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(54) Title: HOT MELT APPARATUS AND METHOD OF USE

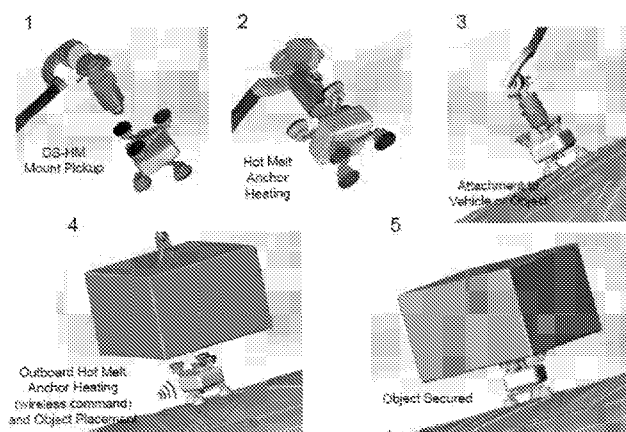


FIGURE 14

(57) **Abstract:** In various embodiments, a hot melt device comprising a heating device that is automatically or manually triggered is configured so as to have its melt surface applied bringing a thermoplastic material (2) in its solid form into contact with a surface via mechanical extrusion; using a heater to heat the thermoplastic material (2) to a temperature above a melting temperature of the thermoplastic material (2) while maintaining the contact of the thermoplastic material (2) with the surface; allowing the heated thermoplastic material (2) to cool to a temperature that is below the thermoplastic material's (2) melting temperature; and allowing the heated thermoplastic material (2) to bond the hot melt apparatus (1) to the contacted surface (14) without a solvent or use of a curing chemical reaction when the heated thermoplastic material (2) is cooled to below the thermoplastic material's (2) melting temperature while remaining connected to the structural body (3).



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Hot Melt Apparatus and Method of Use

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RELATION

[0001] This application claims priority through United States Provisional Application 62/533,608, filed July 17, 2017.

BACKGROUND OF THE INVENTION

[0002] A hot melt device comprising a heating device that is automatically or manually triggered to heat a pre-formed thermoplastic feedstock is recognized as an existing technology. Applications using such devices allow connection of objects to provide mechanical and/or electrical bonding and incorporate flexibility, repeatability and reusability of the connections.

[0003] A hot melt apparatus typically includes a structural body, a heating element of various designs, and an automatic or manual control system to melt thermoplastic materials. In operation, mechanical extrusion of a heated thermoplastic material onto a surface to be joined as the thermoplastic material cools and solidifies is used.

FIGURES

[0004] Various figures are included herein which illustrate aspects of embodiments of the disclosed inventions.

[0005] **Fig. 1** is a block diagrammatic view in partial perspective of a first exemplary system;

[0006] **Fig. 2** is an illustration of various shapes adapted to improve a bond of thermoplastic material 2 with a the contacted surface;

[0007] **Fig. 3** is a block diagrammatic view in partial perspective of a second exemplary system where one or more interchangeable interfaces 5 are disposed intermediate structural body

3 and heater 4 and comprises upper portion 5a connected to structural body 3 and lower portion 5b connected to heater 4, where upper portion 5a and lower portion 5n are selectively disconnectable from each other;

[0008] **Fig. 4** is a block diagrammatic view in partial perspective of a further exemplary system illustrating a separable interface;

[0009] **Fig. 5** is a block diagrammatic view in partial perspective of a further exemplary system illustrating a mechanical integrator;

[0010] **Fig. 6** is a block diagrammatic view in partial perspective of a further exemplary system illustrating an electrical integrator;

[0011] **Fig. 7** is a block diagrammatic view in partial perspective of a further exemplary system illustrating a mechanical integrator;

[0012] **Fig. 8** is a block diagrammatic view in partial perspective of a further exemplary system illustrating a mechanical integrator and an electrical integrator;

[0013] **Fig. 9** is a block diagrammatic view in partial perspective of a further exemplary system illustrating use of a cable manager;

[0014] **Fig. 10** is a block diagrammatic view in partial perspective of a further exemplary system illustrating an electrical integrator and various electrical ground paths;

[0015] **Fig. 11** is a block diagrammatic view in partial perspective of a further exemplary system;

[0016] **Fig. 12** is a block diagrammatic view in partial perspective of an exemplary system;

[0017] **Fig. 13** is a block diagrammatic view in partial perspective of a further exemplary system integrated within a common structural body 3 with thermoplastic material 2 at both ends to create a double sided hot melt apparatus 15; and

[0018] **Fig. 14** is a view in partial perspective of an exemplary system illustrating that system in use.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0019] Referring now to **Fig. 1**, in a first embodiment hot melt apparatus 1 comprises structural body 3; thermoplastic material 2, in a solid form, connected to structural body 3, where the solid form thermoplastic material 2 is mechanically extrudable onto a surface to be joined as the heated solid form thermoplastic material 2 cools and solidifies; and controllable heater 4 connected to the structural body and to the solid form thermoplastic material 2, heater 4 controllable to heat the solid form thermoplastic material 2 to a temperature above its melting temperature and to allow the heated solid form thermoplastic material 2 to cool and solidify without the use of a solvent.

[0020] Referring additionally to **Fig. 2**, solid form thermoplastic material 2 may comprise a shaped thermoplastic material 2, where the shape is adapted to improve a bond of thermoplastic material 2 with a the contacted surface. By way of example and not limitation, the shape may comprises a geometric profile and/or pattern and may further comprise varying thicknesses when melted wherein the connection of rough or uneven surfaces are completed.

[0021] Heater 4 may be an electro-chemical heater activated using a low power electrical signal. In other embodiments, heater 4 may be chemical based and activated through mixing of various chemicals.

[0022] Referring additionally to **Fig. 3**, in embodiments hot melt apparatus 1 may further comprise one or more interchangeable interfaces 5 disposed intermediate structural body 3 and heater 4. Interchangeable interface 5 may comprises upper portion 5a connected to structural body 3 and lower portion 5b connected to heater 4, where upper portion 5a and lower portion 5b are selectively disconnectable from each other. In some of these embodiments, heater 4 and thermoplastic material 2 are integral and may be integrated to, but remain separable from, structural body 3.

[0023] Referring additionally to **Fig. 4**, in embodiments separable interface 6 is present and disposed intermediate heater 4 and thermoplastic material 2. Typically, separable interface 6 is adapted to create an evenly distributed thermal transfer of heat into thermoplastic material 2. Separable interface 6 comprises a metal, a plastic, a ceramic, or a composite, or the like, or a combination thereof.

[0024] In certain of these embodiments, separable interface 6 comprises upper portion 6a connected to heater 4 and lower portion 6b selectively detachable from upper portion 6a, where lower portion 6b is substantially permanently attached to thermoplastic material 2.

[0025] In embodiments separable interface 6 further comprises a thermally conductive material and a heating element operative to melt thermoplastic material by transferring heat to the hot melt pad.

[0026] In other embodiments, separable interface 6 comprises an electrically conductive material and the hot melt pad comprises a heater. For some of these embodiments, separable interface 6 further comprises an electrically conductive separable interface configured to provide a grounding path through the hot melt apparatus.

