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(54) SYSTEMS, METHODS, AND APPARATUSES FOR FLUID INGRESS DETECTION FOR ULTRASOUND TRANSDUCERS

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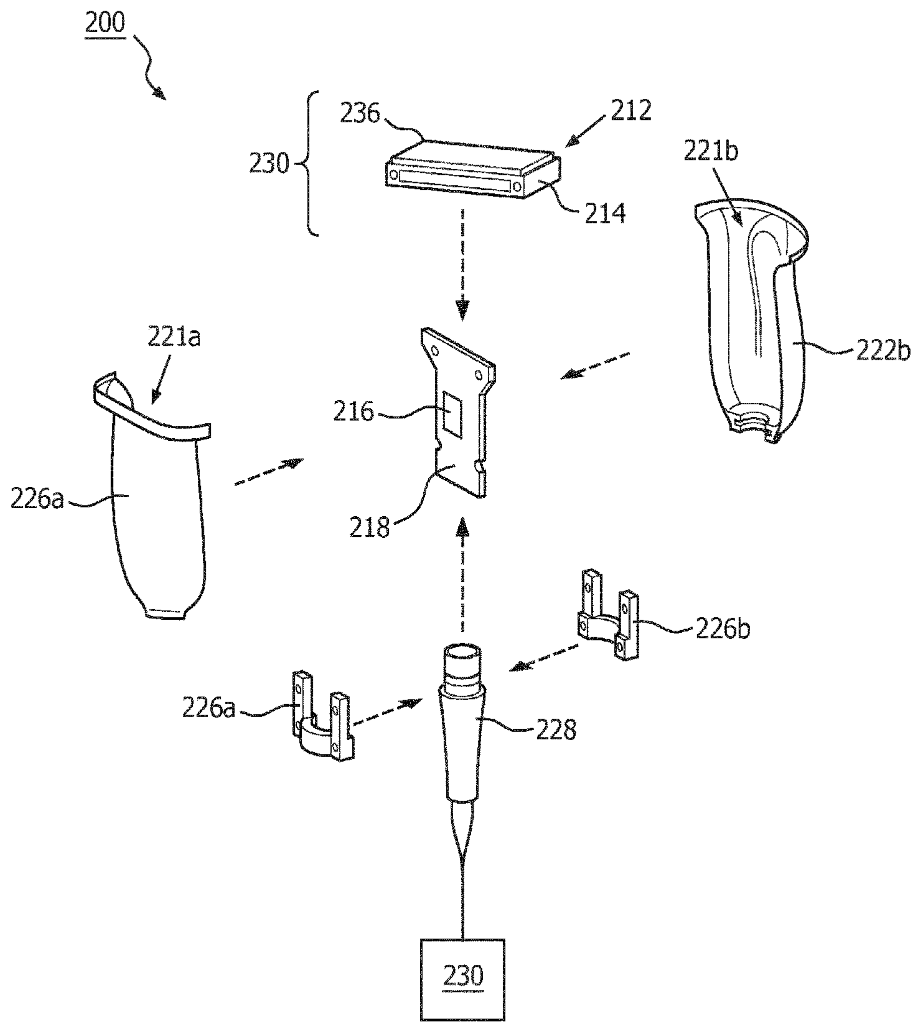
(57) **ABSTRACT**

Systems, methods, and apparatuses for detecting fluid ingress in ultrasound probes are disclosed. A fluid ingress may be detected by a change in resistance, capacitance, and/or current of a fluid ingress detector of a fluid ingress detection assembly. A fluid ingress detector that includes a soluble material is disclosed. A fluid ingress detector that includes a galvanic sensor is disclosed. The fluid ingress detector may provide a signal indicating a fluid ingress to an ultrasound imaging system and/or a maintenance diagnostic system.



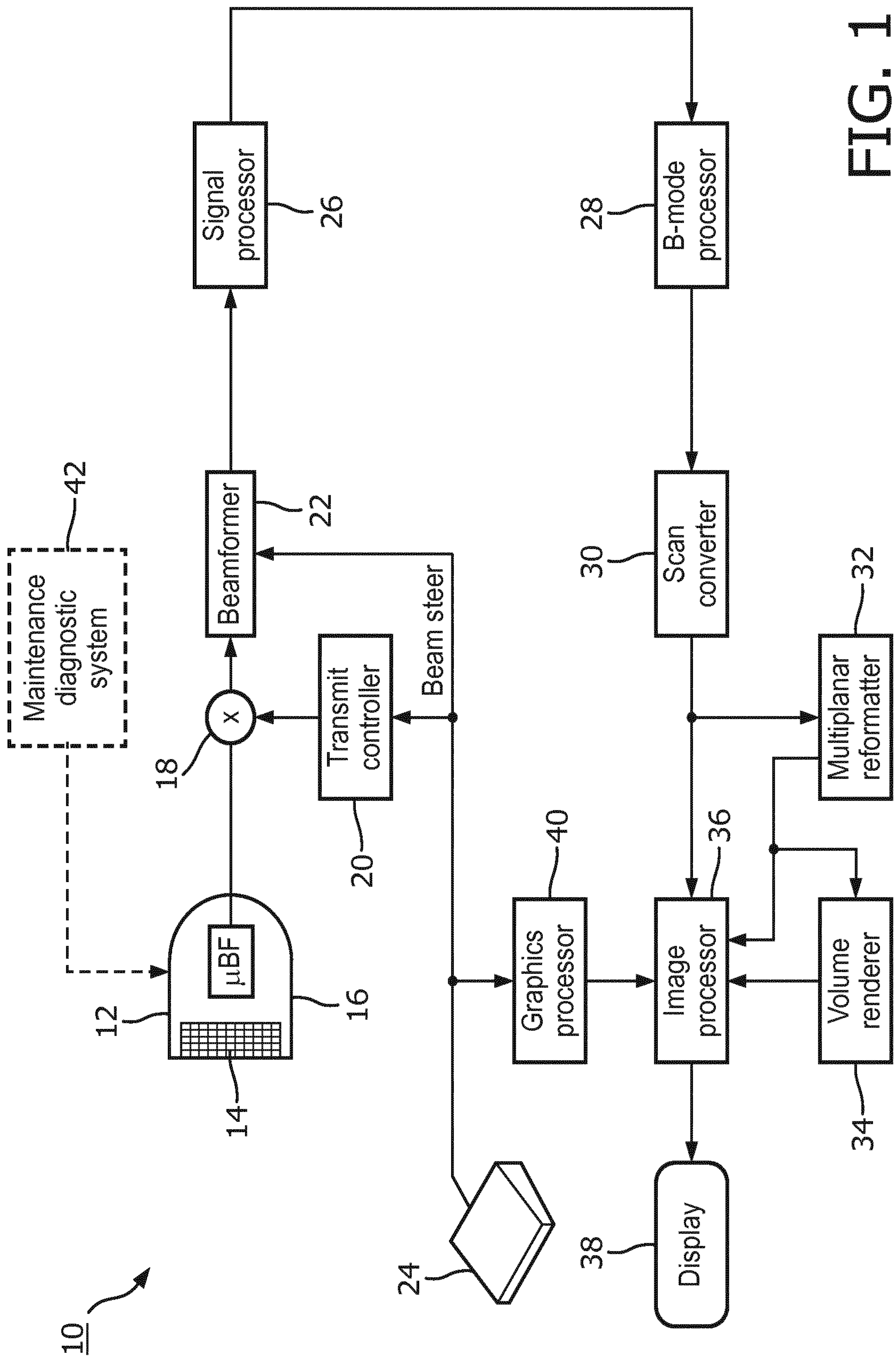

10
12
14
16
μBF
18
x
20
Transmit controller
22
Beamformer
Beam steer
24
26
Signal processor
28
B-mode processor
30
Scan converter
32
Multiplanar reformatter
34
Volume renderer
36
Image processor
38
Display
40
Graphics processor
42
Maintenance diagnostic system

