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(54) **COLD PLATE ASSEMBLY INCORPORATING THERMAL HEAT SPREADER**

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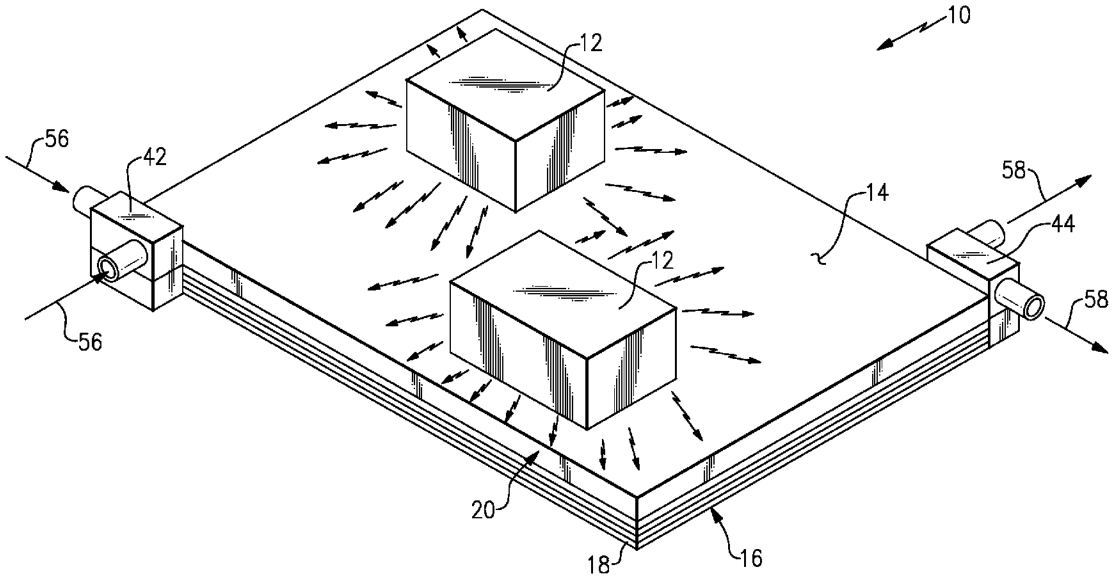
(57) **ABSTRACT**

An example cold plate assembly includes a heat spreader assembly that defines a mounting surface for heat generating devices and provides an improved thermal conduction of heat away from the heat generating devices. The example heat spreader assembly provides a more uniform thermal gradient across the mounting surface of the cold plate assembly and improves thermal conductivity and cooling provided by the cold plate assembly.



