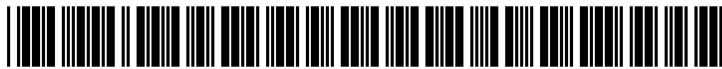

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(54) **SYSTEMS, METHODS, AND APPARATUSES FOR THERMAL MANAGEMENT OF ULTRASOUND TRANSDUCERS**

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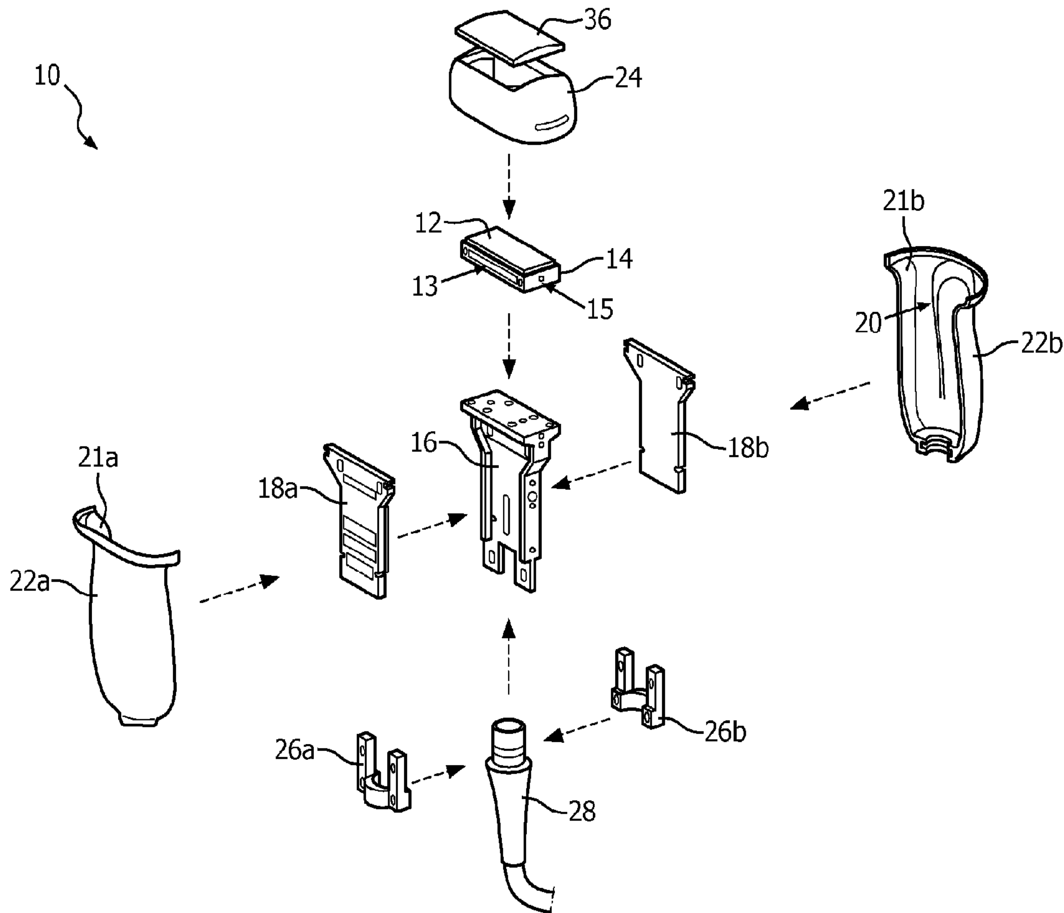
(57) **ABSTRACT**

Systems, methods, and apparatuses for dissipating heat from an ultrasound transducer are disclosed. A passive thermal management system including thermally conductive materials is disclosed. The passive thermal management system may include thermally conductive layers in a flexible circuit coupled to the transducer stack. The flexible circuit may be coupled to a thermally conductive bolster plate. The bolster plate may be coupled to a handle heat spreader that may be coupled to the interior surface of an ultrasound probe housing.