[0027] Referring additionally to **Figs. 5** and **7**, in further embodiments hot melt apparatus 1 comprises mechanical integrator 7 which is configured to allow hot melt apparatus 1 to be mechanically integrated to object 8 such as to become a tool or structural extension of object 8.

[0028] Referring additionally to **Figs. 6** and **10** in further embodiments hot melt apparatus 1 comprises electrical integrator 9 which is configured to allow hot melt apparatus 1 to be electrically integrated to object 8. Electrical integrator 9 provides a power and/or a ground path where power, and/or a ground, may be obtained from object 8 to support the operation of hot melt apparatus 1. Electrically conductive cable 13 may also be present in such embodiments and operatively in communication with electrical integrator 9 at a first end and with object 8 at a second end. Electrically conductive cable 13 may be used to implement an electrical ground path between object 8 and secondary object 14 (**Fig. 10**).

[0029] Referring additionally to **Fig. 11**, in embodiments comprising a pair of hot melt apparatuses 1, electrical integrators 9 of the pair of hot melt apparatuses 1 may be operatively connected by electrically conductive cable 13 which may further be operative to create an electrical ground path when the pair of hot melt apparatuses 1 are bonded separately to object 8 and secondary object 14.

[0030] In other embodiments where there is a plurality of hot melt apparatuses 1, the plurality of hot melt apparatuses 1 may be connected by mechanical integrators 7 and electrical integrators 9 and one or more of the plurality of hot melt apparatuses 1 used to bond object 8 to secondary object 14. These multiple hot melt apparatus 1 may be integrated in a number equal to the number of objects 8,14 to be joined. The plurality of paired hot melt apparatuses may be equal in number to a number of objects 8 to be joined.

[0031] Referring additionally to **Fig. 13**, the plurality of hot melt apparatus 1, which may be a pair, may further be integrated within a common structural body 3 with thermoplastic material 2 at both ends to create a double sided hot melt apparatus 15 which may be used to bond object 8 to secondary object 14. Double sided hot melt apparatus 15 may achieve an electrical ground path between object 8 and secondary object 14.

[0032] Referring additionally to **Fig. 9**, for embodiments with cables, cable manager 11 may be present and operatively connected to hot melt apparatus 1, where cable manager 11 is configured to provide positioning, placement and retention of cables, ropes, or tethers. In certain embodiments, cable manager 11 comprises a hook shape.

[0033] Still referring to **Fig. 9**, in one or more embodiments hot melt apparatus 1 further comprises material manager 12 operatively connected to hot melt apparatus 1. Material manager 12 may comprise a plow or similar shape to aid in providing for the movement, lifting, and retention of moveable surface materials of object 8.

[0034] In most of these embodiments, thermoplastic material 2 may comprise an electrically conductive material which may further provide a grounding path through thermoplastic material 2.

[0035] **In the operation of exemplary embodiments**, referring generally to **Fig. 14**, a thermoplastic material may be applied to a surface using hot melt apparatus 1 as described above in its various embodiments, where the various embodiments and their application methods illustrate a departure from the current art.

[0036] Thermoplastic material 2 is brought in its solid form into contact with a surface via mechanical extrusion of thermoplastic material 2 and heater 4 used to heat thermoplastic material 2 to a temperature at or above a melting temperature of thermoplastic material 2 while

maintaining the contact of thermoplastic material 2 with the surface. Thermoplastic material 2 may be electrically conductive and providing a grounding path through the electrically conductive thermoplastic material 2.

[0037] Once applied, as illustrated in **Fig. 2**, heated thermoplastic material 2 is allowed to cool to a temperature that is below thermoplastic material's 2 melting temperature and the heated thermoplastic material 2 allowed to bond hot melt apparatus 1 to the contacted surface 14 without a solvent or use of a curing chemical reaction when the heated thermoplastic material 2 is cooled to below the melting temperature of thermoplastic material 2.

[0038] Thermoplastic material 2 in solid form may further comprise a predetermined shape selected to comprise as shape that improves the bond of thermoplastic material 2 with the contacted surface. The shape typically comprises a predetermined geometric pattern. Where the surface comprises a rough or uneven surface, the method may further comprise varying a thickness of the selected shape of thermoplastic material 2 wherein the connection of rough or uneven surfaces are completed.

[0039] If present, as illustrated in **Fig. 4**, separable interface 6 may be disposed intermediate heater 4 and thermoplastic material 2, where separable interface 6 comprises upper portion 6a connected to heater 4 and lower portion 6b selectively attachable and detachable from upper portion 6a which is substantially permanently attached to thermoplastic material 2. In such embodiments, separable interface 6 may be used to create an evenly distributed thermal transfer of heat into thermoplastic material 2.

[0040] In embodiments comprising mechanical integrator 7 and referring generally to **Fig. 5**, hot melt apparatus 1 may be mechanically integrated onto and/or in to object 8 using mechanical integrator 7 to become a tool or structural extension of object 8.

[0041] In other embodiments, hot melt apparatus 1 may be temporarily attached to placement device 10 using mechanical integrator 7 and subsequently disconnected from placement device 10 after a bond comprising thermoplastic material 2 is created to object 8.

[0042] In embodiments where hot melt apparatus 1 further comprises electrical integrator 9, and as generally illustrated in **Fig. 8**, hot melt apparatus 1 may be electrically integrated with object 8 using electrical integrator 9 and one or more electrical pathways provided from object 8 to support the operation of hot melt apparatus 1. This may include temporarily attaching hot melt apparatus 1 to placement device 10 using electrical integrator 9 disconnecting placement device 10 from hot melt apparatus 1 after a bond comprising thermoplastic material 2 is created to object 8.

[0043] In embodiments comprising a plurality of hot melt apparatuses 1, and as generally illustrated in **Fig. 11**, one or more electrically conductive cables 13 may be used to operatively interconnect electrical integrator 9 of a first hot melt apparatus 1 of the plurality of hot melt apparatuses 1 to electrical integrator 9 a second hot melt apparatus 1 of the plurality of hot melt apparatuses 1. Additionally, one or more electrical ground paths may be created through electrically conductive cable 13 when one or more of the plurality of hot melt apparatuses 1 are bonded separately to object 8 and, optionally, secondary object 14. In other of these embodiments, two or more of the plurality of hot melt apparatuses 1 may be interconnected by mechanical integrators 7 and electrical integrators 9 and used to bond object 8 to secondary object 1.

[0044] In other contemplated embodiments, and as generally illustrated in **Figs. 13** and **14**, two or more hot melt apparatus 1 may be integrated within a common structural body 3 with

thermoplastic material 2 at both ends to create a double-sided hot melt apparatus 15. The double-sided hot melt apparatus 15 may be used to bond object 8 to secondary object 14.

[0045] Where heater 4 comprises an electro-chemical heater, heater 4 may be activated using a low power electrical signal.

[0046] Where heater 4 comprises a chemical based heater, heater 4 may be activated through mixing of chemicals in heater 4.

[0047] In most of the contemplated embodiments, cooled thermoplastic material 2 may be reheated to allow removal of hot melt apparatus 1 from surface to which the thermoplastic material 2 has been bonded. In these embodiments, multiple heating and cooling cycles of hot melt apparatus 1 may be allowed, further allowing use and reuse of hot melt apparatus 1 multiple times.