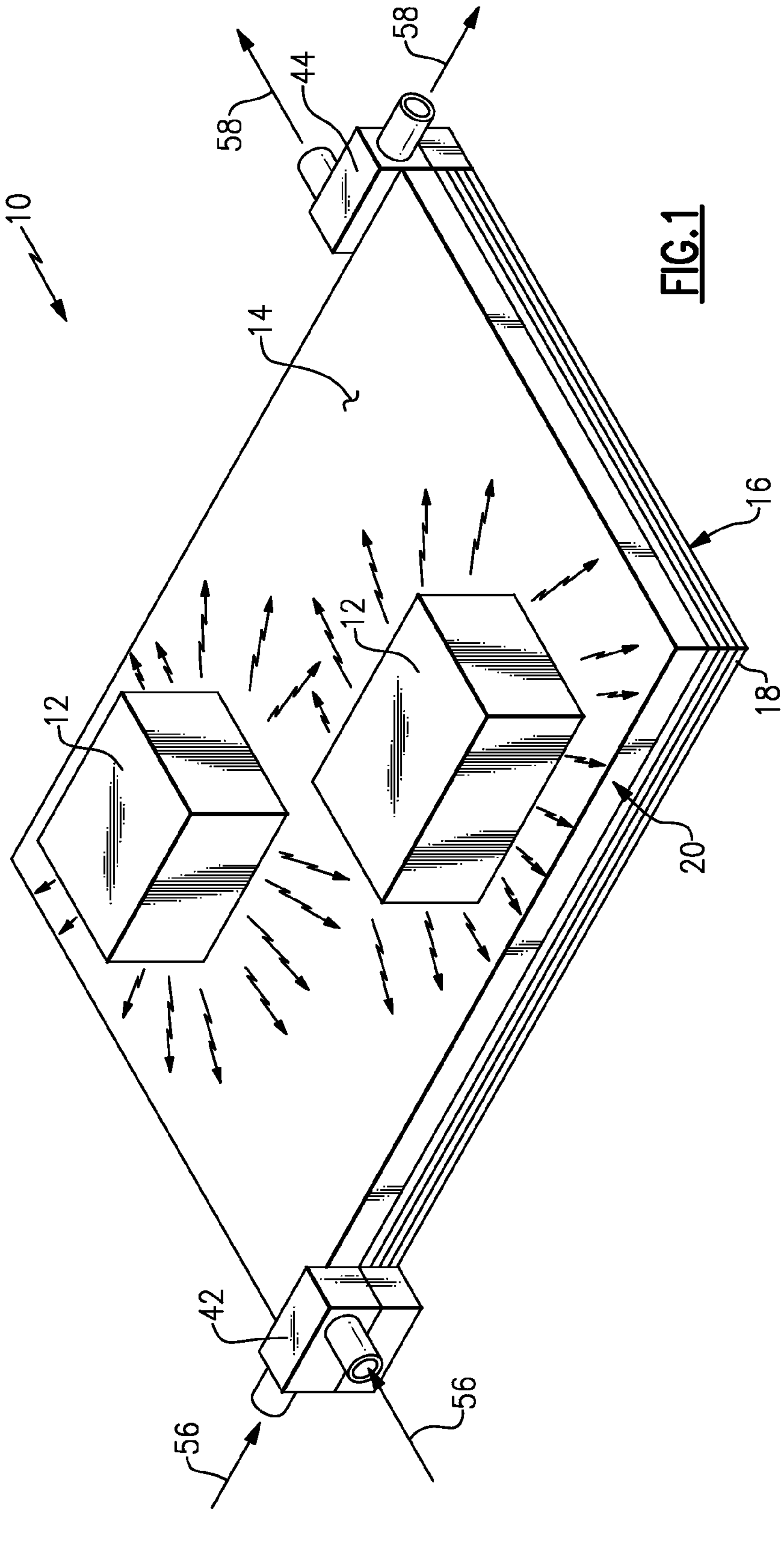


FIG.1

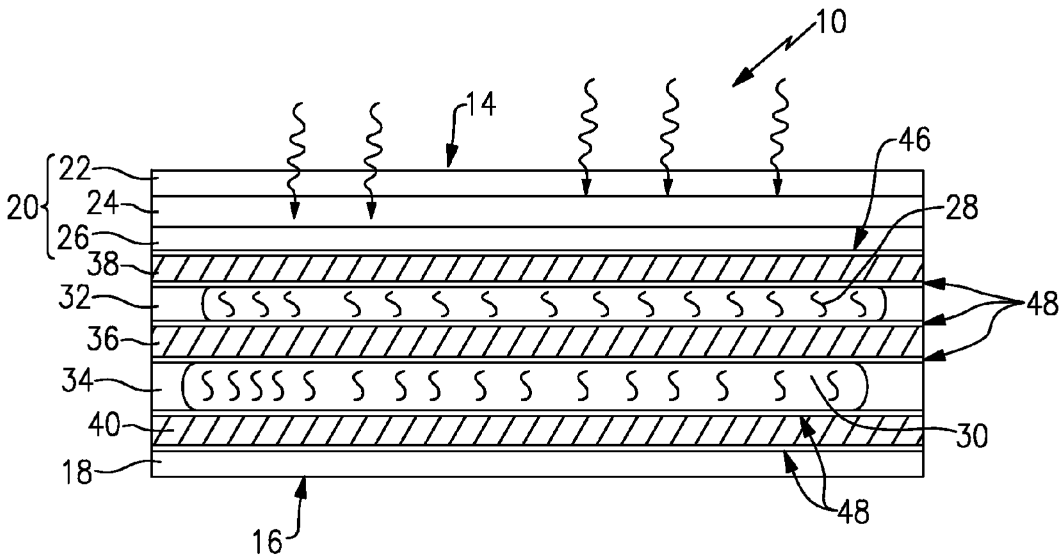


FIG.2

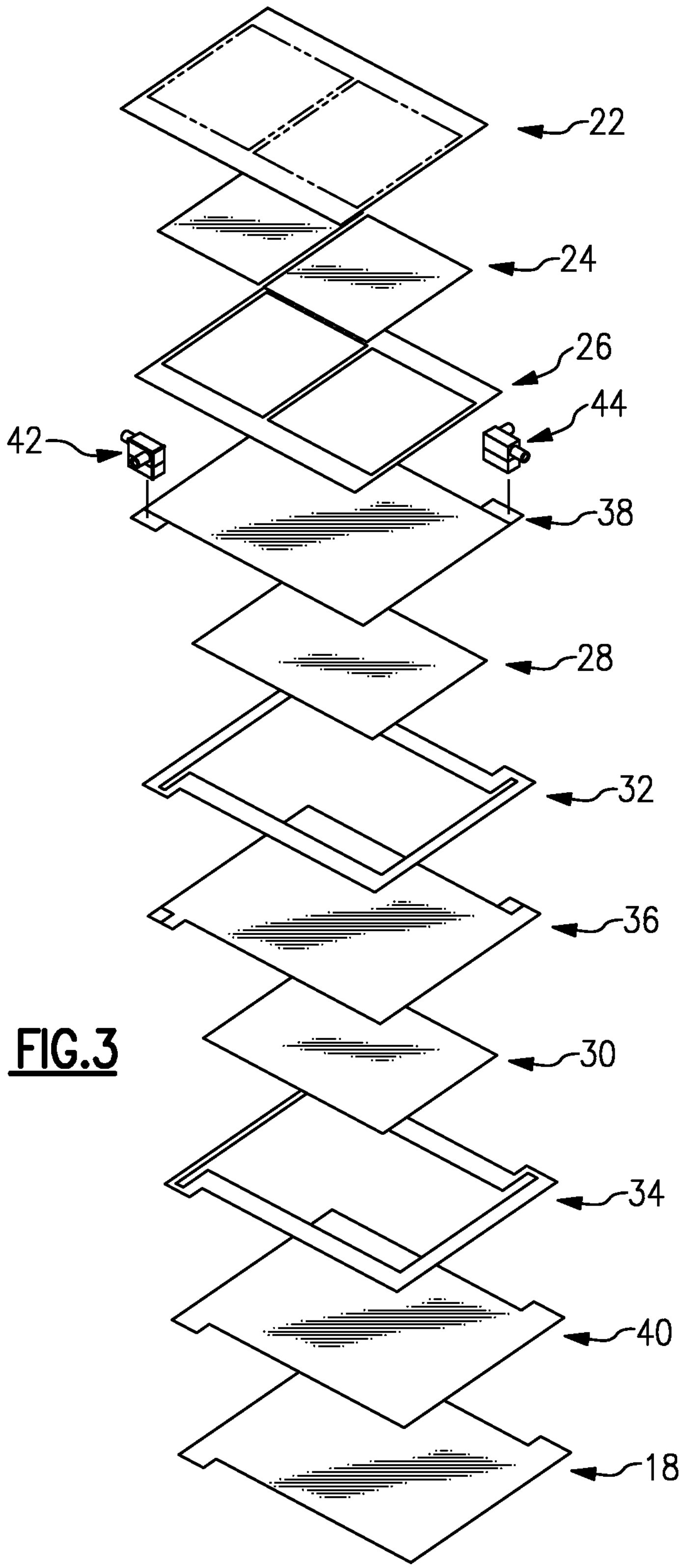


FIG.3

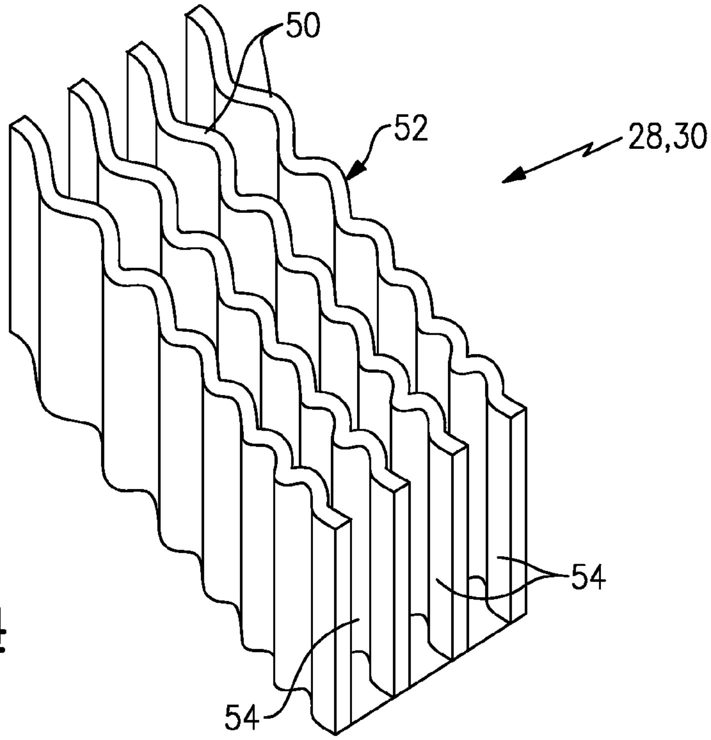


FIG.4