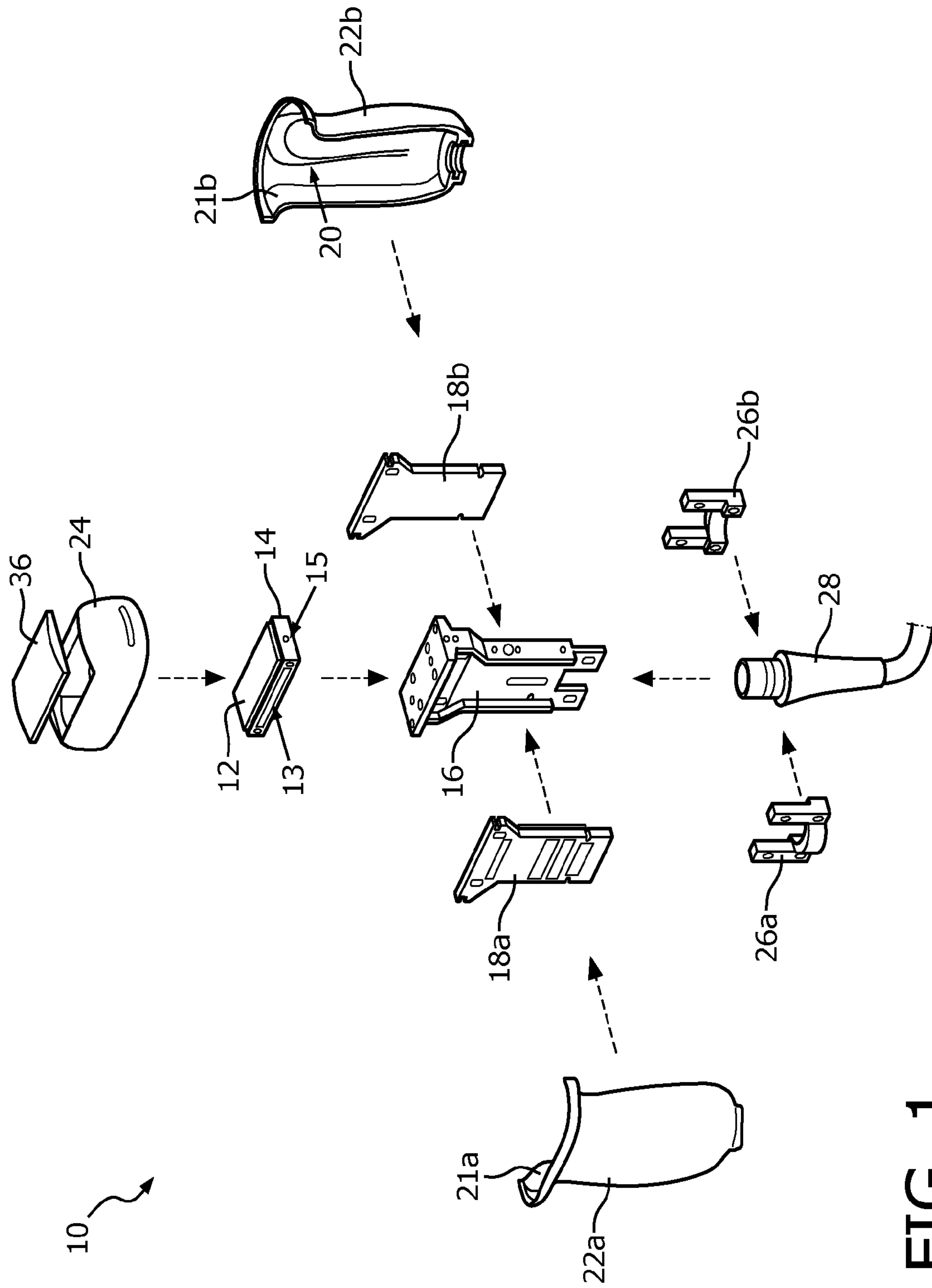


FIG. 1

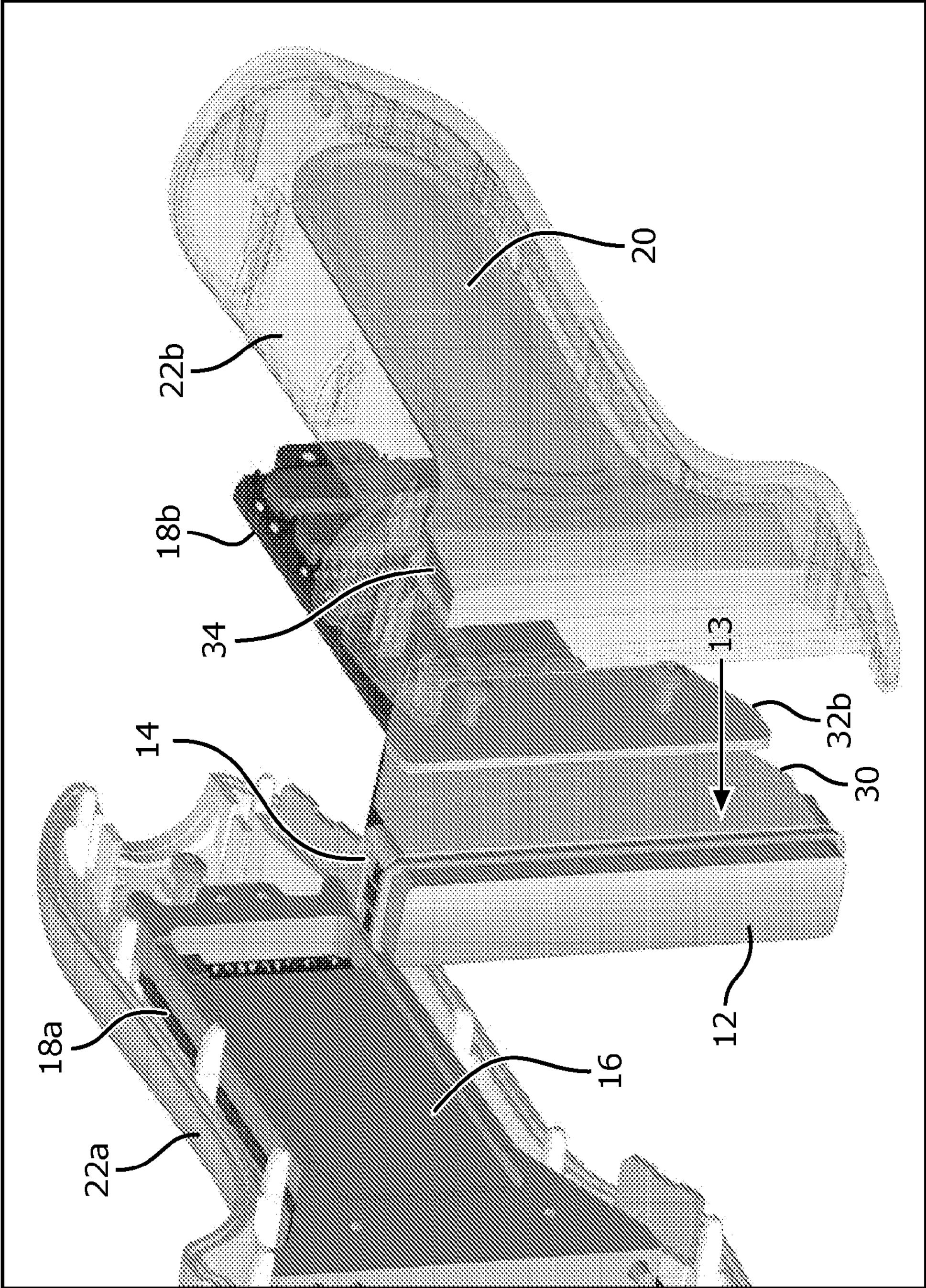


FIG. 2

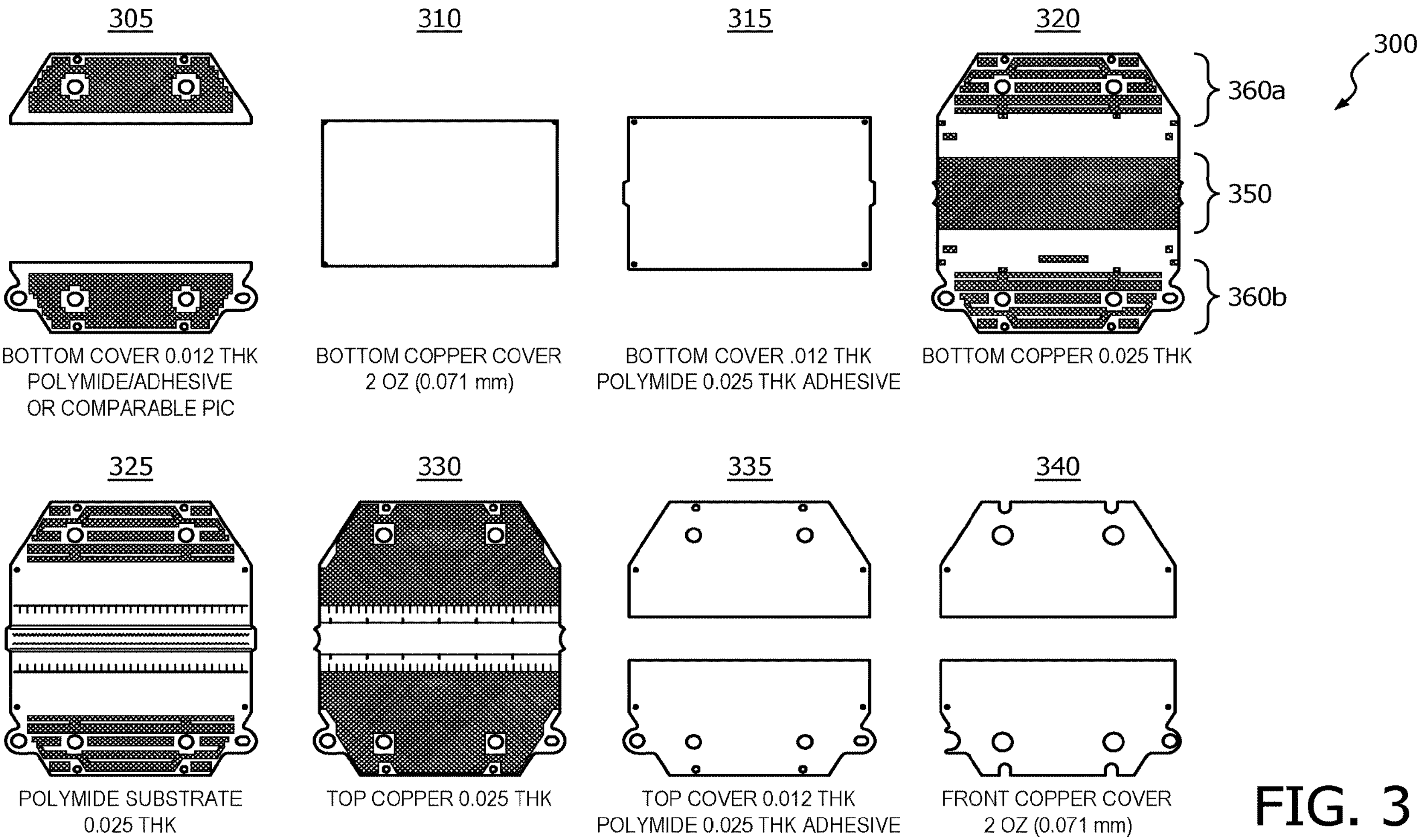


FIG. 3

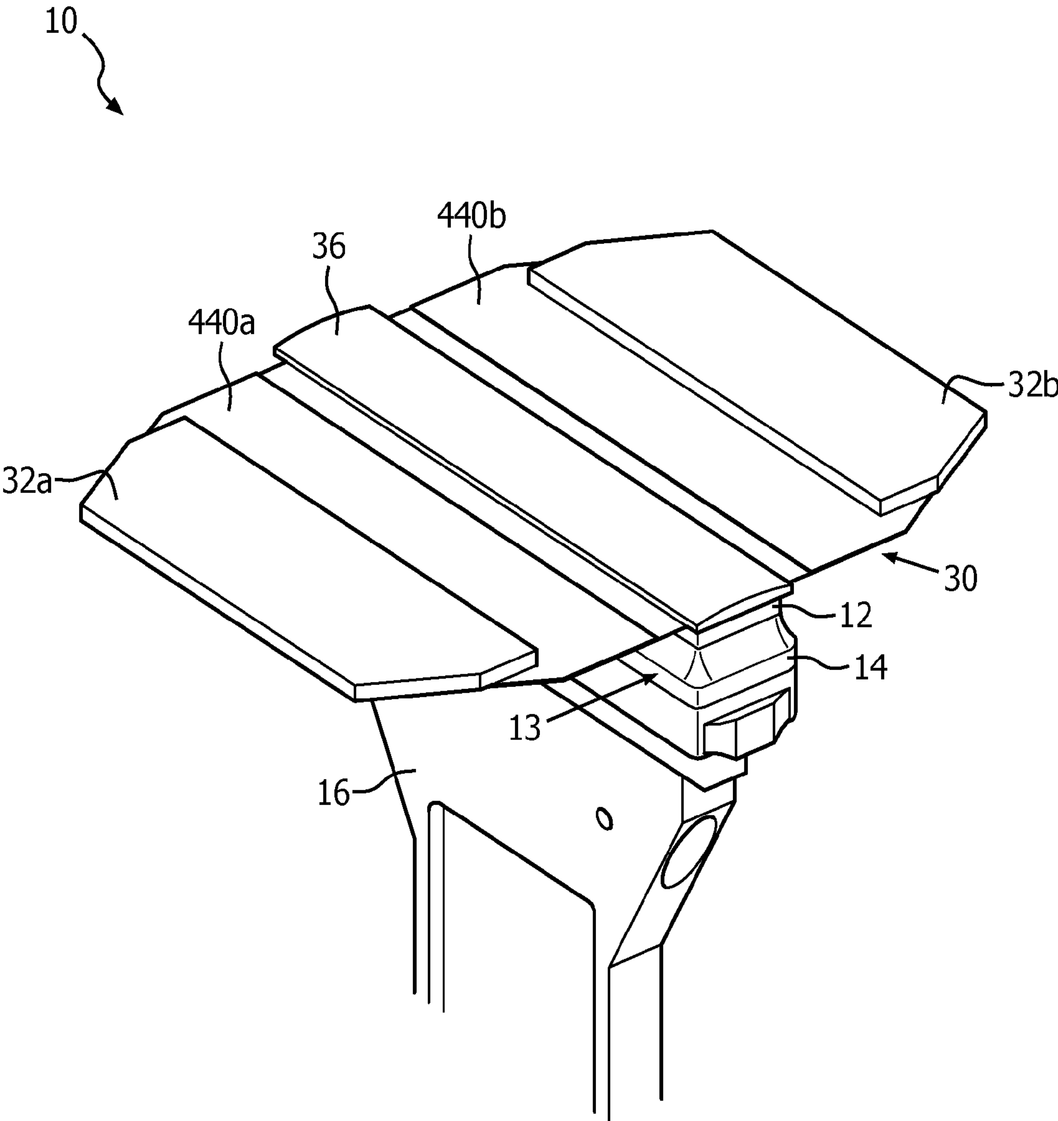


FIG. 4

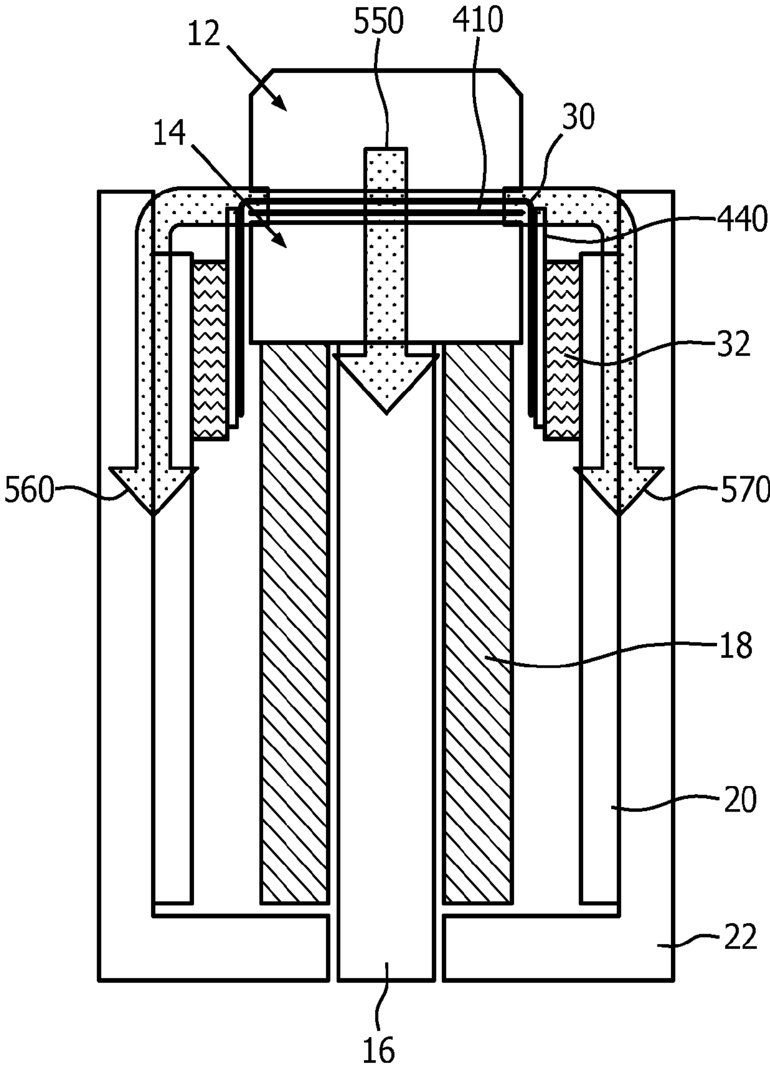


FIG. 5

SYSTEMS, METHODS, AND APPARATUSES FOR THERMAL MANAGEMENT OF ULTRASOUND TRANSDUCERS

BACKGROUND

[0001] Ultrasound transducer arrays produce ultrasound waves for a variety of applications such as imaging, cleaning, and therapeutic treatment of tissue. Many ultrasound transducers convert electrical energy into ultrasound waves, and heat may be produced as a byproduct of the conversion. The heat may require dissipation to avoid damaging the transducer and/or a surface with which the ultrasound transducer is in contact. For example, a medical ultrasound transducer may burn the skin of a patient if heat produced by the transducer is not dissipated adequately.