FIG. 1

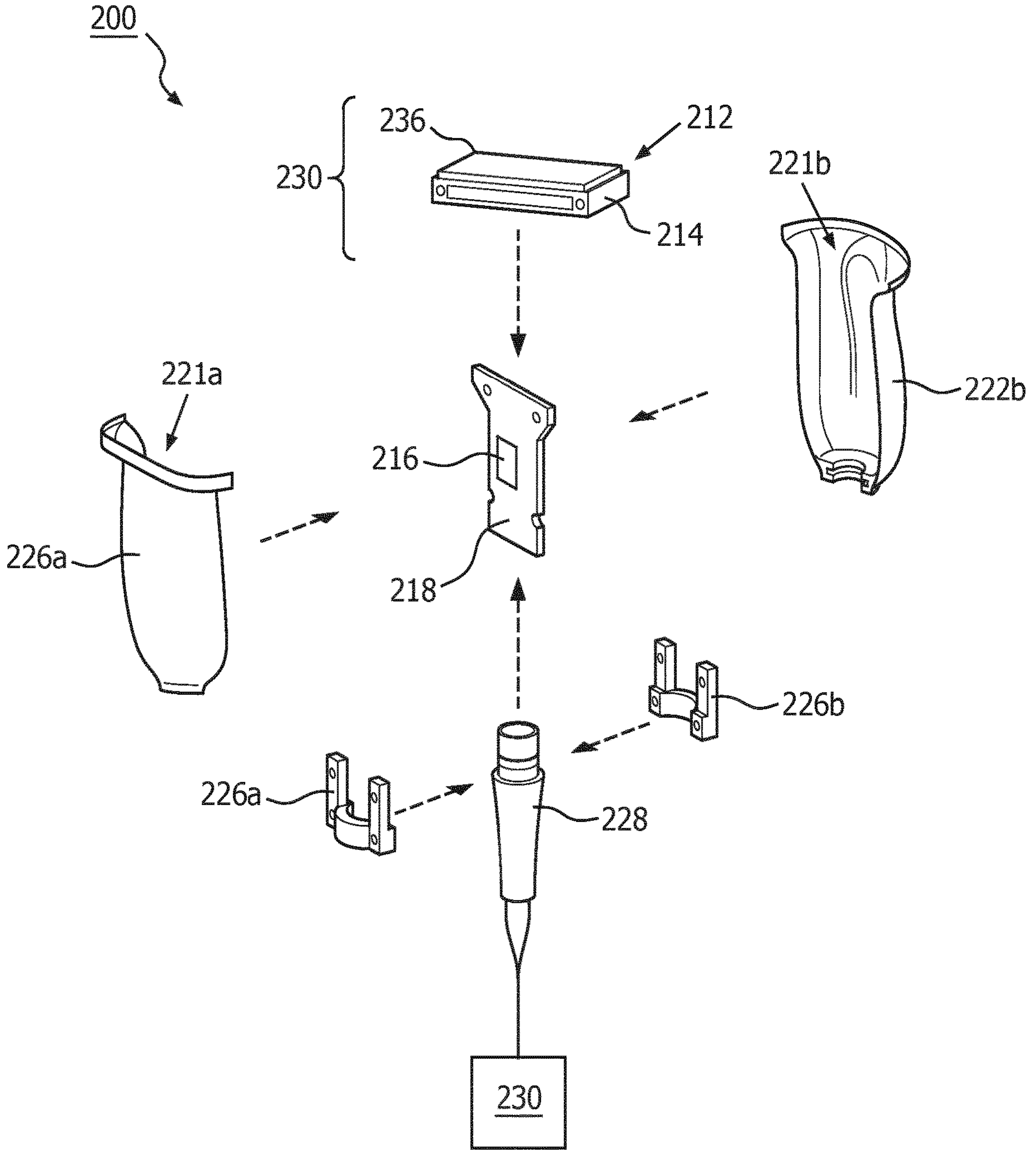

200
236
212
230
214
221b
221a
222b
216
226a
218
226b
226a
228
230

FIG. 2

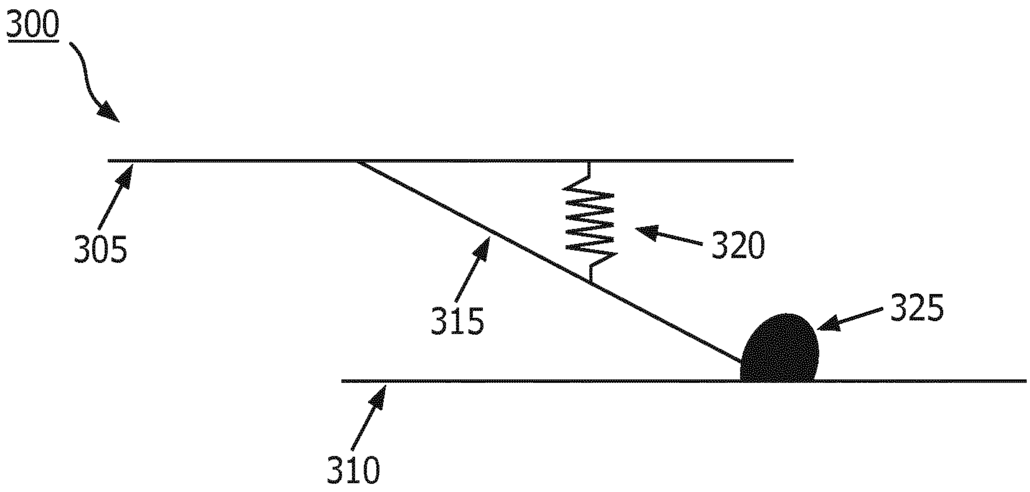


FIG. 3A

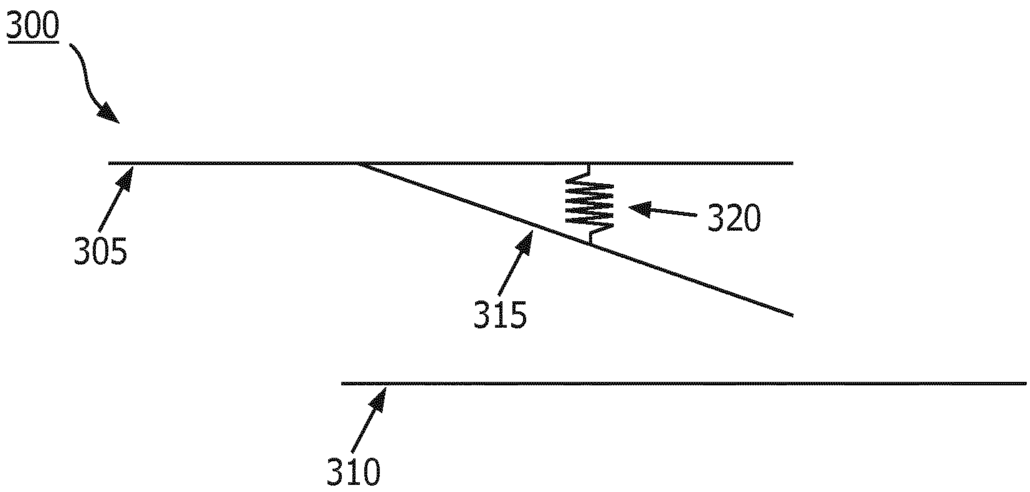


FIG. 3B

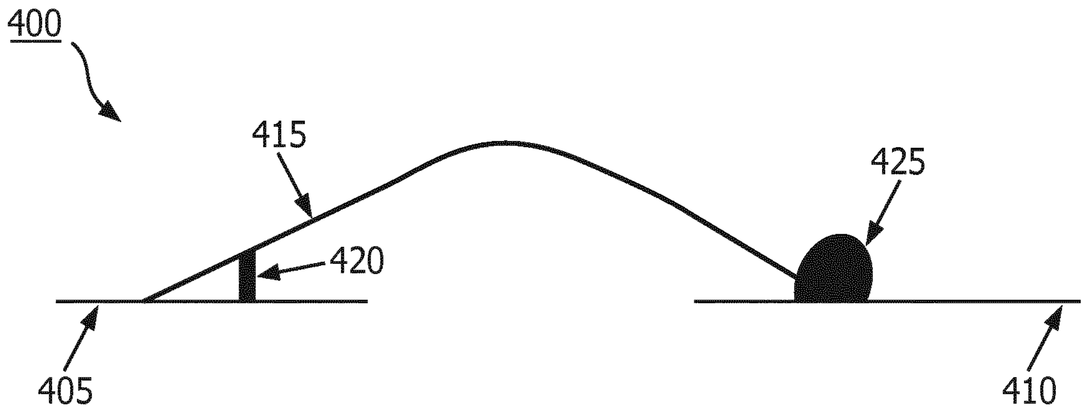


FIG. 4A

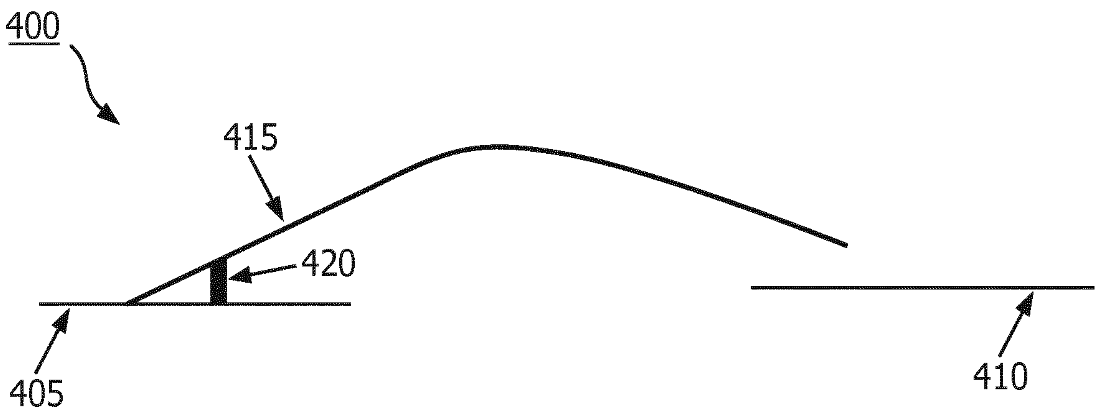


FIG. 4B

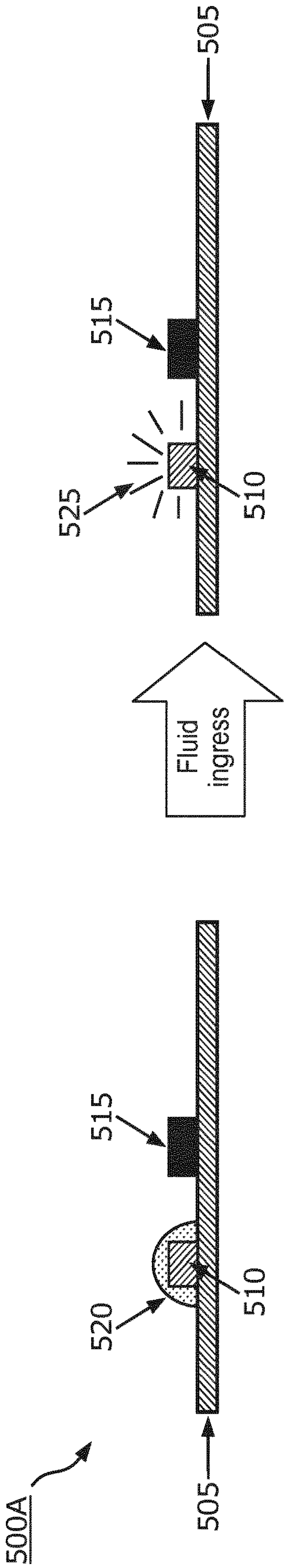

500A
505
520
510
515
525
Fluid ingress

FIG. 5A

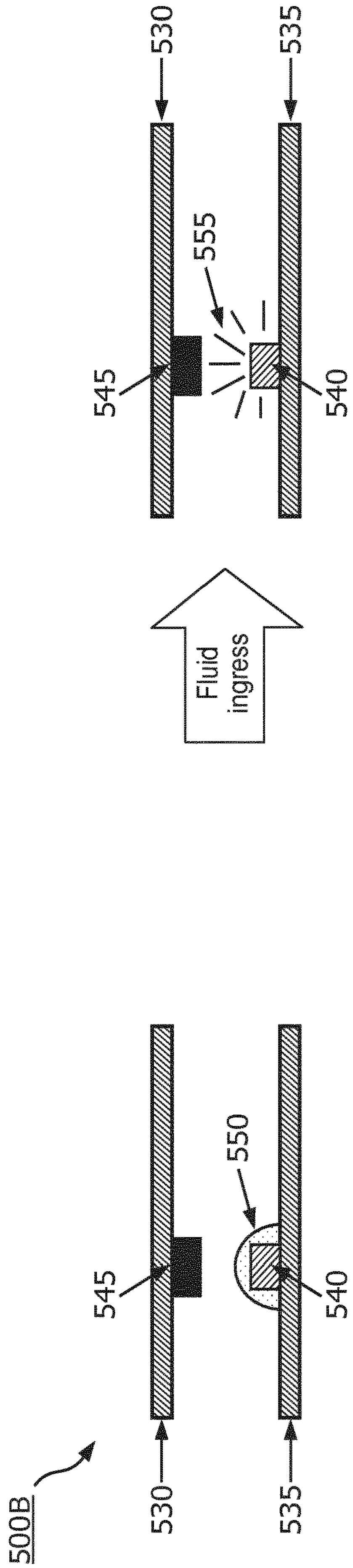

500B
530
535
545
550
540
555
Fluid ingress

FIG. 5B

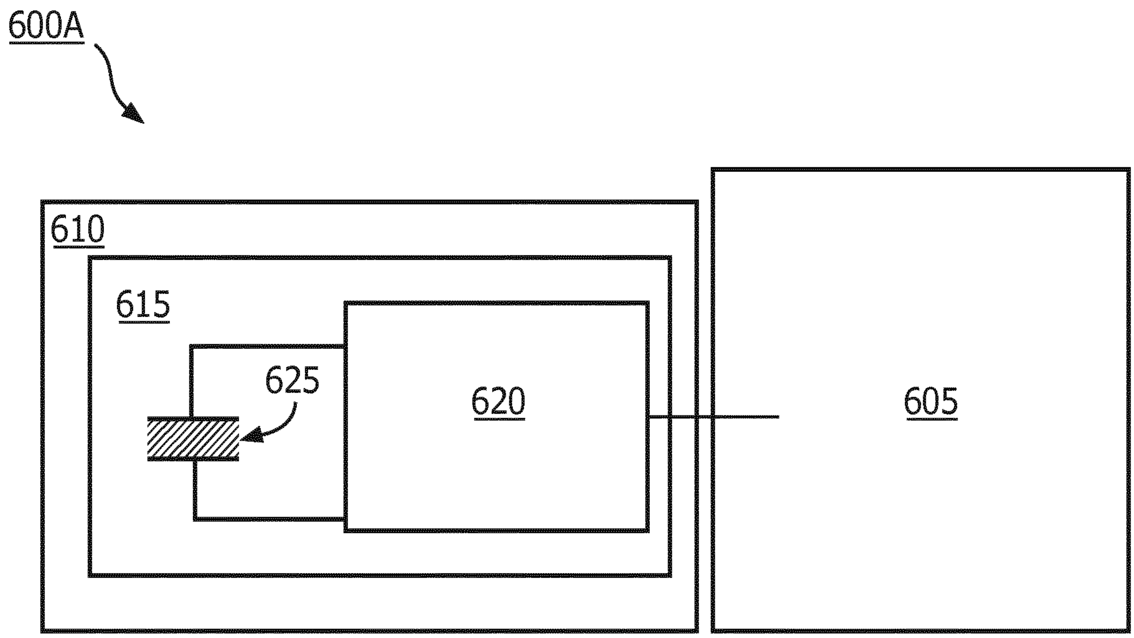


FIG. 6A

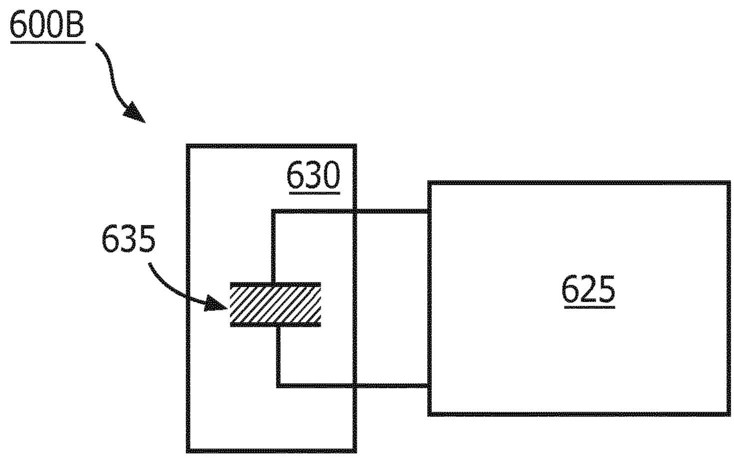


FIG. 6B

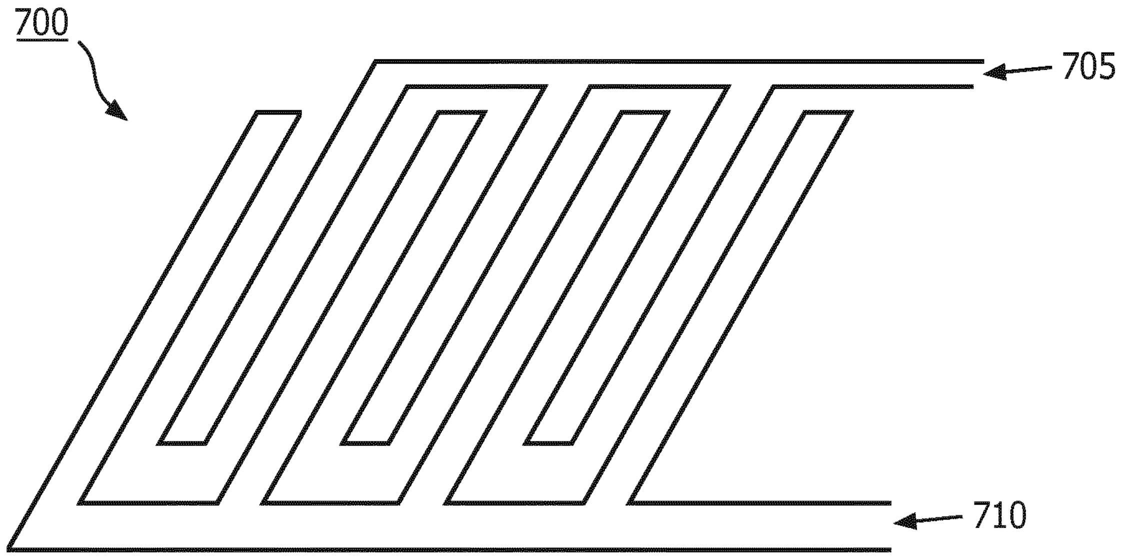


FIG. 7

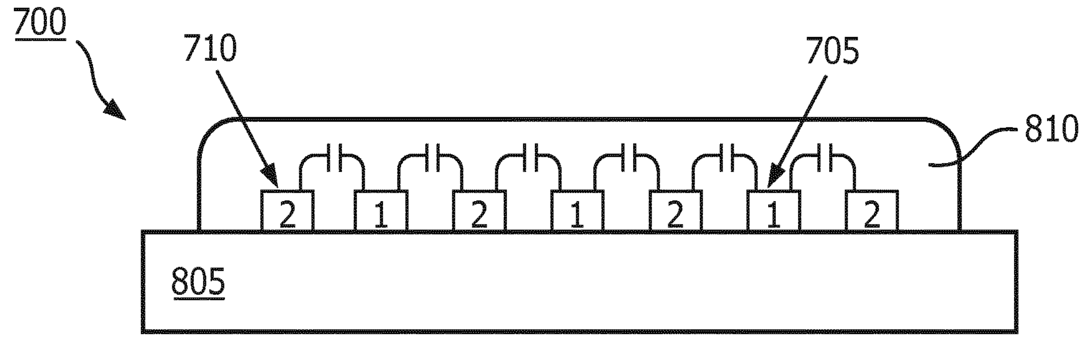


FIG. 8A

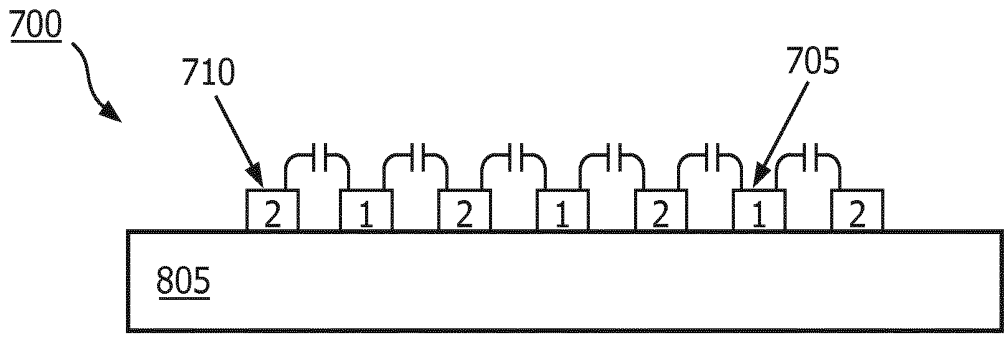


FIG. 8B

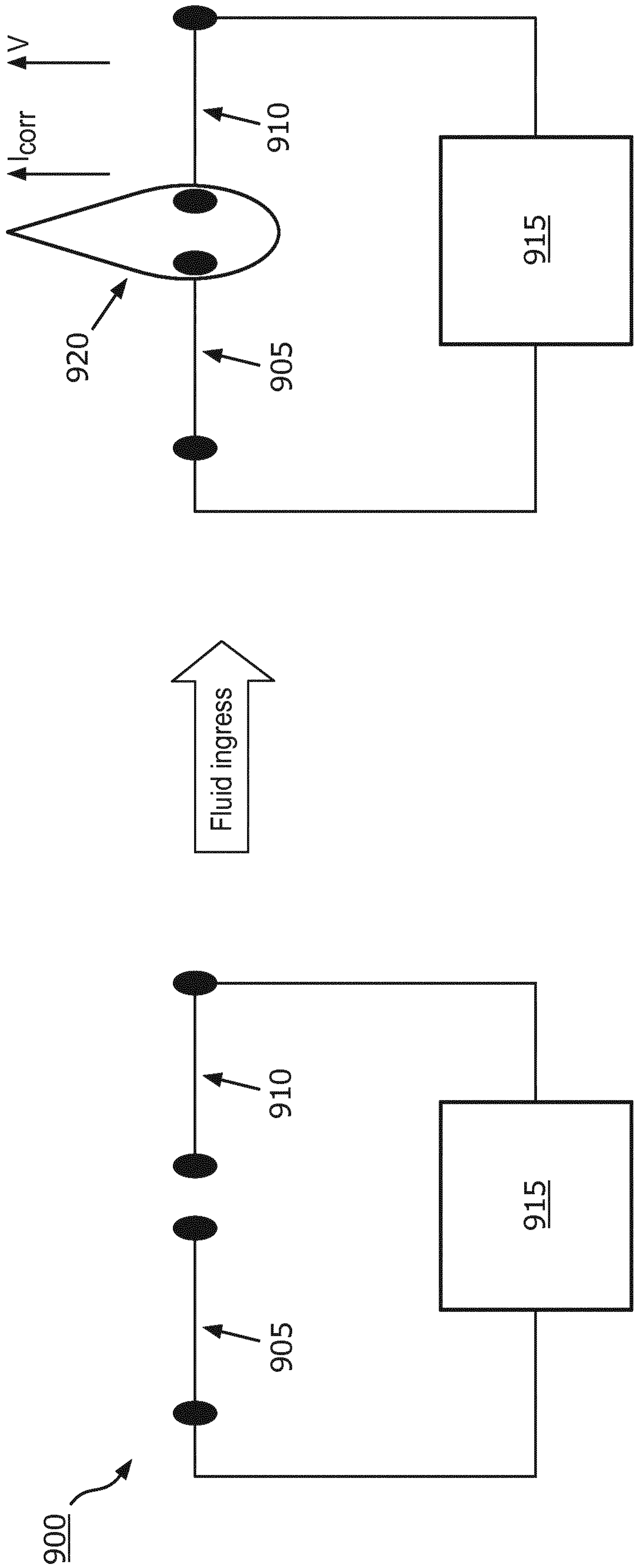


FIG. 9

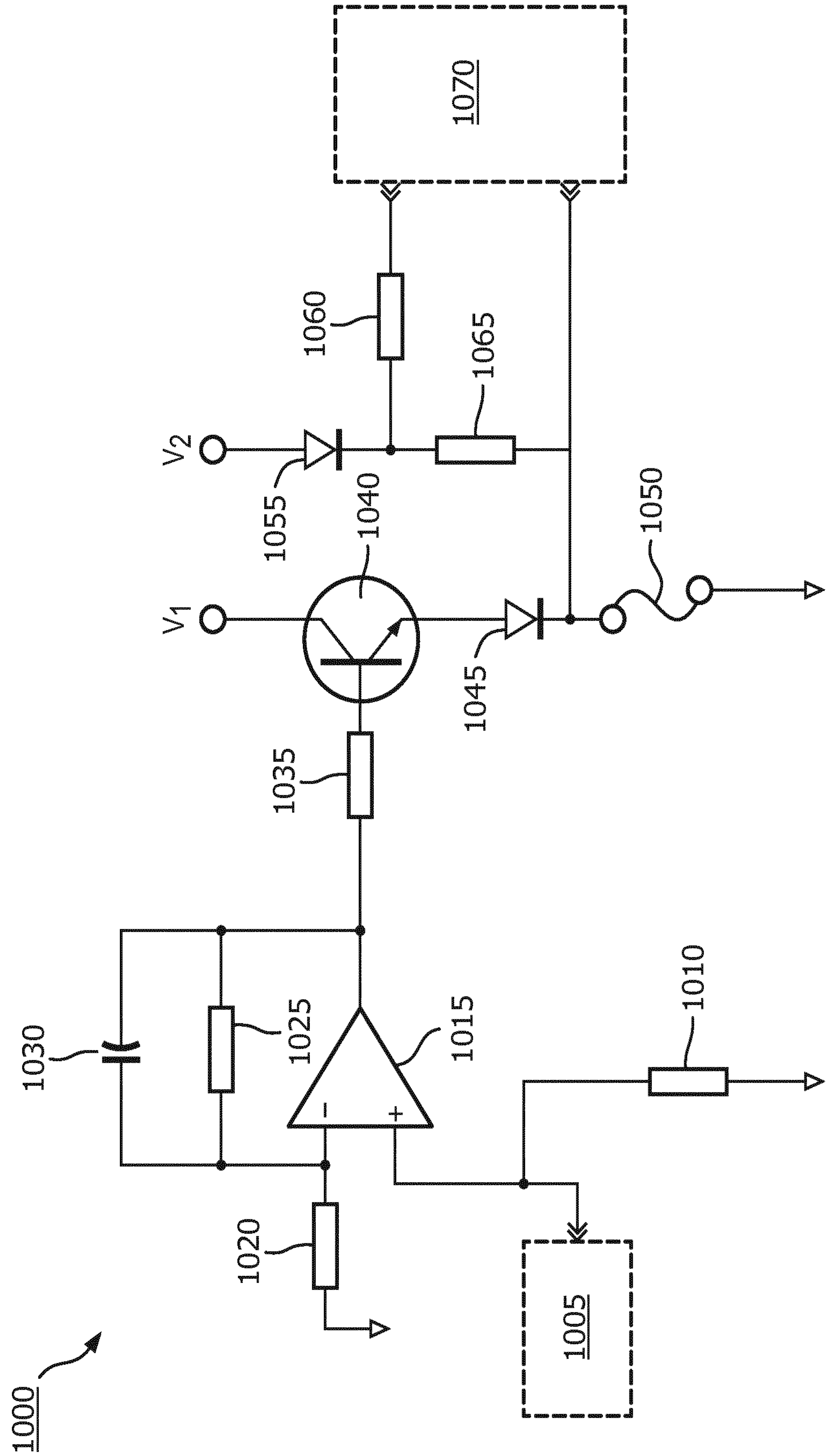

1070
1060
1065
V_2
1055
1040
1050
V_1
1045
1035
1030
1025
1015
1010
1020
1005
1000

FIG. 10

SYSTEMS, METHODS, AND APPARATUSES FOR FLUID INGRESS DETECTION FOR ULTRASOUND TRANSDUCERS

BACKGROUND

[0001] One cause of ultrasound probe failure is fluid ingress. That is, water and/or other fluids leak into the interior of the probe. The fluids may cause electrical shorts that may damage components of the ultrasound probe and/or corrode internal components of the probe. Although external surfaces of ultrasound probes may be exposed to fluids during imaging exams, the fluid barriers of ultrasound probes are often compromised during cleaning rather than during exams. Ultrasound probes may need to be disinfected between exams to prevent transmission of diseases between patients. Probes may be disinfected by enzymatic cleaning and/or high level disinfection. Disinfection procedures may include the use of fluids including strong acids, bases, and/or corrosive compounds (e.g., alcohol, hydrogen peroxide, ammonia, bleach). During disinfection, connectors and/or other components of the ultrasound probe not designed to resist fluid ingress may be exposed to water, disinfectants, and/or other fluids. Users may also bend ultrasound components (e.g., neck and sheath of a transesophageal echo probe, coaxial cable) beyond their designed range of motion during cleaning. This may compromise fluid ingress barriers of the ultrasound probe.

