(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
09 January 2020 (09.01.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/009997 A4

(51) International Patent Classification:
*H01M 10/613* (2014.01) *H01M 10/6556* (2014.01)
*H01M 10/6554* (2014.01) *H01M 10/6568* (2014.01)

(21) International Application Number:
PCT/US2019/040138

(22) International Filing Date:
01 July 2019 (01.07.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/694,201 05 July 2018 (05.07.2018) US
62/735,236 24 September 2018 (24.09.2018) US

(71) Applicant: **MODINE MANUFACTURING COMPANY** [US/US]; 1500 DEKOVEN AVENUE, RACINE, Wisconsin 53403 (US).

(72) Inventors: **BERGNACH, Michael**; 822 Sheridan Road, Kenosha, Wisconsin 53140 (US). **SHISLER, Kyle**; S71W14976 Westcot Drive, Muskego, Wisconsin 53150 (US). **GROTOPHORST, Thomas**; S90W13044 Boxhorn Drive, Muskego, Wisconsin 53150 (US). **MOORE, Christopher**; 4832 Tanglewood Avenue, Racine, Wisconsin 53402 (US).

(74) Agent: **VALENSA, Jeroen** et al.; 1500 Dekoven Avenue, Racne, Wisconsin 53403 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

(54) **Title:** BATTERY COOLING PLATE AND FLUID MANIFOLD

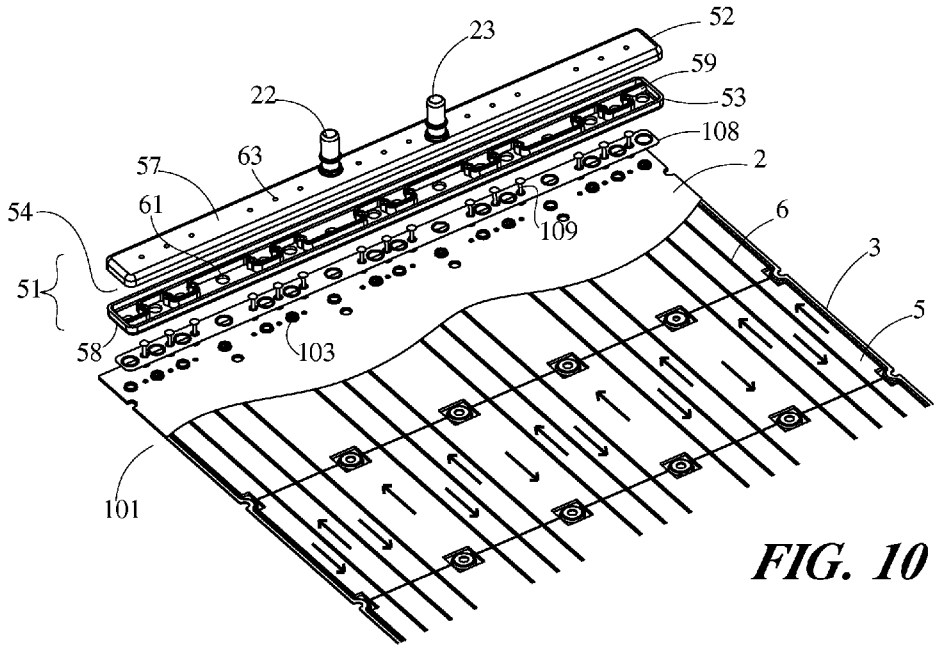


*FIG. 10*

(57) **Abstract:** A battery cooling plate includes a first plate and a second plate that are joined together at their respective edges, and are spaced apart to define a coolant volume therebetween. Turbulating inserts can be arranged side-by-side within the coolant volume and multiple rods can extend through the turbulating inserts to at least partially define flow barriers between coolant flow channels. A fluid manifold for the battery cooling plate includes a non-planar wall that extends along a length-wise direction of the fluid manifold to separate a fluid volume into a first portion and a second portion. A series of apertures are arranged along the length-wise direction and successive ones of the apertures are fluidly connected to the first portion and to the second portion in alternating sequence.

WO 2020/009997 A4

*[Continued on next page]*

SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report (Art. 21(3))*

— *with amended claims and statement (Art. 19(1))*

**Date of publication of the amended claims and statement:**

12 March 2020 (12.03.2020)

AMENDED CLAIMS
received by the International Bureau on 10 January 2020 (10.01.2020)

1. A battery cooling plate comprising:

a turbulating insert arranged between a first planar surface and a second planar surface and bonded thereto;

a first coolant pass extending through the turbulating insert in a first direction;

a second coolant pass extending through the turbulating insert in a second direction opposite the first direction, the first and the second coolant passes being sequentially arranged; and

a flow barrier arranged between the first coolant pass and the second coolant pass to prevent bypass flow between the first and second coolant passes, the flow barrier being at least partially defined by:

a convolution of the turbulating insert extending parallel to the first and the second directions;

a rod arranged within the convolution; and

a pocket provided within an embossment extending from at least one of the first and the second planar surfaces, an end of the rod being received within the pocket.