[0002] Ultrasound transducers may have active and/or passively thermal management systems. Passive systems may include materials that draw heat away from the transducer. For example, an ultrasound probe may include a backing material below the transducer that may dissipate heat away from the transducer surface. However, current passive thermal management systems may not be adequate for new, higher power ultrasound applications such as shear wave imaging. Active thermal management systems may include, for example, circulating liquid coolants and/or spinning fans adjacent to the transducer array. While active thermal management systems may be capable of dissipating more heat than passive systems, active systems may increase the size, cost, and power consumption of the ultrasound system.

SUMMARY

[0003] An example ultrasound probe according to an embodiment of the disclosure may include a transducer stack, a backing block including a first surface, a second surface opposite the first surface, and a side extending between the first and second surfaces, and a flexible circuit, the flexible circuit may include: a central portion disposed between the transducer stack and the backing block, a wing portion coupled to the central portion, the wing portion may be configured to fold adjacent to the side of the backing block, a first heat cover disposed below the central portion and adjacent to the first surface of the backing block wherein the first heat cover may be configured to dissipate heat from the transducer stack, and a second heat cover disposed over the wing portion, wherein the second heat cover may be configured to dissipate heat from the transducer stack. The ultrasound probe may further include a bolster plate in thermal contact with the second heat cover, and a handle heat spreader in thermal contact with the bolster plate, wherein the handle heat spreader may be configured to dissipate heat from the bolster plate.

