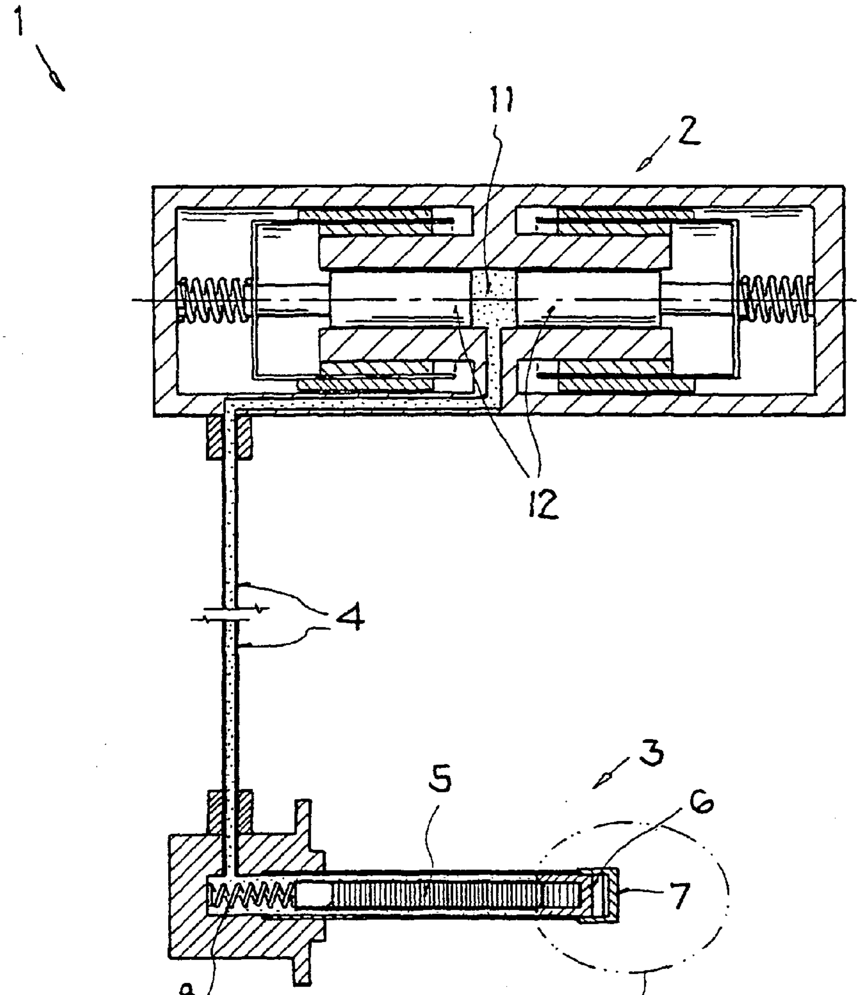


FIG.1

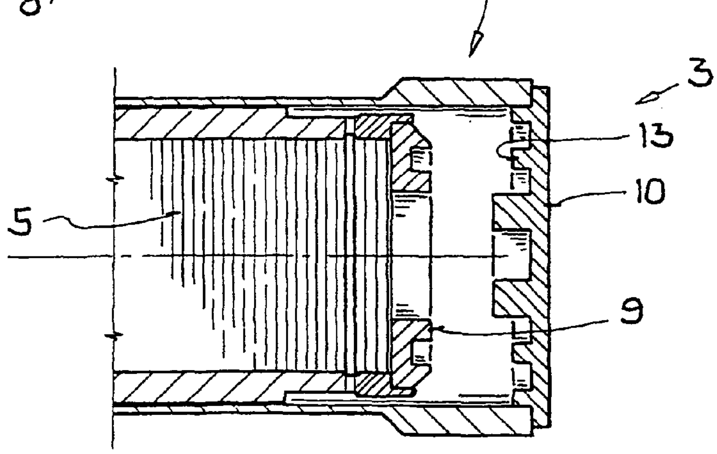


FIG.2

COLD PIECE OF A CRYOGENIC COOLER WITH IMPROVED HEAT TRANSFER

[0001] The invention relates to a cold component for a cryogenic cooler according to the preamble of claim 1.

[0002] Miniature coolers operating according to the Stirling principle are frequently used for cooling electronic structural components such as infrared detectors. These miniature coolers use a motor driven compressor, in order to produce a cyclical variation of the working volume of a gaseous coolant under pressure. The coolant flows as part of the working volume through a closed cylinder of the cold component, the so-called "cold finger". A piston shaped regenerator is positioned in the cold finger. The regenerator has openings at both ends through which the coolant can flow. The regenerator moves, depending on its type of construction, with a phase shift of about 45 to 90° relative to the pistons of the compressor. The coolant passes through the regenerator in alternate directions. Thereby the coolant flows from the compressor side of the cold finger through the regenerator into the expansion space and back again. During this cyclic motion of the regenerator and of the coolant heat is dissipated to the surroundings at the compressor side of the cold finger. Heat is withdrawn from the expansion side of the cold finger. The object to be cooled, generally an electronic structural component, is arranged on the outside of the cold end of the cold finger in such a way that the heat energy of the structural component is transferred to the coolant through the outer wall of the cold finger.