[0048] The foregoing disclosure and description of the inventions are illustrative and explanatory. Various changes in the size, shape, and materials, as well as in the details of the illustrative construction and/or an illustrative method may be made without departing from the spirit of the invention.

CLAIMS

What is claimed is:

1. A hot melt apparatus (1), comprising:
 - a. a structural body (3);
 - b. a solid form thermoplastic material (2) connected to the structural body (3), the solid form thermoplastic material (2) mechanically extrudable onto a surface to be joined as the heated solid form thermoplastic material (2) cools and solidifies while remaining connected to the structural body (3); and
 - c. a controllable heater (4) connected to the structural body and to the solid form thermoplastic material (2), the controllable heater (4) comprising a heat generator able to heat the solid form thermoplastic material (2) to a temperature above its melting temperature and able to cool to a temperature which allows the heated solid form thermoplastic material (2) to cool and solidify without the use of a solvent.
2. The hot melt apparatus of Claim 1, wherein the solid form thermoplastic material (2) further comprises a shape adapted to improve a bond of the thermoplastic material (2) joined with the surface.
3. The hot melt apparatus of Claim 2, wherein the shape comprises a geometric profile comprising a varying thickness of melted thermoplastic material (2) [wherein the connection of rough or uneven surfaces are completed].
4. The hot melt apparatus of Claim 1, further comprising an interchangeable interface (5) disposed intermediate the structural body (3) and the heater (4).
5. The hot melt apparatus of Claim 4, wherein:

- a. the interchangeable interface (5) comprises an upper portion connected to the structural body and a lower portion connected to the heating mechanism and to the upper portion, the upper portion and the lower portion being selectively disconnectable from each other; and
 - b. the heater (4) and the thermoplastic material (2) are integral and are selectively disconnectable to the apparatus structural body (3).
6. The apparatus of Claim 1, further comprising a separable interface (6) disposed intermediate the heater (4) and the thermoplastic material (2), the separable interface (6) comprising an upper portion connected to the heating mechanism and a lower portion selectively attachable from the upper portion, the lower portion permanently attached to the thermoplastic material (2).
7. The apparatus of Claim 6, wherein the separable interface (6) is adapted to create an evenly distributed thermal transfer of heat into the thermoplastic material (2).
8. The apparatus of Claim 6, wherein the separable interface (6) comprises a thermally conductive material, a thermally non-conductive material, an electrically conductive material, or an electrically non-conductive material.
9. The apparatus of Claim 6, wherein the separable interface (6) comprises a metal, a plastic, or a ceramic.
10. The apparatus of Claim 1, further comprising a mechanical integrator (7), configured to allow the hot melt apparatus (1) to be mechanically integrated to an object (8) to become a tool or structural extension of the object.
11. The apparatus of Claim 1, further comprising an electrical integrator (9) configured to allow the hot melt apparatus (1) to be electrically integrated to an object (8) and provide an

electrical pathway [allow power and/or a ground path to be obtained] to be established with [from] the object to support the operation of the hot melt apparatus (1).

12. The apparatus of Claim 11, further comprising an electrically conductive cable (13) operatively in communication with the electrical integrator (9) of the hot melt apparatus (1) at a first end and with the object (8) at a second other end, the electrically conductive cable (13) operative to create an electrical ground path between the object (8) and a secondary object (14).

13. The apparatus of Claim 12 further comprising a pair of the hot melt apparatuses (1) whose electrical integrators (9) are operatively interconnected by an electrically conductive cable (13), the electrically conductive cable (13) operative to create an electrical ground path when the pair of hot melt apparatuses (1) are bonded separately to the object (8) and the secondary object (14).

14. The hot melt apparatus of Claim 1, further comprising a cable manager (11) operatively connected to the hot melt apparatus, the cable manager configured to provide positioning, placement and retention of cables, ropes, or tethers.

15. The hot melt apparatus of Claim 14, wherein the cable manager comprises a hook shape.

16. The hot melt apparatus of Claim 1, further comprising a material manager (12) operatively connected to the hot melt apparatus,

17. The hot melt apparatus of Claim 16, wherein the material manager (12) comprises a plow shape configured to aid in providing for movement, lifting, and retention of moveable surface materials of the object (8).

18. The apparatus of Claim 2 wherein the thermoplastic material (2) comprises an electrically conductive material able to provide a grounding path through the thermoplastic material (2).

19. The apparatus of Claim 1 wherein the controllable heater (4) comprises an electro-chemical heater activated using a low power electrical signal.
20. The apparatus of Claim 1 wherein the controllable heater (4) comprising a chemical based heater activated through mixing of chemicals.
21. A double sided hot melt apparatus (15), comprising:
- a. a shared structural body (3) comprising a first end and second end; and
 - b. a pair of hot melt apparatuses (1), each hot melt apparatus (1) comprising:
 - i. a solid form thermoplastic material (2) connected to and disposed at the first end and the second end of the shared structural body, the solid form thermoplastic material (2) mechanically extrudable onto a surface of an object (8) to be joined as the heated solid form thermoplastic material (2) cools and solidifies while remaining connected to the structural body (3); and
 - ii. a controllable heater (4) connected to the shared structural body and to the solid form thermoplastic material (2), the controllable heater (4) comprising a heat generator able to heat the solid form thermoplastic material (2) to a temperature above its melting temperature and able to cool to a temperature which allows the heated solid form thermoplastic material (2) to cool and solidify without the use of a solvent.
22. The double sided hot melt apparatus of Claim 21, wherein the double sided hot melt apparatus (15) creates an electrical ground path between the object (8) and a secondary object (14) when joined to the object (8).
23. A system of double sided hot melt apparatuses, comprising:

- a. a plurality of double sided hot melt apparatuses (15), each double sided hot melt apparatus comprising:
 - i. a shared structural body (3) comprising a first end and second end; and
 - ii. a pair of hot melt apparatuses (1), each hot melt apparatus (1) comprising:
 - 1. a solid form thermoplastic material (2) connected to and disposed at the first end and the second end of the shared structural body, the solid form thermoplastic material (2) mechanically extrudable onto a surface of an object (8) to be joined as the heated solid form thermoplastic material (2) cools and solidifies while remaining connected to the structural body (3); and
 - 2. a controllable heater (4) connected to the shared structural body and to the solid form thermoplastic material (2), the controllable heater (4) comprising a heat generator able to heat the solid form thermoplastic material (2) to a temperature above its melting temperature and able to cool to a temperature which allows the heated solid form thermoplastic material (2) to cool and solidify without the use of a solvent; and
 - b. an integrator 7,9 connected to the shared structural body (3) and adapted to connect the double sided hot melt apparatuses to a further structure.
24. The apparatus of Claim 23, wherein the integrator 7,9 comprises a mechanical integrator 7 or an electrical integrator 9.
25. The apparatus of Claim 23, wherein the number of the plurality of hot melt apparatuses (1) corresponds to a number of objects to be joined.