[0004] An example thermal management system according to an embodiment of the disclosure may include a top heat cover that may be configured to be applied to an upper surface of a flexible circuit, wherein the top heat cover may be configured to dissipate heat from a transducer stack, a bolster plate in thermal contact with the top heat cover, and a handle heat spreader in thermal contact with the bolster plate, wherein the handle heat spreader may be configured to dissipate heat from the bolster plate, the handle heat spreader further may be configured to conform to an interior surface of a probe housing, the probe housing may be configured to at least partially enclose the thermal management system.

[0005] An example ultrasound probe according to an embodiment of the disclosure may include a transducer stack, and a flexible circuit, including: a central portion disposed below the transducer stack, wing portions extending from parallel sides of the central portion, a first heat cover on the central portion, wherein the first heat cover may be configured to dissipate heat from the transducer stack, a first non-conductive layer on the wing portions, the first non-conductive layer coupled to two parallel sides of the first heat cover, a second non-conductive layer over the first heat cover, a first conductive trace layer over the first and second non-conductive layers, a non-conductive substrate over the first conductive trace layer, a second conductive trace layer over the first non-conductive substrate, a non-conductive top cover over the second conductive trace layer on the wing portions, and a second heat cover over at least a portion of the non-conductive top cover, wherein the second heat cover may be configured to dissipate heat from the first heat cover. The ultrasound probe may further include a handle heat spreader in thermal contact with the second heat cover, wherein the handle heat spreader may be configured to dissipate heat from the second heat cover.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a schematic illustration of an exploded view of an ultrasound probe according to an embodiment of the disclosure.

[0007] FIG. **2** is a schematic illustration of an additional exploded view of the ultrasound probe shown in FIG. **1** according to an embodiment of the disclosure.

[0008] FIG. **3** is a schematic illustration of layers in a flexible circuit including thermal management system components according to an embodiment of the disclosure.

[0009] FIG. **4** is a schematic illustration of a portion of the ultrasound probe shown in FIG. **1** according to an embodiment of the disclosure.

[0010] FIG. **5** is a schematic illustration of a side-view of the ultrasound probe shown in FIG. **1** according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0011] The following description of certain exemplary embodiments is merely exemplary in nature and is in no way intended to limit the invention or its applications or uses. In the following detailed description of embodiments of the present systems and methods, reference is made to the accompanying drawings which form a part hereof, and in which are shown by way of illustration specific embodiments in which the described systems and methods may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the presently disclosed systems and methods, and it is to be understood that other embodiments may be utilized and that structural and logical changes may be made without departing from the spirit and scope of the present system.

[0012] The following detailed description is therefore not to be taken in a limiting sense, and the scope of the present system is defined only by the appended claims. The leading digit(s) of the reference numbers in the figures herein typically correspond to the figure number, with the exception that identical components which appear in multiple

figures are identified by the same reference numbers. Moreover, for the purpose of clarity, detailed descriptions of certain features will not be discussed when they would be apparent to those with skill in the art so as not to obscure the description of the present system.

[0013] An ultrasound probe may be used for imaging, medical therapy, or other applications. The ultrasound probe includes an ultrasound transducer to produce and receive ultrasound signals (e.g., waves, pulses, sequences). The transducer may generate heat as it produces and/or receives ultrasound signals. If the temperature of the transducer increases above a threshold temperature, the transducer and/or an object in contact with the transducer may be damaged.

[0014] To manage the increase in temperature of the transducer, the probe may include components to passively dissipate the heat generated by the transducer. The components may include thermally conductive materials in thermal contact with the transducer and may dissipate heat from the transducer through multiple thermal paths. The components may be coupled to one another and/or positioned parallel relative to each other in the probe. Some of the components may be layers and/or films of thermally conductive materials that may dissipate heat without requiring an increase in probe size and/or increasing the weight of the probe such that it becomes difficult for a user to manipulate. The components may dissipate the heat over a wide area. This may prevent the occurrence of "hot spots," that is, localized sections of the ultrasound probe that have a greater temperature than the surrounding probe. Hot spots may damage other portions of the ultrasound probe and/or make the ultrasound probe uncomfortable or dangerous to handle by a user. The components for dissipating heat from the transducer may be referred to generally as a thermal management system.

[0015] FIG. **1** is a schematic illustration of an exploded view of an ultrasound probe **10** according to an embodiment of the disclosure. The ultrasound probe **10** may include a housing **22** which may form the handle portion of the probe that is held by a sonographer during use. The distal end of the probe **10** may be enclosed by a nosepiece housing **24**. Behind a lens **36** covering the distal end is a transducer stack **12**. The transducer stack **12** may be a matrix array transducer or another transducer type. The transducer stack **12** may include a flexible circuit and portions of a thermal management system (not shown in FIG. **1**). Behind the transducer stack **12** may be a backing block **14** which may attenuate acoustic reverberations from the back of the transducer array and may conduct heat developed in the transducer stack **12** away from the distal end of the probe. The backing block **14** may include graphite in some embodiments. The backing block **14** may include two parallel sides **13** and two parallel sides **15**. The sides **13** and sides **15** may be perpendicular to each other. In some embodiments, the sides **13** and sides **15** may be the same length.

[0016] A probe frame **16** may be in thermal contact with the back of the backing block **14** and may conduct heat further away from the distal end of the probe **10**. The probe frame **16** may be implemented using aluminum, magnesium, steel, and/or a combination of materials. The frame **16** may be used as a mount for electrical components of the probe **10**. For example, the electrical components may be mounted on printed circuit boards (PCB) **18***a-b*, which may be mounted to the frame **16**. Although FIG. **1** shows two PCB's **18***a-b*, one PCB or more than two PCB's may be included in some embodiments. The PCBs **18***a-b* may be coupled to the flexible circuit of the transducer stack **12**.

[0017] At the back of the probe **10** and extending from the proximal end of the probe **10** may be a cable **28**. In some embodiments, the cable **28** may be clamped to the rear of the frame **16** by a clamp **26***a-b*. Other attachment methods may also be used. The cable **28** may couple the probe **10** to an ultrasound imaging system (not shown). In some embodiments, the cable **28** may include a metal braid (not shown), which may be in thermal contact with the frame **16**. The metal braid may conduct heat from the frame **16** along the cable **28**. The frame **16**, circuit boards **18***a-b*, and/or other internal components of the probe **10** may be enclosed in the housing **22**. The housing **22** may include two separate portions **22***a-b* that may be configured to fit together with each other and with the nose housing **24** to form an impervious housing to protect the ultrasound components from electromagnetic field interference, liquids, and/or debris. The housing **22** may comprise plastic, metal, rubber, and/or a combination of materials. In some embodiments, the nose housing **24** may be omitted, and the housing **22** may be configured to enclose the transducer stack **12** and backing block **14**.