[0002] Currently, it is often impossible for a user or field technician to detect fluid ingress without disassembling at least a portion of the ultrasound probe. This may make it difficult to diagnose a maintenance issue when an ultrasound probe is malfunctioning and delay repairs. If fluid ingress is left uncorrected, the ultrasound probe may be damaged beyond repair and need to be fully replaced. Full replacement of an ultrasound probe may increase costs and/or downtime of an ultrasound imaging system.

SUMMARY

[0003] According to an exemplary embodiment of the disclosure, an ultrasound probe may include a transducer assembly including an array of transducer elements, a housing enclosing at least a portion of the transducer assembly, a cable coupled to the housing, a connector coupled to the cable, the connector configured to couple the ultrasound probe to an ultrasound imaging system, and a fluid ingress detection assembly that may include a sense circuit, and a fluid ingress detector that may be configured to change from a first state to a second state responsive to ingress of fluid in an interior of the ultrasound probe, and the sense circuit may be operable to detect the change from the first state to the second state and generate a signal indicative of fluid ingress.

[0004] In one exemplary embodiment, the fluid ingress detector may include a first conductive line, a second conductive line, wherein the first and second conductive lines may be electrically coupled to the sense circuit, a conductive cantilever electrically coupled to the first conductive line, and a soluble epoxy, wherein the soluble epoxy may electrically couple the conductive cantilever to the second conductive line. In some examples, the fluid ingress detector may further include a spring coupled between the first conductive line and the conductive cantilever, wherein the spring may bias the conductive cantilever away from the second conductive line. In some examples, the fluid ingress detector may further include a lever coupled between the first conductive line and the conductive cantilever, wherein the lever may bias the conductive cantilever away from the second conductive line.