26. A method of applying a thermoplastic material to a surface using a hot melt apparatus comprising a structural body (3), a selectively controllable heater (4) connected to the structural body, and a solid form thermoplastic material (2) operatively connected to the structural body (3) and the heater (4), the method comprising:

- a. bringing the thermoplastic material (2) in its solid form into contact with a surface via mechanical extrusion;
- b. using the heater to heat the thermoplastic material (2) to a temperature above a melting temperature of the thermoplastic material (2) while maintaining the contact of the thermoplastic material (2) with the surface;
- c. allowing the heated thermoplastic material (2) to cool to a temperature that is below the thermoplastic material's (2) melting temperature; and
- d. allowing the heated thermoplastic material (2) to bond the hot melt apparatus (1) to the contacted surface (14) without a solvent or use of a curing chemical reaction when the heated thermoplastic material (2) is cooled to below the thermoplastic material's (2) melting temperature while remaining connected to the structural body (3).

27. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, wherein the thermoplastic material (2) in solid form further comprises a predetermined shape, the method further comprising selecting the predetermined shape as shape a that improves the bond of the thermoplastic material (2) with the contacted surface, the shape comprising a geometric profile when the connection of complex surfaces [what surfaces?] are completed.

28. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 27, wherein the surface comprises a rough or uneven surface, the method further comprising varying a thickness of the selected shape of the thermoplastic material (2) wherein the connection of rough or uneven surfaces are completed.

29. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, the hot melt apparatus further comprising a separable interface (6) disposed intermediate the heater (4) and the thermoplastic material (2), the separable interface (6) comprising an upper portion connected to the heating mechanism and a lower portion selectively detachable from the upper portion, the lower portion permanently attached to the thermoplastic material (2), the method further comprising using the separable interface (6) to create an evenly distributed thermal transfer of heat into the thermoplastic material (2).

30. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, further comprising reheating the cooled thermoplastic material (2) to allow removal of the hot melt apparatus (1) the surface to which the thermoplastic material (2) is bonded.

31. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 30, further comprising allowing multiple heating and cooling cycles of the hot melt apparatus (1), wherein the hot melt apparatus (1) may be reused multiple times.

32. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, the hot melt apparatus further comprising a mechanical integrator (7), the method further comprising mechanically integrating the hot melt apparatus (1) to any object (8) to become a tool or structural extension of the object.

33. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 32, further comprising:

- a. temporarily attaching the hot melt apparatus (1) to a placement device (10) using the mechanical integrator (7); and
- b. disconnecting the placement device (10) from the hot melt apparatus after the thermoplastic material (2) bond is created to a surface (8).

34. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, the hot melt apparatus further comprising an electrical integrator (9), the method further comprising:

- a. electrically integrating the hot melt apparatus (1) with an object (8); and
- b. providing an electrical pathway from the object to support the operation of the hot melt apparatus (1).

35. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 34, further comprising:

- a. temporary attachment of the hot melt apparatus (1) to any placement device (10) using the electrical integrator (9); and
- b. disconnecting the placement device (10) from the hot melt device after the thermoplastic material (2) bond is created to any object (8).

36. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 34, further comprising using a pair of hot melt apparatuses (1), the method further comprising:

- a. using an electrically conductive cable (13) to operatively interconnect the electrical integrator (9) of a first hot melt apparatus of the pair of hot melt apparatus to electrical integrator (9) a second hot melt apparatus of the pair of hot melt apparatus; and

- b. creating an electrical ground path through the electrically conductive cable (13) when the hot melt apparatuses (1) are bonded separately to any object (8) and any secondary object (14).

37. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, wherein the hot melt apparatuses (1) are connected by mechanical integrators (7) and electrical integrators (9) and used to bond the object (8) to any other secondary object (14).

38. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, further comprising:

- a. integrating a pair of hot melt apparatus (1) within a common structural body (3) with thermoplastic material (2) at both ends to create a double sided hot melt apparatus (15); and
- b. using the double sided hot melt apparatus (15) to bond the object (8) to any other secondary object (14).

39. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 38, further comprising using a plurality of pairs of hot melt apparatuses, the plurality of paired hot melt apparatuses equal in number to a number of objects to be joined.

40. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 39, further comprising:

- a. using a thermoplastic material (2) that is electrically conductive; and
- b. providing a grounding path through the electrically conductive thermoplastic material (2).

41. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, the heater comprising an electro-chemical heater, the method further comprising activating the electro-chemical heater using a low power electrical signal.

42. The method of applying a thermoplastic material to a surface using a hot melt apparatus of Claim 26, the heater comprising a chemical based heater, the method further comprising activating the chemical based heater through mixing of chemicals in the chemical based heater.