[0018] The housing **22** may include a handle heat spreader **20** on the interior surface **21***a-b* of each portion of the housing **22***a-b* (Only one handle heat spreader **20** is visible in FIG. **1**). The handle heat spreader **20** may be a component of a probe thermal management system. The handle heat spreader **20** may include a copper layer. Other metals and/or thermally conducting materials may also be used. The handle heat spreader **20** may be coupled to the housing **22** by an adhesive or another attachment method may be used. The handle heat spreader **20** may conform to the interior surface **21***a-b* of the housing **22***a-b*. The handle heat spreader **20** may be coupled to one or more other components of the thermal management system included in the transducer stack **12**.

[0019] FIG. **2** is a schematic illustration of an additional exploded view of the ultrasound probe **10** according to an embodiment of the disclosure. Certain elements illustrated in FIG. **1** are omitted from FIG. **2** for clarity. Housing portion **22***b* is shown as translucent FIG. **2** to provide a view of the handle heat spreader **20** on the interior surface of the housing portion **22***b*. However, it will be appreciated that the housing portions **22***a-b* may actually be opaque. Although the frame **16** is illustrated to the side of the transducer stack **12** and backing block **14** in FIG. **2**, when assembled, the frame **16** may be in line with the transducer stack **12** and backing block **14** as illustrated in FIG. **1**. A flexible circuit **30**, as mentioned in reference to FIG. **1**, may be included in the transducer stack **12**. The flexible circuit **30** may be positioned between the transducer stack **12** and the backing block **14**. In some embodiments, the flexible circuit **30** may be a layer within the transducer stack **12**. The flexible circuit **30** may be able to bend, fold and/or twist. This may allow the flexible circuit **30** to curve around another component and/or conform to a surface. The degree of flexibility of the flexible circuit **30** may be determined, at least in part, by materials chosen for the flexible circuit **30** (e.g., films, conductive elements, circuit components). The flexible circuit **30** may include an insulating polymer film with conductive elements (e.g., wires) applied on one surface. A second insulating polymer film may be applied over the

conductive elements and first polymer film. The conductive elements may be made of metals, conductive polymers, or other conductive materials. Some flexible circuits may include multiple alternating layers of elements and insulating film.

[0020] The flexible circuit **30** may extend beyond the transducer stack **12** and/or the backing block **14**, and be configured to fold down on either long side **13** of the backing block **14** and extend to the printed circuit boards (PCB) **18***a-b*. The flexible circuit **30** may be coupled to the PCBs **18***a-b*. The PCBs **18***a-b* may provide power and control signals to the transducer stack **12** through the flexible circuit **30**. The PCBs **18***a-b* may also receive signals from the transducer stack **12** through the flexible circuit **30**. In some embodiments, a portion of the flexible circuit **30** may be in contact with and/or coupled to the handle heat spreader **20**. Heat from the flexible circuit **30** may be conducted to the handle heat spreader **20**, which may dissipate the heat through the housing **22**.

[0021] In some embodiments, for example the embodiment illustrated in FIG. **2**, bolster plates **32***a-b* may be coupled to the top layer of the flexible circuit **30** on each side of the frame **16** (only one bolster plate **32***b* is visible in FIG. **2**). The bolster plates **32***a-b* may be secured to the flexible circuit **30** with screws, adhesive, and/or other coupling methods. The bolster plates **32***a-b* may include copper, aluminum, and/or other thermally conducting materials. The bolster plates **32***a-b* may be components of the thermal management system of the probe **10**. The bolster plates **32***a-b* may thermally couple one or more thermal management system components on the flexible circuit **30** to the handle heat spreader **20**. This may allow heat transferred from the transducer stack **12** to the flexible circuit **30** to be dissipated to the handle of the probe **10**. The heat may then dissipate into the air surrounding the probe **10**. Heat from the transducer stack **12** may also be transferred to the backing block **14** to the frame **16** as previously described. This may provide three thermal paths rather than a single thermal path to dissipate heat from the transducer stack **12**: (1) through the frame **16** and (2-3) the handle heat spreaders **20** on each side of the housing **22***a-b*. As a result, more heat may be dissipated from the transducer stack **12** and/or increase the heat dissipation rate.

[0022] In some embodiments, a compressible block **34** may be included in the heat spreader **20** opposite the bolster plate **32***b*. The compressible block **34** may be coupled between the housing **22** and the handle heat spreader **20**. In some embodiments, the compressible block **34** may be coupled to a portion of the handle heat spreader **20**, and a length of the handle heat spreader **20** may be wrapped around the compressible block **34** as illustrated in FIG. **2**. Other configurations may also be possible. The compressible block **34** may urge the handle heat spreader **20** in contact with the bolster plate **32** and/or flexible circuit **30** when the probe **10** is assembled. The compressible block **34** may increase thermal contact between the bolster plate **32***b* and/or flexible circuit **30** and the heat spreader **20**. A second compressible block similar to compressible block **34** may be included in the handle heat spreader **20** opposite the bolster plate **32***a* (not shown in FIG. **2**). In some embodiments, the compressible block **34** may be implemented with a polymer foam.

[0023] In some embodiments, a portion of the handle heat spreader **20** urged against the bolster plates **32***a-b* may be coated with a laminate (not shown) that may reduce thermal resistance. Alternatively, the bolster plates **32***a-b* may be coated with the laminate on a surface adjacent to the handle heat spreader **20**. The laminate may improve heat transfer from the bolster plates **32***a-b* to the handle heat spreader **20**. An example of a possible laminate is Therm-a-Gap™ G974 available from Parker Chomerics. Other laminates that reduce thermal resistance may also be used.