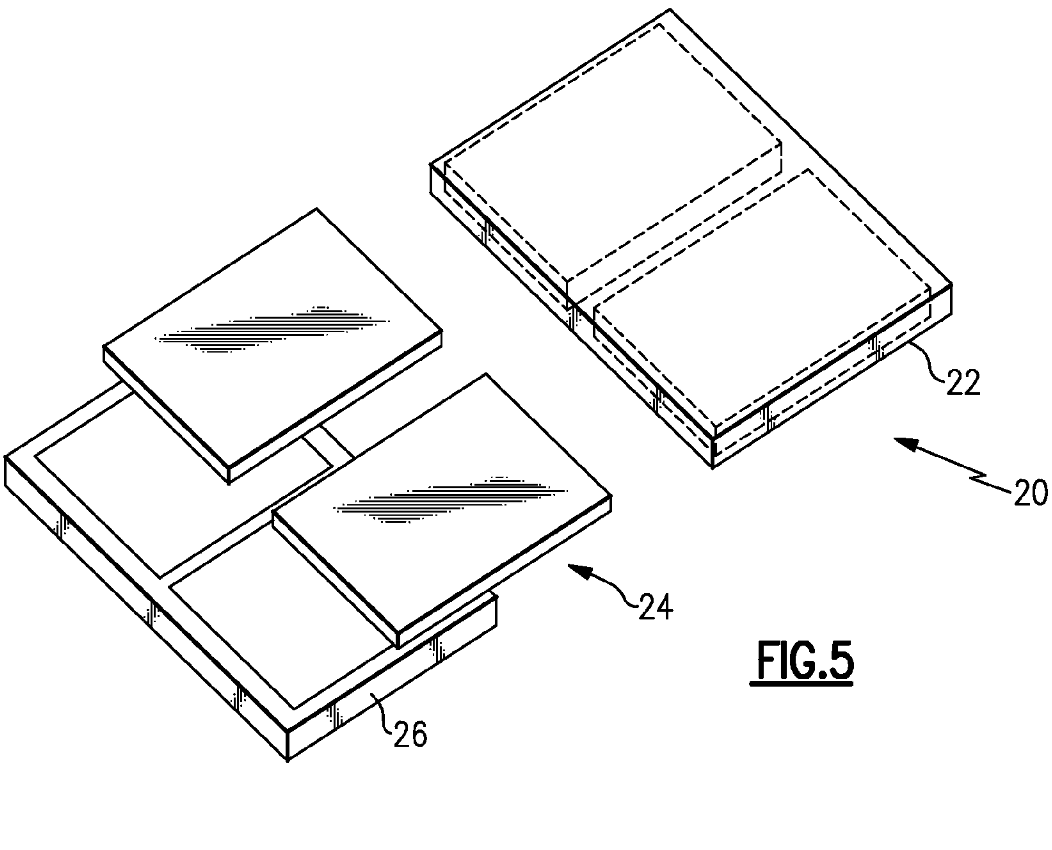


FIG.5

COLD PLATE ASSEMBLY INCORPORATING THERMAL HEAT SPREADER

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0001] This subject of this disclosure was made with government support under Contract No.: NNJO6TA25C awarded by the National Aeronautics and Space Administration. The government therefore may have certain rights in the disclosed subject matter.