[0005] In an alternative exemplary embodiment, the soluble epoxy may electrically isolate the conductive cantilever and the second conductive line of the fluid ingress detector. In some examples, the fluid ingress detector may further comprise a spring coupled between the first conductive line and the conductive cantilever, wherein the spring may bias the conductive cantilever toward the second conductive line. In some examples, the fluid ingress detector may further comprise a lever coupled between the first conductive line and the conductive cantilever, wherein the lever may bias the conductive cantilever toward the second conductive line. In some examples, the conductive cantilever is molded such that the conductive cantilever may be biased toward the second conductive line.

[0006] According to another exemplary embodiment of the disclosure, the fluid ingress detector may include a light source, a soluble epoxy coating the light source, wherein the soluble epoxy may block a light of the light source, and a photodetector electrically coupled to the sense circuit, wherein the photodetector may be configured to detect the light from the light source when at least some of the soluble epoxy dissolves and may generate at least one of a voltage and a current responsive to detecting the light of the light source.

[0007] According to a further exemplary embodiment of the disclosure, the fluid ingress detector may include a first portion comprising a first material and a second portion comprising a second material different from the first material, wherein the first portion and second portion may comprise a galvanic sensor. The first and second portions may form a closed circuit when a fluid contacts the first and second portions and the sense circuit may be configured to sense at least one of a voltage and a current from the galvanic sensor when the closed circuit is formed.

[0008] According to a further exemplary embodiment of the disclosure, an ultrasound imaging system may include an ultrasound probe including a capacitor including a soluble dielectric and a dielectric property sensing circuit electrically coupled to the ultrasound probe, wherein the dielectric property sensing circuit may be configured to detect a change in a dielectric property of the capacitor when at least some of the soluble dielectric reacts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a block diagram of an ultrasound imaging system according to an embodiment of the disclosure.

[0010] FIG. **2** is a schematic illustration of an exploded view of an ultrasound probe according to an embodiment of the disclosure.