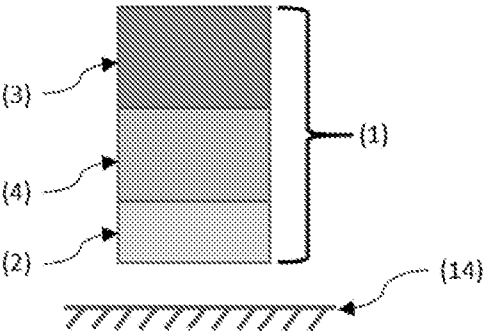


FIGURE 1

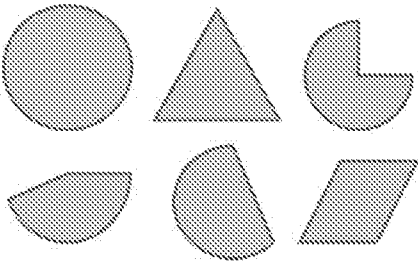


FIGURE 2

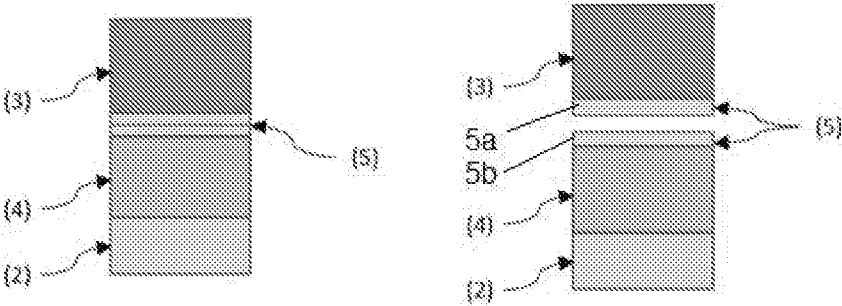


FIGURE 3

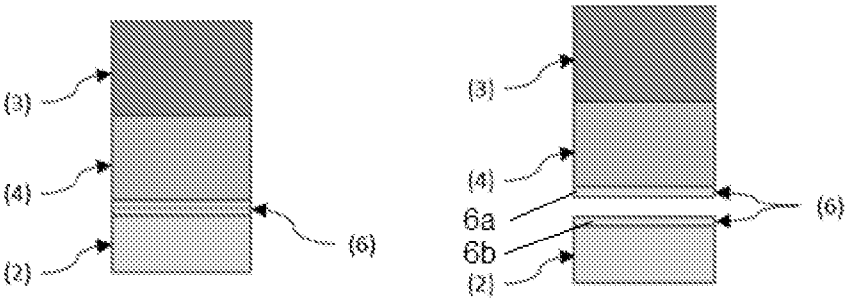


FIGURE 4

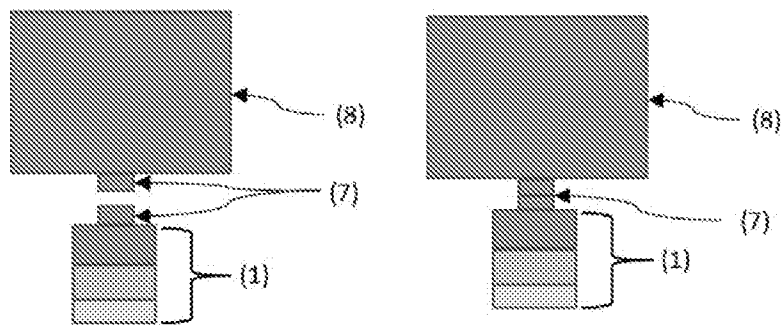


FIGURE 5

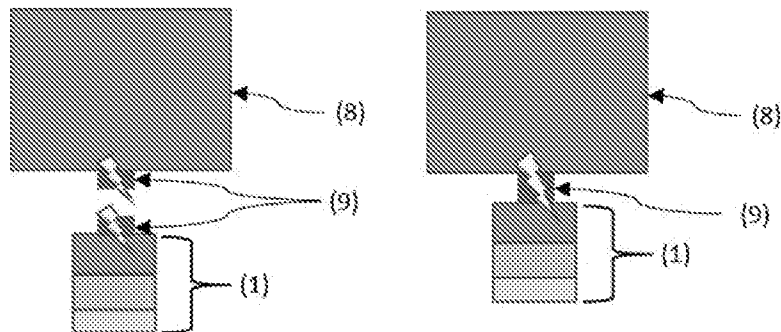