BACKGROUND

[0002] This disclosure generally relates to a cooling structure for cooling electronic components. More particularly, this disclosure relates to a cooling structure including a cold plate support assembly.

[0003] Electronic components onboard aircraft or other vehicles that operate in extreme temperatures are typically protected from overheating by a cooling device. In some environments, air flow is either not available or insufficient to handle the thermal loads generated by the electronic components. In such applications, a cold plate is utilized through which a cooling fluid flows to remove heat from the electronic component. The cold plate is mounted adjacent the electronic component and supplied with fluid flow through appropriate conduits that lead to a fluid delivery system.

SUMMARY

[0004] An example cold plate assembly according to an exemplary embodiment of this disclosure, among other possible things includes a heat spreader assembly that defines a mounting surface for heat generating devices and provides an improved thermal conduction of heat away from the heat generating devices. The example cold plate assembly with the integral heat spreading device spreads heat throughout the area of the mounting surface to reduce non-uniform thermal gradients across the cold plate assembly. Accordingly, the example heat spreader assembly provides a more uniform thermal gradient across the mounting surface of the cold plate assembly and improves thermal conductivity and cooling provided by the cold plate assembly.

[0005] Although the different examples have the specific components shown in the illustrations, embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[0006] These and other features disclosed herein can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a perspective view of an example cold plate assembly.

[0008] FIG. **2** is a cross section of the example cold plate assembly.

[0009] FIG. **3** is an exploded view of the example cold plate assembly.

[0010] FIG. **4** is a perspective view of an example ruffled fin assembly.

[0011] FIG. **5** is a perspective view of an example heat spreader assembly.

DETAILED DESCRIPTION

[0012] Referring to FIG. **1**, an example cold plate assembly **10** includes an upper mounting surface **14** and a bottom surface **16**. The upper mounting surface **14** defines an area for mounting heat generating devices **12**. The example heat generating devices **12** are electronic components that generate heat dissipated through the cold plate assembly **10**. The example cold plate assembly **10** includes fluid inlet fitting **42** that receive a cooling medium input indicated at **56** that removes heat from the cold plate assembly **10** generated by the heat generating device **12** and carries the heated cooling medium away through outlet fitting **44** as indicated at **58**. Further, although the example structural cooling plate assembly **10** includes two separate cooling circuits any number of cooling circuits are also within the contemplation of this disclosure.

[0013] As appreciated, the heat generating devices **12** are mounted to a specific location on the mounting surface **14**. Accordingly, generated heat is not evenly produced across the mounting surface **14**.

[0014] The example mounting surface **14** is part of an upper skin **22** of a heat spreading assembly **20**. A heat spreading assembly **20** provides for not only the dissipation of heat within a localized area but a spreading of the heat across a much wider area or surface to evenly distribute thermal energy produced by locally mounted heat generating devices **12**. The example heat spreader assembly **20** is an integral part of the cold plate assembly **10** and defines the mounting surface **14** on which the various heat generating devices **12** are mounted.

[0015] As appreciated, the example mounting surface **14** is indicated as a planar surface for mounting of the various heat generating devices **12**. However, the mounting surface **14** could be of any shape desired to accommodate application specific mounting requirements for the various heat generating devices. Moreover, although the example heat generating devices **12** are described as electronic components they may also comprise any other devices that generate heat that are desired to be cooled through a passive means as is provided by the example cold plate assembly **10**.

[0016] Referring to FIGS. **2** and **3** with continued reference to FIG. **1**, the example cold plate assembly **10** is made up of a plurality of layers. Heat generated by the heat generating devices **12** is initially absorbed through the mounting surface **14** into the cold plate assembly **10**. Heat produced by the heat producing devices **12** is spread out across the area defined by the heat spreader assembly **20** comprising the mounting surface **14**. The heat is then absorbed within the cold plate assembly **10** through the various layers illustrated in FIG. **2**.

[0017] The example cold plate assembly **10** includes the heat spreader **20** that is attached to a top parting sheet **38**. The parting sheet **38** provides a top layer to seal a conduit through which a fluid medium is provided through inlets **42**. A middle parting sheet **36** is disposed in a middle portion of the cold plate assembly and supports a closure bar **32**. The closure bar **32** surrounds a finned layer **28**. Fluid flows through the fins **28** to remove thermal energy produced by the heat generating devices **12**. Although a single heat spreader **20** is shown, it is within the contemplation of this disclosure that additional heat spreaders could be included within the example cold plate assembly **10**. For example, an additional heat spreader could be installed between the finned layers **28**, **30** to further enhance heat removal.