[0024] FIG. **3** is a schematic illustration of layers in a flexible circuit **300** including thermal management system components according to an embodiment of the disclosure. The flexible circuit **300** may be used to implement flexible circuit **30** illustrated in FIG. **2** in some embodiments. The flexible circuit **300** may include a central portion **350** that may be placed over the upper surface of a backing block, for example backing block **14** shown in FIG. **2**. The flexible circuit **300** may include wing portions **360***a-b* on either side of the central portion **350**. The wing portions **360***a-b* may be configured to fold over the edges of the upper surface of the backing block. A first layer may be a non-conductive layer **305**. The first non-conductive layer **305** may be included in the wing portions **360***a-b* and coupled to either side of a bottom heat cover **310**. The bottom heat cover **310** may be included in the central portion **350**. The bottom heat cover **310** may be a component of a thermal management system to dissipate heat from a transducer stack. The bottom heat cover **310** may be covered by a second non-conductive layer **315**. A first conductive trace layer **320** may be applied over the second non-conductive layer **315**. The first conductive trace layer **320** may provide electrical connections for elements of the transducer stack and/or other electrical components of an ultrasound probe. A non-conductive substrate **325** may be placed over the first conductive trace layer **320**. A second conductive trace layer **330** may be applied over the substrate **325**. All or portions of the second conductive trace layer **330** may be insulated from the first conductive trace layer **320**. A non-conductive top cover **335** may be placed over the second conductive trace layer **330**. A top heat cover **340** may be applied over the top cover **335**. The top heat cover **340** may cover the wing portions **360***a-b* of flexible circuit **300** that extends from the vertical sides of the backing block. In some embodiments, the wing portions **360***a-b* may extend to one or more printed circuit boards (PCB), for example, PCBs **18***a-b* shown in FIG. **2**. In some embodiments, the top heat cover **340** may at least partially cover the central portion **350** flexible circuit **300** that covers the upper surface of the backing block. That is, when a transducer stack is placed on the flexible circuit **300**, a portion of the top heat cover **340** may be covered by the transducer stack. The top heat cover **340** may be another component of the thermal management system to dissipate heat from the transducer stack. The top heat cover **340** may be in thermal contact with one or more bolster plates, for example, the bolster plate **32***b* illustrated in FIG. **2**. In some embodiments, the top heat cover **340** may be in thermal contact with a handle heat spreader, for example, the handle heat spreader **20** illustrated in FIG. **2**. The top heat cover **340** may conduct heat from the flexible circuit **300**, including the bottom heat cover **310**, to the one or more bolster plates and/or handle heat spreader.

[0025] The top and bottom heat covers **340**, **310** may be implemented with copper layers in some embodiments. Other thermally conducting materials may be used. The bottom heat cover **310** may reduce thermal resistance

between the flexible circuit **300** and the backing block, which may increase heat dissipation from a transducer through the flexible circuit **300** to the backing block. In some embodiments, the bottom heat cover **310** may be omitted. The top heat cover **340** may conduct heat from the transducer stack to the bolster plates and/or the handle heat spreader. The top heat cover **340** may conduct heat from the bottom heat cover **310** and/or the backing block through the flexible circuit **300** to the bolster plates.

[0026] Although two conductive trace layers and four non-conductive layers are illustrated in flexible circuit **300**, a flexible circuit may have more or fewer conductive trace and/or non-conductive layers. In some embodiments, the conductive trace layers include copper traces. In some embodiments, the non-conductive layers include polyimide and/or polyimide/adhesive composites.

[0027] FIG. **4** is a schematic illustration of a portion of the ultrasound probe **10** according to an embodiment of the disclosure. The transducer stack **12** with the lens **36** on top is placed on top of the flexible circuit **30** in line with the backing block **14**, which is coupled to the frame **16**. As shown in FIG. **4**, the flexible circuit **30** has not yet been folded down over the sides **13** of the backing block **14**. Two portions of a top heat cover **440***a-b* are located on each end of the flexible circuit **30**. The heat cover **440** may be similar to heat cover **340** illustrated in FIG. **3**. Two bolster plates **32***a-b* are each placed on respective portions of the top heat cover **440***a-b*. However, in some embodiments, the bolster plates **32***a-b* may not be coupled to the top heat cover **440***a-b* until after the flexible circuit **30** is folded over the backing block **14** and secured to PCBs (not shown in FIG. **4**) on either side of the frame **16**. In some embodiments, the bolster plates **32***a-b* may be omitted.

[0028] FIG. **5** is a schematic illustration of a side-view of the ultrasound probe **10** according to an embodiment of the disclosure. Three heat paths are indicated by the arrows **550**, **560**, **570**. Heat may be generated by an ultrasound transducer in the transducer stack **12**. As indicated by arrow **550**, the heat may dissipate through the transducer stack **12** through the flexible circuit **30**, through the bottom heat cover **410** of the flexible circuit **30**, and into the backing block **14**. From the backing block **14**, the heat may be conducted into the probe frame **16** through the central portion of the probe **10**, as shown by arrow **550**. As indicated by arrows **560**, **570**, heat may dissipate through the transducer stack **12** through the top heat cover **440** of the flexible circuit **30** to bolster plates **32**. The heat may be dissipated from the bolster plates **32** into the handle heat spreaders **20**, which may dissipate the heat along the probe housing **22** as shown by arrows **560**, **570**. Although not indicated by an arrow, some heat may be dissipated from the sides of the backing block **14** to the flexible circuit **30**, which may dissipate the heat to the bolster plates **32** via the top heat cover **440**. As illustrated in FIG. **5**, three heat paths may dissipate heat from the transducer stack **12**. In some embodiments, only one of the heat paths indicated by arrows **560**, **570** may be present. Additional heat paths and/or alternative heat paths to those indicated by arrows **560**, **570** may be configured within the probe **10** in some embodiments. For example, additional bolster plates may be coupled to the backing block on sides adjacent to the sides the flexible circuit **30** may cover. The additional bolster plates may couple to additional handle heat spreaders and/or different sections of the handle heat spreaders **20**. In another example, the bolster plates **32** may be omitted, and heat may be dissipated through the top heat cover **440** of the flexible circuit **30** to the handle heat spreaders **20**.