2. The battery cooling plate of claim 1, wherein the rod is joined to the turbulating insert, to one of the first and second planar surfaces, and to the embossment by braze alloy.

3. The battery cooling plate of claim 1, wherein an end of the turbulating insert abuts the embossment.

4. The battery cooling plate of claim 1, wherein the rod has a circular cross-section.

5. The battery cooling plate of claim 1, wherein the embossment is arranged at a first end of the battery cooling plate, further comprising a fluid space arranged at a second end

of the battery cooling plate opposite the first end to fluidly couple the first coolant pass to the second coolant pass.

6. The battery cooling plate of claim 1, further comprising a first fluid chamber arranged at a first end of the battery cooling plate and in fluid communication with one of the first and the second coolant passes to deliver a flow of coolant to that one of the first and the second coolant passes, and a second fluid chamber arranged at the first end of the battery cooling plate and in fluid communication with the other of the first and the second coolant passes to receive the flow of coolant from that other of the first and the second coolant passes, the first fluid chamber and the second fluid chamber being separated from each other by the embossment.

7. The battery cooling plate of claim 1, wherein the flow barrier is a first flow barrier, further comprising:

a third coolant pass extending through the turbulating insert in one of the first and second directions, the third coolant pass being hydraulically in parallel with one of the first and second coolant passes; and

a second flow barrier similar to the first flow barrier arranged between the third coolant pass and that one of the first and the second coolant passes that is not hydraulically in parallel with the third coolant pass.

8. The battery cooling plate of claim 7, wherein the embossment of the first flow barrier and the embossment of the second flow barrier are arranged at a same end of the battery cooling plate.

9. The battery cooling plate of claim 7, wherein the third coolant pass and that one of the first and second coolant passes that is hydraulically in parallel with the third coolant pass are arranged upstream of the other one of the first and second coolant passes, the

other one of the first and second coolant passes receiving the combined flow of coolant from the third coolant pass and from that one of the first and second coolant passes.

10. The battery cooling plate of claim 1, wherein the turbulating insert is one of plurality of inserts, the rod being arranged within aligned convolutions of the plurality of inserts to at least partially define the flow barrier.

11. A battery cooling plate comprising:

a first plate providing a first planar surface extending in a length direction and in a width direction;

a second plate joined to the first plate at edges thereof, the second plate providing a second planar surface extending in the length direction and in the width direction, the first and second planar surfaces being spaced apart to define a coolant volume therebetween;

a plurality of turbulating inserts arranged within the coolant volume and joined to the first and the second planar surfaces, each of the plurality of turbulating inserts extending over the full extent of the coolant volume in the width direction, the plurality of turbulating inserts being arranged side-by-side in the length direction; and

a plurality of rods, each extending through the plurality of turbulating inserts, to at least partially define flow barriers between coolant flow channels that pass through the plurality of turbulating inserts.

12. The battery cooling plate of claim 11, wherein each one of the plurality of rods is received within a convolution of each one of the plurality of turbulating inserts.

13. The battery cooling plate of claim 11, wherein each one of the plurality of rods is joined to each one of the plurality of turbulating inserts by braze joints.

14. The battery cooling plate of claim 11, wherein each one of the plurality of rods has an end closest to a first end of the battery cooling plate that is received within a

pocket provided within an embossment extending from at least one of the first and the second plates.

15. The battery cooling plate of claim 14, wherein at least some of the plurality of rods have an end furthest from the first end of the battery cooling plate that is additionally received within a pocket provided within an embossment extending from at least one of the first and the second plates.

16. The battery cooling plate of claim 11, wherein the plurality of rods includes a first rod at least partially defining a first flow barrier and a second rod at least partially defining a second flow barrier, the first rod having an end furthest from the first end of the battery cooling plate that is received within a pocket provided within a first embossment and the second rod having an end furthest from the first end of the battery cooling plate that is received within a pocket provided within a second embossment, further comprising:

a fluid space extending in the width direction and bounded at one end by the first embossment and at another end by the second embossment;

a first flow channel adjacent the first rod, the first flow channel extending in the length direction and being fluidly coupled to the fluid space at one end and to one of the inlet and outlet manifolds at an opposite end;

a second flow channel adjacent the second rod, the second flow channel extending in the length direction and being fluidly coupled to the fluid space at one end and to said one of the inlet and outlet manifolds at an opposite end;

a third flow channel arranged between the first flow channel and the second flow channel, the third flow channel extending in the length direction and being fluidly

coupled to the fluid space at one end and to the other one of the inlet and outlet manifolds at an opposite end;

a third flow barrier arranged between the first flow channel and the third flow channel; and

a fourth flow barrier arranged between the second flow channel and the third flow channel, wherein the third flow barrier and the fourth flow barrier do not extend into the fluid space.