FIGURE 6

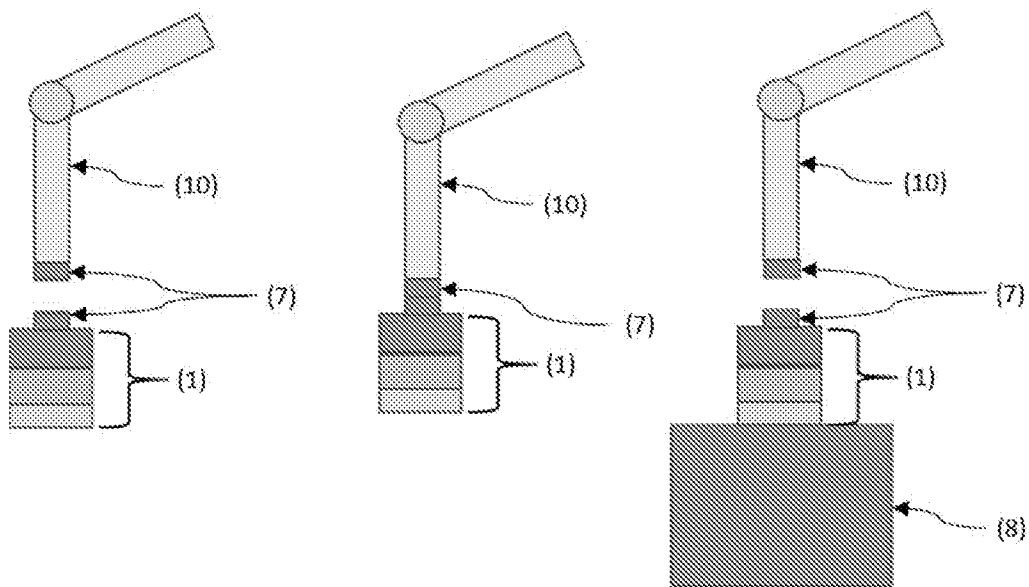


FIGURE 7

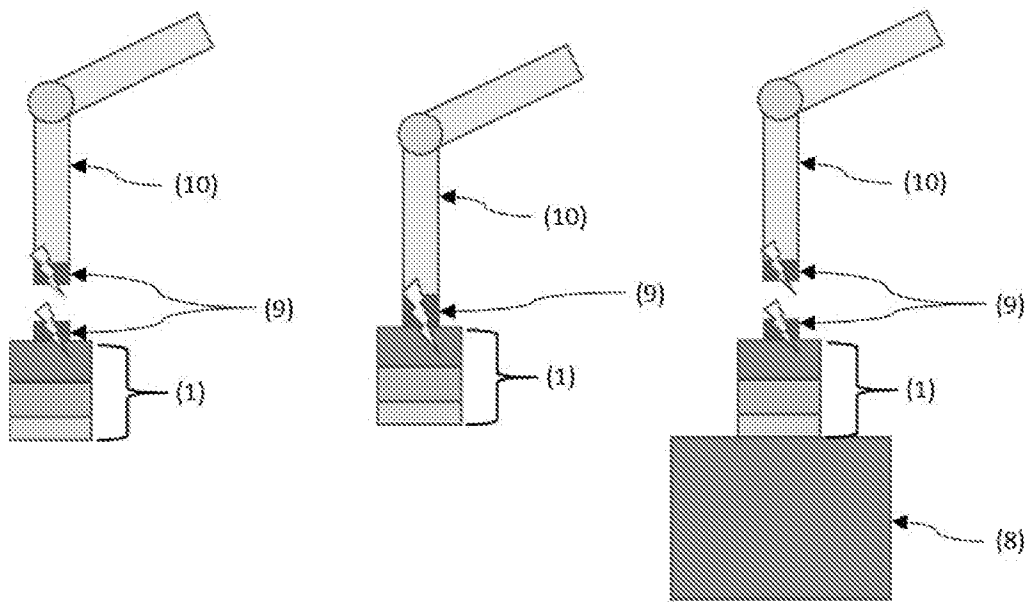


FIGURE 8

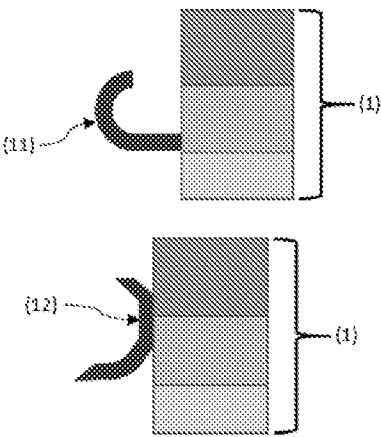


FIGURE 9

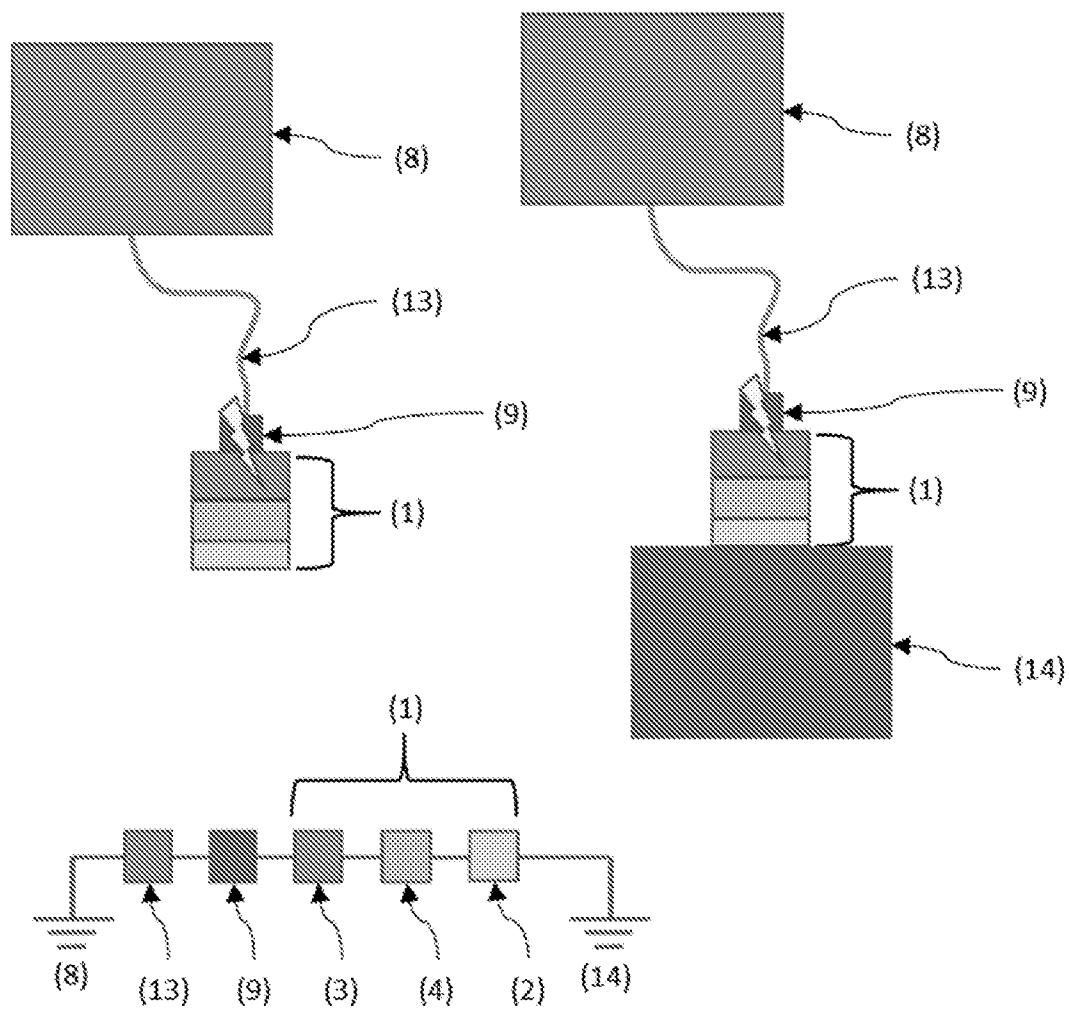


FIGURE 10

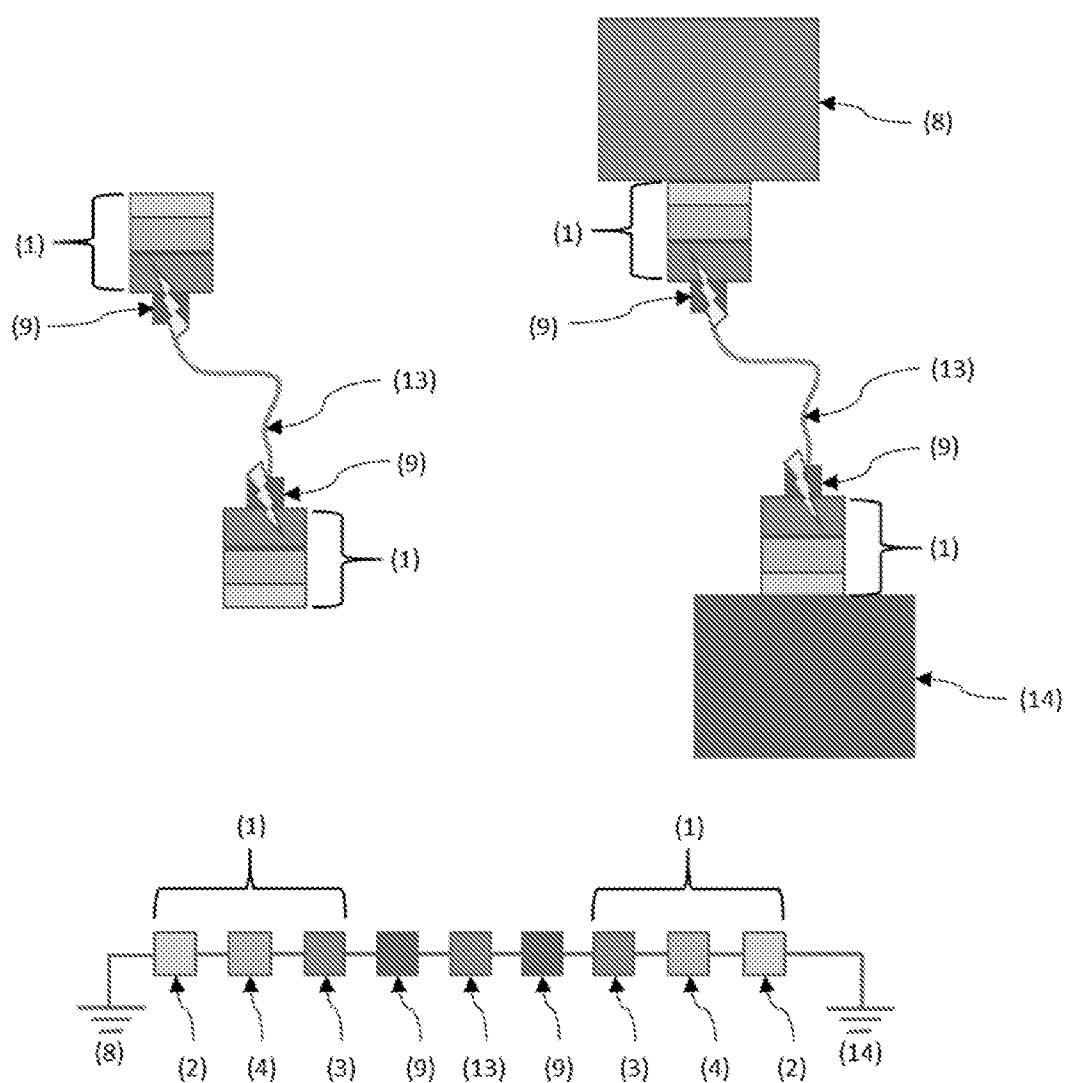


FIGURE 11