[0011] FIGS. **3**A and **3**B illustrate an example of a fluid ingress detector according to an embodiment of the disclosure.

[0012] FIGS. **4**A and **4**B illustrate an example of a fluid ingress detector according to another embodiment of the disclosure.

[0013] FIGS. **5**A and **5**B illustrate examples of fluid ingress detectors according to embodiments of the disclosure.

[0014] FIG. **6**A is a functional block diagram of a system including a fluid ingress detector according to an embodiment of the disclosure.

[0015] FIG. **6**B is a functional block diagram of a system for detecting a fluid ingress according to an embodiment of the disclosure.

[0016] FIG. **7** is an illustration of an example capacitive structure that may be used to implement capacitors shown in FIGS. **6**A and **6**B according to embodiments of the disclosure.

[0017] FIGS. **8**A and **8**B are illustrations of cross-sectional views of the capacitive structure shown in FIG. **7** according to embodiments of the disclosure.

[0018] FIG. **9** is an illustration of an example fluid ingress detector according to an embodiment of the disclosure.

[0019] FIG. **10** shows a circuit diagram of an exemplary sense circuit according to embodiments of the disclosure.

DETAILED DESCRIPTION

[0020] 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.

[0021] 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.

[0022] According to an embodiment of the disclosure, an ultrasound probe may include one or more fluid ingress detectors. The ultrasound probe may include a housing, sheath, cable, connector and/or coupler. The fluid ingress detector may be located in the interior of the ultrasound probe. For example, a fluid ingress detector may be located in an interior of the housing at or near where the cable couples to the housing. In another example, a fluid ingress detector may be located in an interior of the connector that couples the ultrasound probe to an ultrasound imaging system. The detector may provide maintenance diagnostic information to a user and/or a field engineer. In some embodiments, the detector may provide maintenance diagnostic information via a user interface and/or display included in an ultrasound imaging system coupled to the ultrasound probe. In some embodiments, the detector may trigger a visual or audio indicator included in the ultrasound probe to provide maintenance diagnostic information. In some embodiments, the detector may provide maintenance diagnostic information to a maintenance diagnostic system coupled to the ultrasound probe. The maintenance diagnostic information may allow appropriate repairs to the ultrasound probe to be completed. The maintenance diagnostic information may allow the field engineer to detect probe misuse by the user and educate the user on proper disinfecting and/or cleaning procedures that are less likely to cause fluid ingress.

[0023] Referring to FIG. **1**, an ultrasound imaging system **10** constructed in accordance with the principles of the present invention is shown in block diagram form. In the ultrasonic diagnostic imaging system of FIG. **1**, an ultrasound probe **12** includes a transducer array **14** for transmitting ultrasonic waves and receiving echo information. A variety of transducer arrays are well known in the art, e.g., linear arrays, convex arrays or phased arrays. The transducer array **14**, for example, can include a two dimensional array (as shown) of transducer elements capable of scanning in both elevation and azimuth dimensions for 2D and/or 3D imaging. The transducer array **14** is coupled to a microbeamformer **16** in the probe **12** which controls transmission and reception of signals by the transducer elements in the array. In this example, the microbeamformer is coupled by the probe cable to a transmit/receive (T/R) switch **18**, which switches between transmission and reception and protects the main beamformer **22** from high energy transmit signals. In some embodiments, the T/R switch **18** and other elements in the system can be included in the transducer probe rather than in a separate ultrasound system base. The transmission of ultrasonic beams from the transducer array **14** under control of the microbeamformer **16** is directed by the transmit controller **20** coupled to the T/R switch **18** and the beamformer **22**, which receives input from the user's operation of the user interface or control panel **24**. One of the functions controlled by the transmit controller **20** is the direction in which beams are steered. Beams may be steered straight ahead from (orthogonal to) the transducer array, or at different angles for a wider field of view. The partially beamformed signals produced by the microbeamformer **16** are coupled to a main beamformer **22** where partially beamformed signals from individual patches of transducer elements are combined into a fully beamformed signal.

[0024] The beamformed signals are coupled to a signal processor **26**. The signal processor **26** can process the received echo signals in various ways, such as bandpass filtering, decimation, I and Q component separation, and harmonic signal separation. The signal processor **26** may also perform additional signal enhancement such as speckle reduction, signal compounding, and noise elimination. The processed signals are coupled to a B mode processor **28**, which can employ amplitude detection for the imaging of structures in the body. The signals produced by the B mode processor are coupled to a scan converter **30** and a multiplanar reformatter **32**. The scan converter **30** arranges the echo signals in the spatial relationship from which they were received in a desired image format. For instance, the scan converter **30** may arrange the echo signal into a two dimensional (2D) sector-shaped format, or a pyramidal three dimensional (3D) image. The multiplanar reformatter **32** can convert echoes which are received from points in a common plane in a volumetric region of the body into an ultrasonic image of that plane, as described in U.S. Pat. No. 6,443,896 (Detmer). A volume renderer **34** converts the echo signals of a 3D data set into a projected 3D image as viewed from a given reference point, e.g., as described in U.S. Pat. No.

6,530,885 (Entrekin et al.) The 2D or 3D images are coupled from the scan converter **30**, multiplanar reformatter **32**, and volume renderer **34** to an image processor **36** for further enhancement, buffering and temporary storage for display on an image display **38**. The graphics processor **36** can generate graphic overlays for display with the ultrasound images. These graphic overlays can contain, e.g., standard identifying information such as patient name, date and time of the image, imaging parameters, and the like. For these purposes the graphics processor receives input from the user interface **24**, such as a typed patient name. The user interface can also be coupled to the multiplanar reformatter **32** for selection and control of a display of multiple multiplanar reformatted (MPR) images.

[0025] In some embodiments, the user interface **24** may allow a user and/or a field technician to run maintenance diagnostics on one or more components of the ultrasound imaging system **10**. For example, a field technician may be able to run test functions on the ultrasound probe **12** via the user interface **24**. The ultrasound system **10** may provide error codes and/or other maintenance diagnostic information to the filed technician via the display **38**. In some embodiments, the user interface **24** and/or ultrasound probe **12** may provide maintenance diagnostic indicators (e.g., LCD screen, LED, audio signal). In some embodiments, the field technician may couple one or more components of the ultrasound imaging system **10** to a separate maintenance diagnostic system **42** to acquire maintenance diagnostic information on the component (e.g., ultrasound probe **12**).

[0026] FIG. **2** is a schematic illustration of an exploded view of an ultrasound probe **200** that may be used to implement ultrasound probe **12** shown in FIG. **1**, according to an embodiment of the disclosure. As used herein, distal refers to an end of the ultrasound probe that is typically closest to and/or in contact with a subject or object to be imaged during use. Proximal refers to an end of the ultrasound probe that is typically farther from the subject or object to be imaged and/or closer to an ultrasound imaging system (not shown) during use. The ultrasound probe **200** may include a housing **222** which may form the handle portion of the probe that is held by a sonographer during use. The housing **222** is shown as having two portions **222***a-b*, which may be configured to mate to form the housing **222**. However, the housing **222** may be a unitary body and/or be composed of more than two portions configured to mate in some embodiments. When the two portions **222***a-b* of the housing **222** are joined, the housing **222** may define an opening (not numbered) at a distal end of the probe **200** that may expose at least a portion of a lens **236** of a transducer assembly **230**. The transducer assembly **230** may include the lens **236** at the distal end, a transducer stack **212** on the proximal side of the lens **236**, and a backing subassembly **214** on the proximal side of the transducer stack **212**. The transducer stack **212** may be between the lens **236** and the backing subassembly **214**. The transducer stack **212** may include an array of transducer elements, for example a 1D or 2D array of piezoelectric, CMUT or another type of transducer elements configured to transmit ultrasonic waves and receive ultrasound echoes. The transducer assembly **230** may include a flexible circuit and/or other electrical components (not shown). In some embodiments, the flexible circuit may be included in the transducer stack **212**. The flexible circuit and/or electrical components may couple the transducer or other components of the transducer stack **212** to other electrical components of the ultrasound probe **210**. The backing subassembly **214** may attenuate acoustic reverberations from the back of the transducer stack **212** and/or may conduct heat developed in the transducer stack **212** away from the distal end of the probe **200**. The backing subassembly **214** may include a graphite block in some embodiments. Although the transducer assembly **230** is shown as having a substantially rectangular shape, the transducer assembly **230** may have other shapes. Example suitable shapes include, but are not limited to, a dome, an arc, and a half-cylinder. The shape of the transducer assembly **230** may be determined, at least in part, by the ultrasound imaging application (e.g., thoracic, cardiac, esophageal).

[0027] The probe **200** may include a PCA **218** may include electrical circuits and/or other electrical components for operation of the ultrasound probe **200** (e.g., for applying voltage to the transducer elements for generating ultrasonic waves). In some examples, the PCA **218** may be coupled to the transducer assembly **230**. The PCA **218** may be coupled to a flexible circuit (not shown) or other electrical components of the transducer assembly **230**. The PCA **218** may be coupled to the housing **222**. In some embodiments, the probe **200** may include two or more PCAs **218**.

[0028] In some embodiments, the PCA **218** may include a fluid ingress detection assembly **216**. The fluid ingress detection assembly **216** may include springs, levers, soluble capacitors, soluble epoxy, light emitting diodes, light sensors, galvanic sensors, a battery, a sense circuit, and/or other elements (e.g., wires, traces, latches, clock circuit). In some embodiments, one or more components of the fluid ingress detection assembly **216** may be coupled to the PCA **218**, and in some embodiments between the PCA **218** and the interior surface **221** of the housing **222**. In some embodiments, components of the fluid ingress detection assembly **216** may be located on another internal component (e.g., transducer stack **212**, backing subassembly **214**, housing **222**) and electrically coupled to the PCA **218** and/or a flexible circuit of the transducer stack **212**. In some embodiments, the probe **200** may include multiple fluid ingress detection assemblies **216**. The fluid ingress detection assembly **216** may be positioned near locations vulnerable to fluid ingress (e.g., seam in the housing) and/or internal components sensitive to fluid ingress (e.g., electrical circuitry).

[0029] At the proximal end of the probe **200** and extending therefrom may be a cable **228** of the ultrasound probe **200**. In some embodiments, the cable **228** may be a coaxial cable. In some embodiments, the cable **228** may be clamped to a proximal end of the PCA **218** by a clamp **226***a-b*. Other attachment methods may also be used. The cable **228** may include a connector **230** at a proximal end. The connector **230** may couple the probe **200** to an ultrasound imaging system such as ultrasound imaging system **10** shown in FIG. **1**.