[0018] The example cold plate assembly includes a first layer **28** of fins and a second layer **30** of fins. Each of the layers of fins **28**, **30** are bounded by closure bars **32**, **34**. The closure bars **32**, **34** define a boundary for the various fluid passages that are defined between the plurality of fins **50** (FIG. **4**) within each of the layers **28**, **30**. A bottom parting sheet **40** is disposed on a bottom surface of the second layer **30** of fins that is opposite the middle parting sheet **36**. The end sheet **18** is disposed in contact with the bottom parting sheet **40**.

[0019] In this example, each of the parting sheets **36**, **38**, and **40** comprise an aluminum sheet material that is brazed in place to form the desired fluid conduits through which a cooling medium is provided. Each of the parting sheets **36**, **38**, and **40** of the example cold plate assembly **10** are brazed to each other at brazed joints indicated at **48**. The heat spreader assembly **20** is further attached by a brazed joint **46** with the top parting sheet **38**.

[0020] The example heat spreader assembly **20** includes the upper skin **22**, a middle skin **24**, and a lower skin **26**. The middle skin **24** comprises a material that is selected from a group of materials that provides for the dissipation in a direction transverse to a thickness of the sheet. In other words, the heat spreader assembly **20** is comprised of layers of material that not only provide a low thermal resistance in a direction through the thickness of the material but also spreads the heat in a direction perpendicular to the thickness of the material about the area of the mounting surface **14**. The outer skins **22**, **26** are of a material brazeable and that mechanically encapsulate the center skin **24**.

[0021] In this example, the heat spreader **20** comprises a material including graphite. The graphite provides for the spreading of thermal energy produced by the various heat generating components **12** across the area of the mounting surface **14** as indicated by arrows shown in FIG. **1**. In this example, the heat spreader center skin **24** is fabricated from annealed pyrolytic graphite (APG). As should be appreciated, although an APG material is used in the disclosed example cold plate assembly **10** and heat spreader assembly **20** other materials and configurations that provide for the spreading of heat are also within the contemplation of this disclosure. The outer skins **22**, **26** are comprised of material that is brazeable to the other cold plate components.

[0022] Referring to FIG. **4** with continued reference to FIG. **2**, the example fin layers **28** and **30** comprise a ruffled fin configuration. Each of the layers **28** and **30** comprise a plurality of fins **50** that are spaced apart to define passages **54** through which a cooling medium may be flowed. Each of the example fins **50** comprises a surface **52** that includes a wavy or undulating surface referred to as a ruffle. The ruffled surface defines walls for the passages **54**. The undulated surface **52** defines a tortuous path for cooling medium that enhance the cooling efficiency of the example cooling plate assembly **10**. Moreover, with the ruffled undulating configuration of the example finned layers **28**, **30** increases the surface area available for dissipation of heat and communicating the heat between the plurality of fins **50** and a cooling medium that flows there through. Although finned layers **28**, **30** having ruffled configuration are shown by way of example, other fin configurations are within the contemplation of this disclosure. As appreciated, the cooling medium can includes air, liquid, or gas as is required for a specific application.

[0023] Referring to FIG. **5** with continued reference to FIGS. **2** and **3**, the example heat spreader assembly **20** includes a top skin **22** and a bottom skin **26** that sandwiches a middle skin **24** there between. Each of the top and bottom skins **22**, **26** are fabricated of a brazeable material. The middle skin **24** of the example heat spreader assembly is fabricated from an APG material. The APG material provides for the dissipation and spreading of heat in a direction that is perpendicular to a thickness of the heat spreader assembly.

[0024] The brazed joint **46** between the heat spreader assembly and the remainder of the cold plate assembly **10** provides a less restrictive thermal conduit through which heat may be dissipated from the mounting surface **14** through the top or first parting sheet **38** into the fin sections **28**, **30** where the heat may be carried off by a flow of cooling medium indicated at **58** in FIG. **1**.