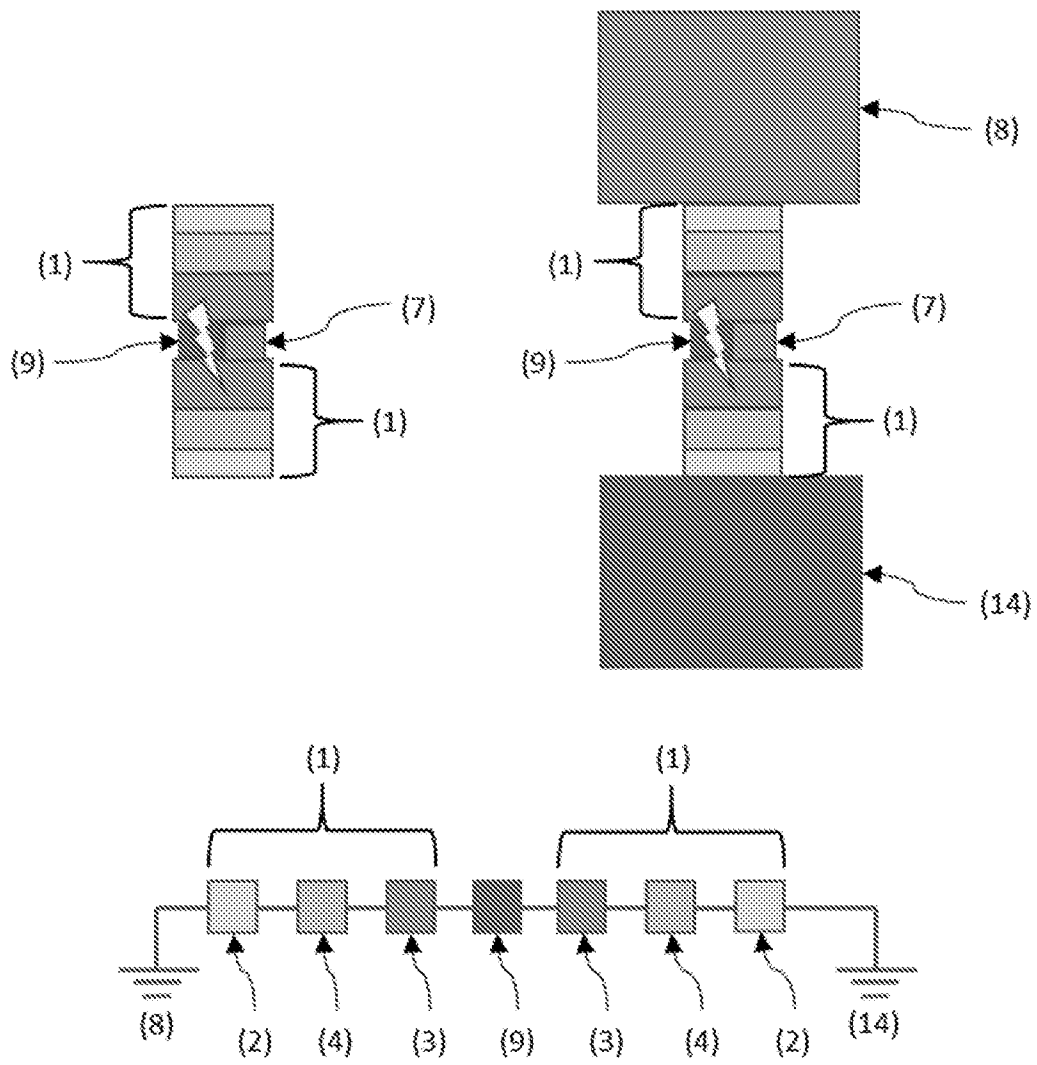


FIGURE 12

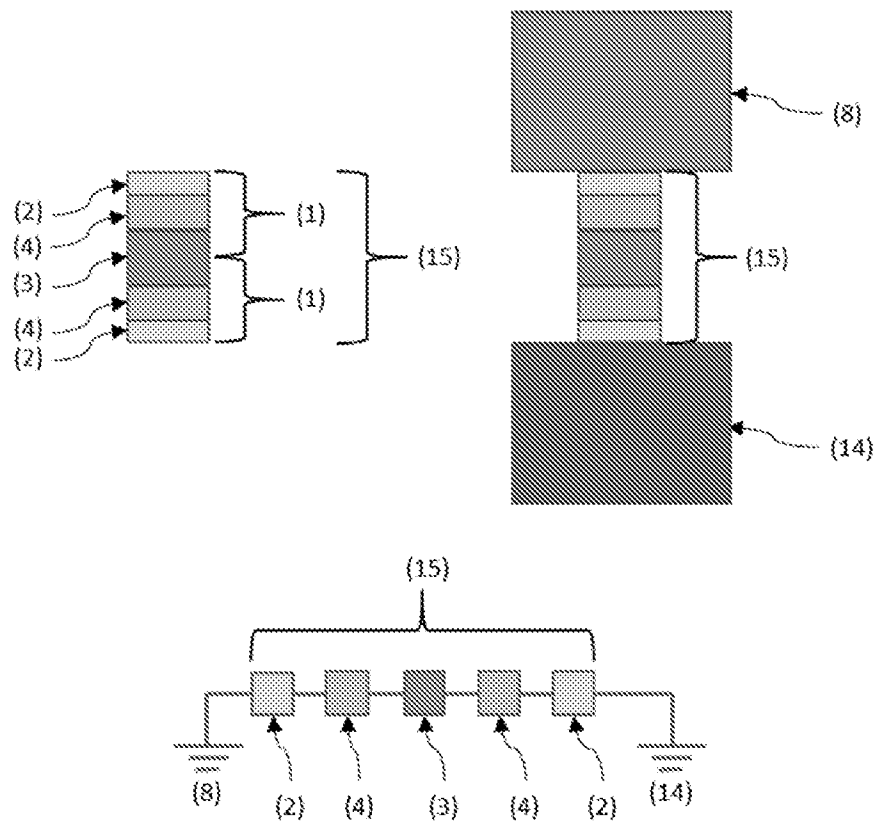


FIGURE 13

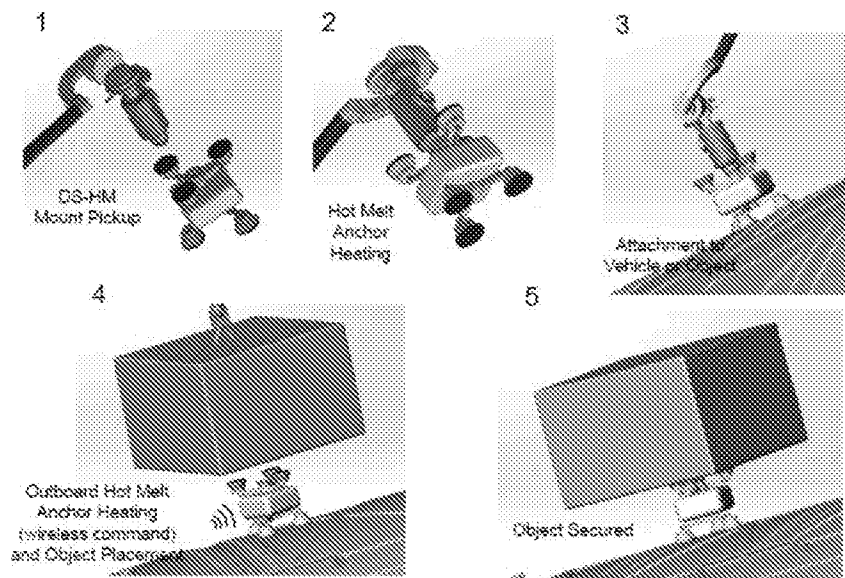


FIGURE 14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/042526

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B29B 13/02; C08L 101/00; H05B 3/22 (2018.01)