[0030] In some embodiments, the fluid ingress detection assembly **216** or portions of the fluid ingress detection assembly **216** may be included in the cable **228** and/or connector **230**. For example, one or more fluid ingress detectors may be included in the connector **230** and electrically coupled via the cable **228** to another component of the fluid ingress detection assembly **216** included with the PCA **218**. In another example, the fluid ingress detection assembly **216** may be included in the connector **230** and may communicate with an ultrasound imaging system via the connector **230** when the ultrasound probe **200** is coupled to the ultrasound imaging system.

[0031] The PCA **218**, at least a portion of the transducer assembly **230**, and/or other internal components of the probe **200** may be enclosed in the housing **222**. The housing **222** may include two separate portions **222***a-b* that may be configured to fit together with each other to form an impervious housing to protect the ultrasound components from electromagnetic field interference, liquids, and/or debris. The housing **222** may comprise plastic, metal, rubber, and/or a combination of materials. In some embodiments, the housing **222** may be configured to enclose the transducer stack **212** and backing subassembly **214** of the transducer assembly **230** while leaving at least a portion of the lens **236** exposed.

[0032] Although ultrasound probe **200** as shown in FIG. **2** is configured as a hand-held probe, ultrasound probe **200** may be configured as an intravaginal probe, a transesophageal echo probe, and/or other ultrasound probe type. Ultrasound probe **200** may include all or some of the same components shown in FIG. **2**, but the shape and/or dimensions of one or more components may be altered based on the desired application. For example, an intravaginal probe may have a dome-shaped lens **236** and/or transducer stack **212**. In another example, a transesophageal probe may have an elongated, flexible housing **222**.

[0033] FIGS. 3A and 3B illustrate components of an example of a fluid ingress detection assembly according to an embodiment of the disclosure. The fluid ingress detection assembly of the example in FIGS. 3A and 3B includes a fluid ingress detector **300**. Fluid ingress detector **300** may include a first conductive line **305**, a conductive cantilever **315** electrically coupled to the first conductive line **305**, and a second conductive line **310**. The conductive cantilever **315** may be electrically coupled to the second conductive line **310** by a soluble epoxy **325**. In some embodiments, the soluble epoxy **325** electrically couples the conductive cantilever **315** to the second conductive line **310** by maintaining the conductive cantilever **315** in physical contact with the second conductive line **310**. In some embodiments, the soluble epoxy **325** or a portion thereof may be disposed between the conductive cantilever **315** and the second conductive line **310**. In such embodiments, the soluble epoxy **325** may be electrically conductive and may thus electrically couple the conductive cantilever **315** to the second conductive line **310** even if the conductive cantilever **315** is not physically in contact with the second conductive line **310**. The conductive cantilever **315** may be mechanically biased away from the second conductive line. For example, the fluid ingress detector **300** may include a spring **320** coupled between the first conductive line **305** and the conductive cantilever **315**, which biases the conductive cantilever **315** away from the second conductive line **310**. The soluble epoxy **325** acts against the mechanical bias to maintain the conductive cantilever **315** in electrical contact with the second conductive line.

[0034] As illustrated in FIG. 3A, prior to a fluid ingress, the conductive cantilever **315** may close a circuit that includes the first and second conductive lines **305**, **310** by virtue of the electrical coupling provided by the soluble epoxy **325**. The spring **320** may be in a strained state again by virtue of the soluble epoxy **325** which acts against the mechanical bias applied by the spring **320**. FIG. 3B illustrates the fluid ingress detector **300** after a fluid ingress. At least some of the soluble epoxy **325** has been dissolved, and the spring **320** is in a resting or partially unstrained state. In this resting or partially unstrained state, in the absence of the soluble epoxy **325** acting against the spring, the biasing force of the spring acts freely on the conductive cantilever **315** to bias the conductive cantilever **315** away from the second conductive line **310** and to physically separate the conductive cantilever **315** from the second conductive line **310**. Thus, as shown in FIG. 3B, the conductive cantilever **315** is no longer electrically coupled to the second conductive line **310**. Thus, the circuit including the conductive cantilever **315** and the first and second conductive lines **305**, **310** is open. While the spring **320** in this example is shown between the first conductive line **305** and the conductive cantilever **315**, in other examples, the spring may be provided between the conductive cantilever **315** and the second conductive line **310**. A sense circuit (not shown), may be coupled to the fluid ingress detector **300**. The sense circuit may detect a change in voltage, resistance, and/or current between the closed circuit shown in FIG. 3A and the open circuit shown in FIG. 3B. The detected change in voltage, resistance, and/or current may cause the sense circuit to transmit a signal which produces an indication of fluid ingress. The signal may be provided to another component within the ultrasound probe which is operable to provide the indication (e.g., in the form of illuminated light connected to the housing, an audible indication provided by a speaker, or a tactile indication provided by a vibrator built into the probe) and/or an external system coupled to the ultrasound probe (e.g., in the form of a visual indication provided on a display of an ultrasound scanner).

[0035] An example sense circuit is shown in FIG. **10** and is described in more detail below. However, it will be understood to those skilled in the art that a variety of sense circuits may be suitable for implementing a sense circuit coupled to the fluid ingress detector **300**. For example, a current sensing circuit or a voltage comparator circuit may be used as a sense circuit.

[0036] The first and second conductive lines **305**, **310** may be implemented as wires and/or plates in some embodiments. The first and second conductive lines **305**, **310** may be included on a PCA in some embodiments. In some embodiments, the first and second conductive lines **305**, **310** may be included on separate PCA's. In some embodiments, the first and/or second conductive lines **305**, **310** are separate from a PCA and are electrically coupled to one or more PCA's.

[0037] The conductive cantilever **315** may be implemented as a wire or a strip of conductive material in some embodiments. In some embodiments, the conductive cantilever **315** is shaped, e.g., bent and/or molded into a shape which has a natural bias away from the second conductive line **310**. For example, the conductive cantilever **315** may be shaped into a pre-loaded state in which the conductive cantilever **315** tends towards a shape that would separate the first and second conductive lines in the absence of the holding force applied by the soluble epoxy. In some embodiments, the conductive cantilever **315** is biased away from the second conductive line **310** by the spring **320** or another biasing mechanism now known or later developed. In some embodiments, the conductive cantilever **315** and the first and second conductive lines **305**, **310** include copper or a copper-beryllium alloy. However, other conductive materials may be used (e.g., conductive polymers, gold).

[0038] FIGS. **4**A and **4**B illustrate another example of a fluid ingress detector **400** according to an embodiment of the disclosure. Fluid ingress detector **400** may be used to implement a fluid ingress detector of the fluid ingress detection assembly **216** shown in FIG. **2** in some embodiments. Fluid ingress detector **400** may include a first conductive line **405**, a conductive cantilever **415** electrically coupled to the first conductive line **405**, and a second conductive line **410**. The conductive cantilever **415** may be electrically coupled to the second conductive line **410** by a soluble epoxy **425**. The fluid ingress detector **400** may further include a biasing mechanism in the form of a post **420** coupled between the first conductive line **405** and the conductive cantilever **415**. In some embodiments, the post **420** may be compressible and may elongate in the absence of the holding force applied by the soluble epoxy **425**. In some embodiments, the post **420** is rigid and acts as a fulcrum of the cantilever **415**, which may be a flexible member naturally biased away from the second conductive line **405** but held in physical and/or electrical contact by the soluble epoxy **425**.

[0039] As illustrated in FIG. **4**A, prior to a fluid ingress, the conductive cantilever **415** may close a circuit that includes the first and second conductive lines **405**, **410**. FIG. **4**B illustrates the fluid ingress detector **400** after a fluid ingress. At least some of the soluble epoxy **425** has been dissolved. The conductive cantilever **415** is no longer electrically coupled to the second conductive line **410**. Thus, the circuit including the conductive cantilever **415** and the first and second conductive lines **405**, **410** is open.

[0040] A sense circuit (not shown), may be coupled to the fluid ingress detector **400**. The sense circuit may detect a change in voltage, resistance, and/or current between the closed circuit shown in FIG. **4**A and the open circuit shown in FIG. **4**B. The detected change in voltage, resistance, and/or current may cause the sense circuit to transmit a signal indicating a fluid ingress. The signal may be provided to another component within the ultrasound probe and/or an external system coupled to the ultrasound probe.

[0041] The first and second conductive lines **405**, **410** may be implemented as wires and/or plates in some embodiments. The first and second conductive lines **405**, **410** may be included on a PCA in some embodiments. In some embodiments, the first and second conductive lines **405**, **410** may be included on separate PCA's. In some embodiments, the first and/or second conductive lines **405**, **410** are separate from a PCA and are electrically coupled to one or more PCA's.

[0042] The conductive cantilever **415** may be implemented as a wire or a strip of conductive material in some embodiments. In some embodiments, the conductive cantilever **415** is bent and/or molded to have a bias away from the second conductive line **410**. In some embodiments, the conductive cantilever **415** is biased away from the second conductive line such that the post **420** is optional. For example, the conductive cantilever **415** may be shaped into a pre-loaded state in which the conductive cantilever **415** tends towards a shape that would separate the first and second conductive lines in the absence of the holding force applied by the soluble epoxy. In some embodiments, the conductive cantilever **415** and the first and second conductive lines **405**, **410** include copper or a copper-beryllium alloy. However, other conductive materials may be used (e.g., conductive polymers, gold).

[0043] Although the fluid ingress detectors **300** and **400** are described as closing a circuit in response to a fluid ingress, in some embodiments, fluid ingress detectors **300** and **400** may be configured to open a circuit in response to a fluid ingress. For example, soluble epoxy **325** of fluid ingress detector **300** may electrically isolate conductive cantilever **315** and conductive line **310**. Soluble epoxy **325** may secure conductive cantilever **315** such that spring **320** is in a compressed state. After at least a portion of soluble epoxy **325** dissolves, the spring **320** may urge conductive cantilever **315** into electrical contact with conductive line **310**. In another example, conductive cantilever **415** of fluid ingress detector **400** may be molded to be biased toward conductive line **410** and/or conductive cantilever **415** may be biased toward conductive line **410** by lever **420**. The soluble epoxy **425** may electrically isolate conductive line **410** and conductive cantilever **415**. After at least some of the soluble epoxy **425** dissolves due to a fluid ingress, conductive cantilever **415** may come into electrical contact with conductive line **410**.