17. The battery cooling plate of claim 11, further comprising a coolant inlet manifold and a coolant outlet manifold each extending along the width direction and each joined to one of the first and second plates, both the coolant inlet manifold and the coolant outlet manifold being arranged at a first end of the battery cooling plate in the length direction and both being fluidly communicative with the coolant volume, wherein the coolant flow channels include a first flow channel fluidly connected to one of the coolant inlet manifold and the coolant outlet manifold and a second and a third flow channel fluidly connected to the other of the coolant inlet manifold and the coolant outlet manifold, the second and the third flow channels being arranged on opposite sides of the first flow channel.

18. The battery cooling plate of claim 17, wherein at least one of the second and the third flow channels is fluidly connected to the first flow channel by a fluid space at an end of the battery cooling plate opposite the first end in the length direction.

19. The battery cooling plate of claim 18, wherein both the second and the third flow channels are fluidly connected to the first flow channel by a fluid space at an end of the battery cooling plate opposite the first end in the length direction.

20. The battery cooling plate of claim 19, wherein the fluid space is one of a plurality of fluid spaces that are aligned in the width direction, adjacent ones of the plurality of fluid spaces being separated from each other by one of the flow barriers.

21. A fluid manifold for a heat exchanger, comprising:

a planar top wall and a planar bottom wall spaced apart to define a fluid volume therebetween;

a non-planar wall extending along a length-wise direction of the fluid manifold between the planar top wall and the planar bottom wall to separate the fluid volume into a first portion and a second portion;

a first fluid port connected to the first portion of the fluid volume and a second fluid port connected to the second portion of the fluid volume; and

a plurality of apertures arranged along the length-wise direction and extending through the planar bottom wall, successive ones of the plurality of apertures along the length-wise direction being fluidly connected to the first portion and to the second portion in alternating sequence.

22. The fluid manifold of claim 21, wherein the first fluid port is a coolant inlet port and wherein the second fluid port is a coolant outlet port.

23. The fluid manifold of claim 21, wherein the first fluid port and the second fluid port both extend outward from the planar top wall.

24. The fluid manifold of claim 21, wherein at least one of the first fluid port and the second fluid port extends in the length-wise direction.

25. The fluid manifold of claim 21, further comprising a plurality of fastening holes extending through the planar top wall and the planar bottom wall.

26. The fluid manifold of claim 25, wherein the plurality of fastening holes extend through thickened portions of the non-planar wall.

27. The fluid manifold of claim 21, wherein the fluid manifold is constructed of a plastic material.

28. The fluid manifold of claim 27, comprising a first plastic part that provides the planar top wall and a second plastic part that provides the planar bottom wall.

29. The fluid manifold of claim 28, wherein at least one of the first and second fluid ports is provided by the first plastic part.

30. The fluid manifold of claim 28, wherein at least one of the first and second fluid ports is provided by the second plastic part.

31. The fluid manifold of claim 28, wherein a first portion of the non-planar wall is provided by the first plastic part and a second portion of the non-planar wall is provided by the second plastic part.

32. The fluid manifold of claim 28, wherein the first plastic part and the second plastic part are joined together to provide a leak-free seal around an outer perimeter of the fluid manifold.

33. The fluid manifold of claim 21, wherein the non-planar wall includes a first non-planar surface bounding the first portion of the fluid volume, a second non-planar surface spaced apart from the first non-planar surface and bounding the second portion of the fluid volume, and a cavity arranged between the first non-planar surface and the second non-planar surface.

34. The fluid manifold of claim 21, wherein the centers of the plurality of apertures are arranged in a straight line extending along the length-wise direction.

35. The fluid manifold of claim 34, wherein the centers of the fastening holes are aligned with the straight line in which the centers of the plurality of apertures are arranged.

36. The fluid manifold of claim 21, wherein the non-planar wall includes a first plurality of planar wall sections extending along the length-wise direction and offset to one side of the plurality of apertures, a second plurality of wall sections extending along the length-wise direction and offset to another side of the plurality of apertures, and a third plurality of wall sections joining ones of the first plurality of wall sections to ones of the second plurality of wall sections.

37. The fluid manifold of claim 36, wherein each one of the third plurality of wall sections is arranged between two adjacent ones of the plurality of apertures.

38. The fluid manifold of claim 36, further comprising a plurality of fastening holes extending through thickened portions of the third plurality of wall sections.

**STATEMENT UNDER ARTICLE 19(1)**

Amendments to claims 7, 10, 16, and 21 are simply to correct typographical errors. No new matter has been added.