[0029] The thermal management system of the ultrasound probe may be a passive thermal management system. This may reduce cost, size, and weight requirements of the probe compared to an active thermal management system. The thermal management system may include top and bottom heat covers in the flexible circuit, bolster plates coupled to the flexible circuit, and handle heat spreaders located in the ultrasound probe housing in thermal contact within the bolster plates. The thermal management system may improve dissipation of heat from a transducer stack of the probe compared to when only a backing block and probe frame coupled to the backing block are used to dissipate heat from the ultrasound probe. This may allow the transducer stack to use higher energy ultrasound waves, pulses, and/or sequences. The thermal management system may allow the transducer stack to produce higher frequency ultrasound waves, pulses, and/or sequences, which may allow the ultrasound probe to be used for a wider range of imaging and/or therapeutic techniques.

[0030] Although the present system has been described with reference to an ultrasound imaging system, the present system may be extended to other ultrasound transducers. Additionally, the present system may be used to obtain and/or record image information related to, but not limited to renal, testicular, prostate, breast, ovarian, uterine, thyroid, hepatic, lung, musculoskeletal, splenic, nervous, cardiac, arterial and vascular systems, as well as other imaging applications related to ultrasound-guided interventions and other interventions which may be guided by real-time medical imaging. Further, the present system may also include one or more elements which may be used with non-ultrasound imaging systems with or without real-time imaging components so that they may provide features and advantages of the present system.

[0031] Further, the present methods, systems, and apparatuses may be applied to existing imaging systems such as, for example, ultrasonic imaging systems. Suitable ultrasonic imaging systems may include a Philips® ultrasound system which may, for example, support a conventional broadband linear array transducer that may be suitable for small-parts imaging.

[0032] Certain additional advantages and features of this invention may be apparent to those skilled in the art upon studying the disclosure, or may be experienced by persons employing the novel system and method of the present invention, chief of which is thermal dissipation in ultrasound transducers and method of operation thereof is provided. Another advantage of the present systems and method is that conventional medical image systems may be easily upgraded to incorporate the features and advantages of the present systems, devices, and methods.

[0033] Of course, it is to be appreciated that any one of the above embodiments or processes may be combined with one or more other embodiments and/or processes or be separated and/or performed amongst separate devices or device portions in accordance with the present systems, devices and methods.

[0034] Finally, the above-discussion is intended to be merely illustrative of the present system and should not be construed as limiting the appended claims to any particular embodiment or group of embodiments. Thus, while the

present system has been described in particular detail with reference to exemplary embodiments, it should also be appreciated that numerous modifications and alternative embodiments may be devised by those having ordinary skill in the art without departing from the broader and intended spirit and scope of the present system as set forth in the claims that follow. Accordingly, the specification and drawings are to be regarded in an illustrative manner and are not intended to limit the scope of the appended claims.

What is claimed is:

1. An ultrasound probe, comprising:

a transducer stack;

a backing block including a first surface, a second surface opposite the first surface, and a side extending between the first and second surfaces;

a flexible circuit, the flexible circuit including:

a central portion disposed between the transducer stack and the backing block;

a wing portion coupled to the central portion, the wing portion configured to fold adjacent to the side of the backing block;

a first heat cover disposed below the central portion and adjacent to the first surface of the backing block wherein the first heat cover is configured to dissipate heat from the transducer stack; and

a second heat cover disposed over the wing portion, wherein the second heat cover is configured to dissipate heat from the transducer stack;

a bolster plate in thermal contact with the second heat cover; and

a handle heat spreader in thermal contact with the bolster plate, wherein the handle heat spreader is configured to dissipate heat from the bolster plate.

2. The ultrasound probe of claim **1**, further comprising a probe housing configured to at least partially enclose the transducer stack, backing block, flexible circuit, bolster plate, and handle heat spreader.

3. The ultrasound probe of claim **2**, wherein the handle heat spreader is coupled to an interior surface of the probe housing.

4. The ultrasound probe of claim **3**, further comprising a compressible block disposed between a portion of the handle heat spreader and the interior surface of the probe housing, wherein the compressible block is configured to urge the handle heat spreader against the bolster plate.

5. The ultrasound probe of claim **1**, further comprising a laminate disposed between the bolster plate and the handle heat spreader, wherein the laminate is configured to reduce thermal resistance between the bolster plate and the handle heat spreader.

6. The ultrasound probe of claim **1**, wherein the first and second heat covers comprise copper.

7. The ultrasound probe of claim **1**, further comprising a probe frame coupled to the second surface of the backing block.

8. The ultrasound probe of claim **7**, further comprising a printed circuit board coupled to the probe frame and the flexible circuit.

9. The ultrasound probe of claim **1**, wherein the handle heat spreader comprises copper.

10-16. (canceled)

17. The ultrasound probe of claim **1**, wherein the flexible circuit further comprises:

a first non-conductive layer on the wing portion, the first non-conductive layer coupled to two parallel sides of the first heat cover;

a second non-conductive layer over the first heat cover; and

a first conductive trace layer over the first and second non-conductive layers; a non-conductive substrate over the first conductive trace layer; a second conductive trace layer over the first non-conductive substrate; a non-conductive top cover over the second conductive trace layer on the wing portion.

18. The ultrasound probe of claim **17**, wherein the first and second heat covers of the flexible circuit comprise copper.

19. The ultrasound probe of claim **17**, wherein the first and second conductive trace layers of the flexible circuit comprise copper.

20. The ultrasound probe of claim **17**, wherein the first and second conductive trace layers of the flexible circuit are at least partially electrically insulated from each other.

21. The ultrasound probe of claim **17**, wherein the first and second non-conductive layers, non-conductive substrate, and non-conductive top cover of the flexible circuit comprise polyimide.

22. The ultrasound probe of claim **1**, wherein the backing block comprises graphite.

* * * * *

patsnap

专利名称(译)	用于超声换能器的热管理的系统，方法和设备		
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摘要(译)

公开了用于从超声换能器散热的系统，方法和设备。公开了一种包括导热材料的被动热管理系统。被动热管理系统可以包括耦合到换能器叠层的柔性电路中的导热层。柔性电路可以耦合到导热垫板。垫板可以连接到手柄散热器，手柄散热器可以耦合到超声探头外壳的内表面。