[0044] FIGS. **5**A and **5**B illustrate examples of fluid ingress detectors **500**A and **500**B according to embodiments of the disclosure. Fluid ingress detectors **500**A and **500**B may be used to implement a fluid ingress detector for the fluid ingress detection assembly **216** shown in FIG. **2** in some embodiments. Fluid ingress detector **500**A may be included with a PCA **505**. The fluid ingress detector **500**A may include a light source **510** (e.g., LED, quantum dot) and a photodetector **515** (e.g., charged-coupled device, photodiode). As shown on the left-hand side of FIG. **5**A, the light source **510** may be coated in a soluble epoxy **520**. After fluid ingress, at least some of the soluble epoxy **520** may be dissolved, and light **525** emitting from the light source **510** may be detected by the photodetector **515** as shown on the right-hand side of FIG. **5**A.

[0045] A sense circuit (e.g., the sense circuit shown in FIG. **10**), may be coupled to the fluid ingress detector **500**A. The sense circuit may detect a voltage and/or current from the photodetector **515**. The detected voltage and/or current may cause the sense circuit to transmit a signal indicating a fluid ingress. The signal may be provided to another component within the ultrasound probe and/or an external system coupled to the ultrasound probe.

[0046] In some embodiments, the light source **510** may be a visible light source. In some embodiments, the light source **510** may be an infrared light source. The wavelength range of the light source **510** may be selected based, at least in part, on the properties of the soluble epoxy **520**. For example, many epoxies strongly absorb in the infrared region. Selecting an infrared light source may allow a thinner coating of soluble epoxy **520** to be used over the light source **510** to block light **525** from reaching the photodetector **515** prior to a fluid ingress.

[0047] FIG. **500**B is an illustration of a fluid ingress detector **500**B. Fluid ingress detector **500**B may include a light source **540** coated in a soluble epoxy **550** and a photodetector **545**. In the arrangement shown in FIG. **5**B, the light source **540** is included with PCA **535** and the photodetector **545** is included with PCA **530**. Fluid ingress detector **500**B may operate in a similar manner as fluid ingress detector **500**A. As shown on the left-hand side of FIG. **5**B, the light source **540** may be coated in a soluble epoxy **550**. After fluid ingress, at least some of the soluble epoxy **550** may be dissolved, and light **555** emitting from the light source **540** may be detected by the photodetector **545** as shown on the right-hand side of FIG. **5**B.

[0048] FIGS. **5**A and **5**B are two exemplary arrangements of a fluid ingress detector including light source and photodetector components. In some embodiments, a fluid ingress detector may include multiple light sources included on one or more PCA's. The light sources may be evenly spaced throughout an ultrasound probe and/or placed near areas vulnerable to fluid ingress. In some embodiments, a fluid ingress detector may include multiple photodetectors included on one or more PCA's. In some embodiments, there may be a greater number of light sources than photodetectors. In some embodiments, there may be a greater number of photodetectors than light sources.

[0049] FIG. **6**A is a functional block diagram of a system **600**A including a fluid ingress detector **615** according to an embodiment of the disclosure. System **600**A may include an ultrasound imaging system **605** coupled to an ultrasound probe **610**. System **600**A may be implemented with ultrasound imaging system **10** shown in FIG. **1** in some embodiments. In some embodiments, ultrasound probe **610** may be used to implement ultrasound probe **12** shown in FIG. **1**. Ultrasound probe **610** may include fluid ingress detector **615**. Fluid ingress detector **615** may include a dielectric property sensing circuit **620** coupled to a capacitor **625** including a soluble dielectric. In some embodiments, fluid ingress detector **615** may include multiple capacitors **625**. At least some of the dielectric may react (e.g., dissolve, absorb fluid) if ultrasound probe **610** experiences a fluid ingress. The dielectric properties (e.g., capacitance, impedance) of capacitor **625** may change when some or all of the dielectric reacts. The change in dielectric properties may be detected by the dielectric property sensing circuit **620**. Based on the detected change, the dielectric property sensing circuit **620** may transmit a signal indicating a fluid ingress. The signal may be provided to another component within the ultrasound probe **610** and/or the ultrasound system **605**. In some embodiments, the ultrasound system **605** may be replaced by a maintenance diagnostic system such as maintenance diagnostic system **42** shown in FIG. **1**. In some embodiments, ultrasound probe **610** may include multiple fluid ingress detectors **615**.

[0050] FIG. **6**B is a functional block diagram of a system **600**B for detecting a fluid ingress according to an embodiment of the disclosure. System **600**B may include an ultrasound probe **630**. In some embodiments, ultrasound probe **630** may be used to implement ultrasound probe **12** shown in FIG. **1**. Ultrasound probe **630** may include a capacitor **635** including a soluble dielectric. In some embodiments, ultrasound probe **630** may include multiple capacitors **635**. At least some of the dielectric may react (e.g., dissolve, absorb fluid) if ultrasound probe **630** experiences a fluid ingress. The dielectric properties (e.g., capacitance, impedance) of capacitor **635** may change when some or all of the dielectric reacts and/or dissolves. The change in dielectric properties may be detected by an external dielectric property sensing system **625** coupled to ultrasound probe **630**. In some embodiments, the external dielectric property sensing system **625** may be included with a maintenance diagnostic system, such as maintenance diagnostic device **42** shown in FIG. **1**. In some embodiments, the external dielectric property sensing system **625** may be included with an ultrasound imaging system, such as ultrasound imaging system **10** shown in FIG. **1**. Based on the detected change in dielectric properties, the dielectric property sensing device **625** may transmit a signal indicating a fluid ingress. The signal may be used to provide maintenance diagnostic information to a user or field engineer (e.g., error message, LED, audio signal).

[0051] FIG. **7** is an illustration of an example capacitive structure **700** that may be used to implement capacitors **625**, **635** according to embodiments of the disclosure. Capacitive structure **700** may include alternating PCA trace "fingers" which form two plates **705**, **710** of the capacitive structure **700**. Plate **705** and **710** may be spaced apart from one another. Although shown as straight lines, plates **705**, **710** may be implemented as other shapes. For example, plates **705**, **710** may be implemented as spirals or curved lines around other components included with the PCA. In some embodiments, a PCA may include multiple capacitive structures **700**. In some embodiments, the capacitive structure **700** is implemented on multiple PCA's. In some embodiments, plates **705**, **710** may be implemented as parallel lines that follow near seams in the ultrasound probe housing and/or other areas vulnerable to fluid ingress. In some embodiments, the capacitive structure **700** may be implemented on a flexible circuit.

[0052] FIGS. **8**A and **8**B are illustrations of cross-sectional views of capacitive structure **700** according to embodiments of the disclosure. In the example shown in FIGS. **8**A and **8**B, plates **705**, **710** are implemented on a PCA **805**. FIG. **8**A shows plates **705**, **710** covered in a soluble dielectric **810** prior to a fluid ingress. Soluble dielectric **810** coats plates **705**, **710** and fills the spaces between the "fingers." FIG. **8**B shows the capacitive structure **700** after a fluid ingress when some or all of soluble dielectric **810** has reacted and/or dissolved. Capacitive structure **700** may have a capacitance of 1-100 pF. The capacitance may be based, at least in part, on the size of the capacitive structure **700**, the number of capacitive structures **700** included in an ultrasound probe, a desired sensitivity of a fluid ingress detector, and/or the power specifications of the ultrasound probe. Depending on the nature of a fluid that invades the interior of the ultrasound probe, the fluid may leave a residue on the plates **705**, **710** even though some or all of the soluble dielectric **810** is dissolved. In some embodiments, the size of capacitance structure **700**, spacing between plates **705**, **710**, and/or a sensitivity of a dielectric property sensing circuit (e.g., dielectric sensing circuit **620**) may be selected based, at least in part, on the effects of the residue.

[0053] Capacitive structure **700** shown in FIGS. **7**, **8**A, and **8**B is provided for exemplary purposes. Other capacitive structures may be used to implement capacitors **625**, **635** in other embodiments.

[0054] FIG. **9** is an illustration of an example fluid ingress detector **900** according to an embodiment of the disclosure. Fluid ingress detector **900** includes first portion **905** and a second portion **910**. In some embodiments, the first portion **905** and second portion **910** may be implemented as conductive wires, traces, and/or plates. In some embodiments, the first portion **905** is implemented as a wire, trace, and/or plate and the second portion **910** is an interior surface of an ultrasound probe housing, for example, interior surface **221** of housing **222** of ultrasound probe **200** shown in FIG. **2**. In another example, the second portion **910** is a graphite block of a backing subassembly of an ultrasound probe, for example, backing subassembly **214** shown in FIG. **2**. The first portion **905** and second portion **910** may be different materials to form a galvanic sensor. For example, first portion **905** may be copper or a copper alloy and the second portion **910** may be aluminum, nickel-plated aluminum, or an aluminum alloy. In some embodiments, an ultrasound probe may include multiple fluid ingress detectors **900**.

[0055] As shown on the left-hand side of FIG. **9**, prior to a fluid ingress, first portion **905** and second portion **910** are not electrically coupled, forming an open circuit. Other sections of the first portion **905** and second portion **910** may be coupled to a sense circuit **915** in some embodiments. As shown on the right-hand side of FIG. **9**, during a fluid ingress, a fluid **920** may, at least temporarily, electrically couple first portion **905** and second portion **910**. This may form a closed circuit between the first portion **905** and the second portion **910**. In some embodiments, the fluid **920** may include a strong acid, base, and/or oxidative compound that may have a corrosive effect on the first portion **905** and/or second portion **910**. The galvanic sensor may generate a current and/or voltage responsive, at least in part, to the fluid **920**. The sense circuit **915** electrically coupled to the first portion **905** and second portion **910** may detect a change in voltage, resistance, and/or current. The detected change in voltage, resistance, and/or current may cause the sense circuit **915** to transmit a signal indicating a fluid ingress. The signal may be provided to another component within the ultrasound probe and/or an external system coupled to the ultrasound probe (not shown).

[0056] FIGS. **3-9** illustrate examples of fluid ingress detectors according to embodiments of the disclosure. An ultrasound probe and/or ultrasound imaging system may include a fluid ingress detection assembly including one or more of the example fluid ingress detectors. The fluid ingress detectors may be the same or may be different detector types. For example, an ultrasound probe, such as ultrasound probe **12** shown in FIG. **1** or ultrasound probe **200** shown in FIG. **2**, may include fluid ingress detector **300** and fluid ingress detector **400**. In another example, an ultrasound probe may include fluid ingress detector **500**A and an ultrasound imaging system may include fluid ingress detector **600**A. The examples are provided for illustrative purposes only, and other configurations of ultrasound probes and/or ultrasound imaging systems including fluid ingress detection assemblies as described herein may be implemented.