CPC - B29B 13/022; B29B 13/02; B29K 2105/0097; C08L 101/00; H05B 3/22 (2018.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 222/146.5 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,691,567 A (LO et al) 25 November 1997 (25.11.1997) entire document	1-4, 10-12, 14-20
Y	EP 0 629 674 A1 (THE KENDALL COMPANY) 21 December 1994 (21.12.1994) entire document	1-4, 10-12, 14-20
Y	US 2015/0306817 A1 (WOODWELDING AG) 29 October 2015 (29.10.2015) entire document	2, 3, 18
Y	US 2016/0249413 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 25 August 2016 (25.08.2016) entire document	4
Y	US 2006/0182887 A1 (MILLER) 17 August 2006 (17.08.2006) entire document	10, 16, 17
Y	US 2004/0011817 A1 (COLANGELO et al) 22 January 2004 (22.01.2004) entire document	11, 12
Y	US 2003/0086673 A1 (ZAH et al) 08 May 2003 (08.05.2003) entire document	14, 15
Y	US 2016/0129822 A1 (TITAN TRAILERS INC) 12 May 2016 (12.05.2016) entire document	17
Y	US 2016/0257394 A1 (THE BOEING COMPANY) 08 September 2016 (08.09.2016) entire document	18
Y	US 2017/0198947 A1 (XERGY INC) 13 July 2017 (13.07.2017) entire document	19
Y	US 2017/0131211 A1 (UNIVERSITY OF WASHINGTON) 11 May 2017 (11.05.2017) entire document	20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

01 November 2018

Date of mailing of the international search report

19 NOV 2018

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2018/042526

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Extra Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-25

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I: Claims 1-25 are drawn to hot melt apparatuses.

Group II: Claims 26-42 are drawn to methods of applying a thermoplastic material to a surface using a hot melt apparatus.

The inventions listed in Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, hot melt apparatuses, are not present in Group II; and the special technical features of Group II, methods of applying a thermoplastic material to a surface using a hot melt apparatus, are not present in Group I.

Groups I and II share the technical features of a method of applying a thermoplastic material to a surface using a hot melt apparatus comprising a structural body (3), a controllable heater (4) connected to the structural body, and a solid form thermoplastic material (2) operatively connected to the structural body (3) and the heater (4), the method comprising: a. bringing the thermoplastic material (2) in its solid form into contact with a surface via mechanical extrusion; b. using the heater to heat the thermoplastic material (2) to a temperature above a melting temperature of the thermoplastic material (2) while maintaining the contact of the thermoplastic material (2) with the surface; c. allowing the heated thermoplastic material (2) to cool to a temperature that is below the thermoplastic material's (2) melting temperature; and d. allowing the heated thermoplastic material (2) to bond the hot melt apparatus (1) to the contacted surface (14) without a solvent when the heated thermoplastic material (2) is cooled to below the thermoplastic material's (2) melting temperature while remaining connected to the structural body (3). However, these shared technical features do not represent a contribution over the prior art.

Specifically, US 5,691,567 A to Lo et al. teach a method of applying a thermoplastic material to a surface using a hot melt apparatus (Abstract, In one embodiment, a layer of thermally conductive, electrically insulating epoxy is formed on a heat sink and the epoxy layer is fully cured. A thermoplastic adhesive layer is formed on the epoxy layer, and the heat sink is clamped to the lead frame such that the thermoplastic layer contacts the lead frame. The thermoplastic layer is heated to its melting point and then cooled, thereby joining the heat sink and the lead frame) comprising a structural body (3) (Col. 4 Lns. 10-28, After epoxy layer 311 is applied to heat sink 104...after epoxy layer 311 has been fully cured, adhesive layer 312 is formed over epoxy layer 311 (FIG. 4b). In the present embodiment, adhesive layer 312 is made of a thermoplastic material...; Col. 4 Lns. 50-59, To connect heat sink 104 to lead frame 108, heat sink 104 is mechanically clamped to lead frame 108, such that thermoplastic adhesive layer 312 contacts lead frame 108; see Fig. 4b at heat sink 104 connected to thermoplastic adhesive layer 312), a controllable heater (4) connected to the structural body (Col. 4 Lns. 50-59, The clamped structure is then heated until thermoplastic adhesive layer 312 melts; as the heater is operable to heat the clamped structure including the heat sink, and heats the structure once clamped, it is at least thermally connected to the structural body, and is controllable), and a solid form thermoplastic material (2) operatively connected to the structural body (3) and the heater (4) (Col. 4 Lns. 10-28; Col. 4 Lns. 50-59, Thermoplastic adhesive layer 312 is then cooled until it returns to its original solid state...; see Fig. 4b at heat sink 104 connected to thermoplastic adhesive layer 312), the method comprising: a. bringing the thermoplastic material (2) in its solid form into contact with a surface (Col. 4 Lns. 10-28; Col. 4 Lns. 50-59, To connect heat sink 104 to lead frame 108, heat sink 104 is mechanically clamped to lead frame 108, such that thermoplastic adhesive layer 312 contacts lead frame 108; see Fig. 3b at thermoplastic adhesive layer 312 contacting lead frame 108); b. using the heater to heat the thermoplastic material (2) to a temperature above a melting temperature of the thermoplastic material (2) while maintaining the contact of the thermoplastic material (2) with the surface (Col. 4 Lns. 10-28; Col. 4 Lns. 50-59, The clamped structure is then heated until thermoplastic adhesive layer 312 melts); c. allowing the heated thermoplastic material (2) to cool to a temperature that is below the thermoplastic material's (2) melting temperature (Col. 4 Lns. 10-28; Col. 4 Lns. 50-59, Thermoplastic adhesive layer 312 is then cooled until it returns to its original solid state, thereby connecting heat sink 104 to lead frame 108); and d. allowing the heated thermoplastic material (2) to bond the hot melt apparatus (1) to the contacted surface (14) without a solvent when the heated thermoplastic material (2) is cooled to below the thermoplastic material's (2) melting temperature while remaining connected to the structural body (3) (Col. 4 Lns. 10-28; Col. 4 Lns. 50-59; see Fig. 3b at thermoplastic adhesive layer 312 connecting heat sink 104 to lead frame 108).

Further, EP 0 629 674 A1 to The Kendall Company teaches bringing a thermoplastic material in its solid form into contact with a surface via mechanical extrusion (Pg. 3 Lns. 53-58, ...the primer tape may be prepared by first extruding the tape adhesive layer onto the tape backing. The solid primer may be coated, e.g. by extrusion, onto a release sheet. Thereafter, a roll of the tape containing the adhesive layer and a roll of the release sheet containing the solid primer may be fed in superposition between one or more pairs of superposed pressure rollers spaced apart at the requisite gap to provide sufficient pressure to adhere the free surface of the adhesive layer to the free surface of the solid primer, thereby providing a laminar pipewrap having a release sheet on its outer surface).

The inventions listed in Groups I and II therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.