[0003] In order to achieve an effective cooling of the object it is necessary to minimize the heat resistance between the coolant and the facing outer wall surface of the cold end of the cold finger. Considering the relationship between the outer wall surface and the coolant on which the heat transfer $\dot{Q}$ is based, namely

$$\dot{Q} = \alpha \cdot \Delta T \cdot A; \quad \text{wherein } [\alpha] = \frac{W}{m^2 \cdot K}$$

[0004] one recognizes, assuming the temperature difference ΔT to be constant, that either (α), a material depending constant, or the area A must be increased for improving the heat transfer $\dot{Q}$. The material of the outer wall is customarily so selected that the constant (α) cannot be improved any further. The structural enlargement of the area (A), however, entails an undesirable enlargement of the volume of the expansion space.

[0005] It is the object of the invention to provide a cold component of a cryogenic cooler which has an effectively enlarged heat transfer area while the volume of the expansion space remains substantially unchanged.

[0006] The object is achieved by a cold component of a cryogenic cooler having the characteristics of claim 1. The advantageous further development is achieved in accordance with the features of the dependent claims.

[0007] In a cold component of a cryogenic cooler with a piston shaped regenerator having openings at each end through which a coolant can flow, with a closed cylinder in which the regenerator moves cyclically between an upper and lower position, and with a heat transmitter arranged at a facing end, there are provided ribs on the inside of the heat transmitter and on the regenerator end facing the heat transmitter in such a way that the ribs intermesh in the upper position of the regenerator.

[0008] In an advantageous embodiment the ribs of the heat transmitter and of the regenerator have a trapezoidal cross-section.

BRIEF DESCRIPTION OF THE FIGS.

[0009] **FIG. 1** shows a cross-section of a Split-Stirling cooler.

[0010] **FIG. 2** shows the cold end of the cold section in detail.

[0011] The invention will be explained in the following with reference to an example embodiment and with the aid of the FIGS.

[0012] **FIG. 2** shows in detail the cold end **7** of the cold component **3** of the Split-Stirling cooler **1**.

[0013] As has been mentioned above, a motor driven compressor **2** produces a cyclical variation of the working volume of a pressurized gaseous coolant **11**. A connecting conduit **4** connects the compressor of the Split-Stirling cooler with the cold component **3**. In connection with other structural types of cryogenic coolers it is possible to unite the compressor and the cold component. The coolant **11** flows, as part of the working volume, through a closed cylinder of the cold section, the so-called cold finger. A piston shaped regenerator **5** is positioned within the cold finger **3**. The regenerator has openings at each end through which the coolant **11** can flow. The regenerator **5** moves, depending on the type of construction, with a phase shift of 45 to 90° relative to the piston **12** of the compressor **2** in the cylinder of the cold finger **3** thereby causing the coolant **11** to pass through the regenerator **5** in alternating directions. Thus, the coolant **11** flows from the compressor side **8** of the cold finger through the regenerator **5** into an expansion space **6** and back again. During this cyclic movement of the regenerator **5** and of the coolant **11** the compressor side **8** of the cold finger **3** becomes warmer than the surroundings and the expansion side **7** of the cold finger becomes colder than the surroundings. The coolant withdraws heat from the expansion side **7** of the cold finger and discharges the heat to the surroundings at the compressor side of the cold finger. The object to be cooled, for example an electronic structural component, is so arranged on the outside of the cold end of the cold finger that a heat flow from the object through the outer wall of the cold finger is taken up by the coolant.

[0014] For this purpose the cylinder of the cold section is closed by a heat transmitter **10** on the side of the expansion space.

[0015] In order to increase the effective area for the heat flow ribs **9** and **13** are attached to the inside of the heat transmitter **10** and to the end of the regenerator **5** facing the heat transmitter **10**. The shape of the ribs **9**, **13** is so selected that the ribs **9** at the end of the regenerator **5** and the ribs **13** on the inside of the heat transmitter intermesh with each other when the regenerator **5** is in its expansion end position that is, when the regenerator **5** assumes the smallest spacing toward the heat transmitter **10**. However, the ribs do not touch each other. Thereby it is avoided that the volume of the coolant **11** enclosed between the inside of the heat transmitter **10** and the end of the regenerator **5** would be increased and thus the coefficient of efficiency would be reduced again. Stated differently, the area effective for the heat flow of the heat transmitter **10** is effectively increased by the ribs without enlarging the volume of the coolant **11** enclosed between the inside of the heat transmitter **10** and the end of the regenerator **5**.

[**0016**] In an advantageous further embodiment of the invention the cross-sections of the ribs **9**, **13** have a trapezoidal shape. Thereby, a further improvement of the heat transfer is achieved.

[**0017**] The invention is not limited to the above described embodiment of a Split-Stirling cooler. The invention is also suitable for other cryogenic coolers, which have a cold component with a regenerator piston.

1. Cold component **(3)** of a cryogenic cooler **(1)** with a piston shaped regenerator **(5)** which has openings at each end through which a coolant **(11)** can flow, with a closed cylinder in which the regenerator **(5)** moves cyclically between a compressor side end position and an expansion side end position, and with a heat transmitter **(10)** arranged on a facing side, characterized in that ribs **(13)** are provided on the inside of the heat transmitter **(10)** and ribs **(9)** are provided on the end of the regenerator **(5)** facing said heat transmitter **(10)** in such a way that the ribs **(9, 10)** intermesh when the regenerator **(5)** is in its expansion end position.

2. Cold component of claim 1, characterized in that the ribs **(13, 9)** of the heat transmitter **(10)** and of the regenerator **(5)** have a trapezoidal cross-section.

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