[0025] Referring to FIGS. **2** and **3**, the example cold plate assembly **10** is assembled by mounting the layer of fins **28**, **30** to first and second sides of the middle sheet **36**. Each of the layers of fins **28**, **30** are then surround by closure bars **32**, **34** to define a boundary for cooling medium. In the disclosed example, the fin sections **28**, **30** comprise ruffled fins that have an undulating surface. Onto each side of the fin layers **28**, **30** is brazed and attached parting sheets **38**, **40** to define and passages through the fin sections **28**, **30** by closing off one side of the passages **54** through the fins **50**. In this example, the top (first) parting sheet **38** is attached utilizing a brazed joint **48** to a top surface of the closure bar **32** and the accompanying fin layer **28**. A corresponding bottom (second) sheet **40** is attached through brazed joint **48** to the closure bar **34** and over the fin layer **30**.

[0026] The example heat spreader assembly **20** is assembled as a separate unit by attaching the upper skin **22** and the lower skin **26** to the middle layer **24**. The attachment may be performed utilizing welding, brazing, or any other attachment means as is known. Once the heat spreader assembly **20** is completed it is mounted by way of the brazed joint **46** to the partially assembled parts to complete the example cold plate assembly **10**. All of the joints are brazed to provide the desired fluid tightness and thermal conductivity.

[0027] The example cold plate assembly **10** includes the heat spreader assembly **20** that defines the mounting surface **14** and provides an improved thermal conduction of heat away from the heat generating devices **12**. The example cold plate assembly **10** with the heat spreading assembly **20** spreads heat throughout the area of the mounting surface **14** produced by the heat generating devices **12** to reduce non-uniform thermal gradients across the cold plate assembly **10**. Utilizing the example heat spreader assembly **20**, the thermal gradient across the mounting surface **14** of the cold plate assembly **10** is substantially uniform and improves thermal conductivity and cooling provided by the cold plate assembly.

[0028] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the scope and content of this disclosure.

What is claimed is:

1. A cold plate assembly comprising:

a heat spreader defining a surface for mounting heat generating devices;

a plurality of heat dissipating members comprising ruffled fins in thermal communication with the heat spreader; and

an end sheet defining a surface opposite the heat spreader.

2. The cold plate assembly as recited in claim **1**, wherein the heat spreader comprises a graphite material.

3. The cold plate assembly as recited in claim **2**, wherein the heat spreader comprises an annealed pyrolytic graphite.

4. The cold plate assembly as recited in claim **1**, wherein the heat spreader comprises an upper skin, a bottom skin and a layer of annealed pyrolytic graphite between the upper and lower skin.

5. The cold plate assembly as recited in claim **1**, wherein the heat dissipating members comprise first and second layers of ruffled fins separated by a parting sheet.

6. The cold plate assembly as recited in claim **5**, including a first closure bar disposed about the first layer of ruffled fins and a second closure bar disposed about the second layer of ruffled fins.

7. The cold plate assembly as recited in claim **6**, including additional parting sheets disposed on corresponding sides of the first and second layers of ruffled fins opposite the first parting sheet.

8. The cold plate assembly as recited in claim **7**, including an inlet and outlet for communicating a cooling medium through the first and second layers of ruffled fins.

9. The cold plate assembly as recited in claim **7**, including a brazed joint attaching the heat spreader to a parting sheet.

10. A method of assembling a cold plate comprising:

defining a mounting surface with a heat spreader;

attaching the heat spreader to a fin assembly including a plurality of ruffled fins; and

attaching an end sheet to a side of the fin assembly opposite the heat spreader.

11. The method as recited in claim **10**, wherein the fin assembly includes a first parting sheet defining a first surface of the fin assembly, a closure bar surrounding the plurality of ruffled fins and a second sheet defining a second surface opposite the first surface to which the heat spreader is attached.

12. The method as recited in claim **10**, including assembling the heat spreader by attaching a top skin and a bottom skin to a middle layer of heat spreading material.

13. The method as recited in claim **12**, wherein the heat spreading material comprises annealed pyrolytic graphite.

14. The method as recited in claim **11**, including attaching an inlet fitting to the first parting sheet to define a fluid inlet and attaching an outlet fitting to the first parting sheet to define a fluid outlet.

15. The method as recited in claim **11**, including attaching the heat spreader to the fin assembly with a brazed joint.

16. The method as recited in claim **10**, including defining a fluid passage through the heat dissipating layer through the ruffled fins.

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