[0057] In some embodiments, a fluid ingress detection assembly including one or more of the fluid ingress detectors described in reference to FIGS. **3-9** may not include power sources. That is, the fluid ingress detection assembly may only detect and/or provide signals indicating fluid ingress when the ultrasound probe is coupled to an ultrasound imaging system or other external device that provides a power source. For example, a fluid ingress detector may be operable to detect a fluid ingress even without a power source, but the fluid ingress detection assembly may not provide an indication of the detected fluid ingress until the ultrasound probe is coupled to an ultrasound imaging system. In another example, a fluid ingress that occurs while the ultrasound probe is disconnected may not be detected until the ultrasound probe is coupled to an ultrasound imaging system and/or other power source.

[0058] In some embodiments, the fluid ingress detection assembly includes a battery or is electrically coupled to a battery included with the ultrasound probe. The fluid ingress detector of the fluid ingress detection assembly may detect fluid ingress and/or provide signals indicating fluid ingress when the ultrasound probe is not coupled to an external power source. For example, a fluid ingress detection assembly may provide a visual indicator (e.g., LED) on the exterior of an ultrasound probe even when the ultrasound probe is not coupled to an ultrasound imaging system. In some embodiments, such as the galvanic sensor-based fluid ingress detector shown in FIG. **9**, the fluid may provide a power source for the fluid ingress detector and/or fluid ingress detection assembly.

[0059] In some embodiments, the fluid ingress detection assembly may include or may be electrically coupled to a switch, latch, and/or clock. When a fluid ingress occurs, the external, battery, and/or galvanic power may allow a trigger of the switch, latch, and/or clock. The fluid ingress detector of the fluid ingress detection assembly may trigger the switch, latch, and/or clock via a sense circuit included with the fluid ingress detection assembly and/or electrically coupled to the fluid ingress detection assembly. The switch and/or latch may store a state that indicates a fluid ingress occurred. The clock may store a state that indicates a time when the fluid ingress occurred. The states of the switch, latch, and/or clock may be read the next time the ultrasound probe is coupled to a power source and/or a diagnostic process is run on the ultrasound probe by an ultrasound imaging system and/or diagnostic maintenance system.

[0060] FIG. **10** shows a circuit diagram of an exemplary sense circuit **1000** according to embodiments of the disclosure. Sense circuit **1000** may be coupled to the fluid ingress detectors described in reference to FIGS. **3-9**. Sense circuit **1000** may be coupled to a fluid ingress detector **1005**. Fluid ingress detector **1005** may be implemented by one or more of the fluid ingress detectors described in FIGS. **3-9**. In some embodiments, sense circuit **1000** may be included as an integral component of the fluid ingress detector **1005**. The fluid ingress detector **1005** may be coupled to a first resistance **1010** and a positive input of an operational amplifier (op-amp) **1015**. As shown, in some embodiments, the op-amp **1015** may be configured as a differential amplifier. The first resistance **1010** may be further coupled to a common voltage (e.g. 0 V, ground). The negative input of the op-amp **1015** may be coupled to a second resistance **1020**. The second resistance **1020** may be further coupled to the common voltage. The negative input of the op-amp **1015** and the output of the op-amp **1015** may be coupled by a third resistance **1025** and a capacitance **1030** coupled in parallel. The output of the op-amp **1015** may further be coupled to a fourth resistance **1035**. The fourth resistance **1035** may also be coupled to the base of a transistor **1040**. In some embodiments, the transistor **1040** is a NPN bipolar junction transistor. In some embodiments, the fourth resistance **1035** is omitted, and the output of op-amp **1015** is coupled to the base of transistor **1040**. The collector of the transistor **1040** may be coupled to a voltage source V_1. The emitter of the transistor **1040** may be coupled to the anode of a first diode **1045**. The cathode of first diode **1045** may be coupled to a fuse **1050**, which may be further coupled to the common voltage. The cathode of first diode **1045** may be further coupled to a fifth resistance **1065**. The fifth resistance **1065** may be coupled to a sixth resistance **1060** and the cathode of a second diode **1055**. The anode of the second diode **1055** may be coupled to a voltage source V_2.

[0061] A change in the voltage and/or current provided by the fluid ingress detector **1005** to the sense circuit **1000** may be amplified and output by the op-amp **1015**. The output may activate the transistor **1040** and allow a current to flow through the diode **1045** and generate an output. The output of the sense circuit **1000** may be provided to an external system **1070**. In some embodiments, external system **1070** may be an ultrasound imaging system coupled to an ultrasound probe including sense circuit **1000**. In some embodiments, external system **1070** may be a maintenance diagnostic system coupled to an ultrasound probe including sense circuit **1000**. In some embodiments, external system **1070** may be internal to an ultrasound probe that includes sense circuit **1000**, for example, an ultrasound probe that includes a fluid ingress indicator (e.g., LED, LCD screen, audio signal).

[0062] In an example embodiment of sense circuit **1000**, resistance **1010** may have a resistance of 1 MΩ, resistance **1020** may have a resistance of 1 kΩ, resistance **1025** may have a resistance of 20 kΩ, resistance **1065** may have a resistance of 1 kΩ, and resistance **1060** may have a resistance of 1 kΩ. Continuing this example, capacitance **1030** may have a capacitance of 0.01 μF. Voltage sources V_1 and V_2 may provide +5 V. Fuse **1050** may be a 50 mA fast fuse. Fuse **1050** may be a 100 mA fast fuse. Diodes **1045**, **1055** may be 1N4002 diodes. Transistor **1040** may be a 2N3904 transistor. The values of the resistances, capacitance, fuse, and voltage sources of sense circuit **1000** may be selected based, at least in part, on the power specifications of the ultrasound probe, power specifications of the ultrasound imaging system, the sensitivity of the fluid ingress detector, and/or power specifications of a maintenance diagnostic system.

[0063] Sense circuit **1000** is provided merely as an example sense circuit that may be used to implement one or more embodiments of the disclosure. Other sense circuits known in the art may be used to implement a sense circuit coupled to a fluid ingress detector.

[0064] 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.

[0065] 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.

[0066] 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 detection of fluid ingress in ultrasound transducers and method of operation thereof is provided. Another advantage of the present systems and method is that conventional medical imaging systems may be easily upgraded to incorporate the features and advantages of the present systems, devices, and methods.

[0067] 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.

[0068] 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.

1. An ultrasound probe comprising:
- a transducer assembly including an array of transducer elements;
- a housing enclosing at least a portion of the transducer assembly;
- a cable coupled to the housing;
- a connector coupled to the cable, the connector configured to couple the ultrasound probe to an ultrasound imaging system; and
- a fluid ingress detection assembly comprising:
  - a sense circuit, and
  - a fluid ingress detector configured to change from a first state to a second state responsive to ingress of fluid in an interior of the ultrasound probe, and wherein the sense circuit is operable to detect the change from the first state to the second state and generate a signal indicative of fluid ingress.

2. The ultrasound probe of claim **1**, wherein the fluid ingress detector comprises:
- a first conductive line;
- a second conductive line, wherein the first and second conductive lines are electrically coupled to the sense circuit;
- a conductive cantilever electrically coupled to the first conductive line; and
- a soluble epoxy, wherein the soluble epoxy electrically couples the conductive cantilever to the second conductive line.

3. The ultrasound probe of claim **2**, wherein the fluid ingress detector further comprises a spring coupled between the first conductive line and the conductive cantilever, wherein the spring biases the conductive cantilever away from the second conductive line.

4. The ultrasound probe of claim **2**, wherein the fluid ingress detector further comprises a lever coupled between the first conductive line and the conductive cantilever, wherein the lever biases the conductive cantilever away from the second conductive line.

5. The ultrasound probe of claim **2**, wherein the conductive cantilever is molded such that the conductive cantilever is biased away from the second conductive line.

6. The ultrasound probe of claim **2**, wherein the sense circuit is configured to sense at least one of a change in resistance, capacitance, and current when at least a portion of the soluble epoxy dissolves.

7. The ultrasound probe of claim **1**, wherein the fluid ingress detector comprises:

a first conductive line;

a second conductive line, wherein the first and second conductive lines are electrically coupled to the sense circuit;

a conductive cantilever electrically coupled to the first conductive line; and

a soluble epoxy, wherein the soluble epoxy electrically isolates the conductive cantilever and the second conductive line.

8. The ultrasound probe of claim **7**, wherein the fluid ingress detector further comprises a spring coupled between the first conductive line and the conductive cantilever, wherein the spring biases the conductive cantilever toward the second conductive line.

9. The ultrasound probe of claim **7**, wherein the fluid ingress detector further comprises a lever coupled between the first conductive line and the conductive cantilever, wherein the lever biases the conductive cantilever toward the second conductive line.

10. The ultrasound probe of claim **7**, wherein the conductive cantilever is molded such that the conductive cantilever is biased toward the second conductive line.

11. The ultrasound probe of claim **7**, wherein the sense circuit is configured to sense at least one of a change in resistance, capacitance, and current when at least a portion of the soluble epoxy dissolves.

12. The ultrasound probe of claim **1**, wherein the fluid ingress detector comprises:

a light source;

a soluble epoxy coating the light source, wherein the soluble epoxy blocks a light of the light source; and

a photodetector electrically coupled to the sense circuit, wherein the photodetector is configured to detect the light from the light source when at least some of the soluble epoxy dissolves and to generate a voltage or a current responsive to detecting the light of the light source, and wherein the sense circuit is configured to do something with the voltage or current.

13. The ultrasound probe of claim **12**, wherein the fluid ingress detector includes a plurality of light sources coated by the soluble epoxy.

14. The ultrasound probe of claim **12**, wherein the light source includes an infrared light source.

15. The ultrasound probe of claim **12**, wherein the photodetector includes a photodiode.

16. The ultrasound probe of claim **1**, wherein the fluid ingress detector comprises:

a first portion comprising a first material; and

a second portion comprising a second material different from the first material, wherein the first portion and second portion comprise a galvanic sensor;

wherein the first and second portions form a closed circuit when a fluid contacts the first and second portions and the sense circuit is configured to sense at least one of a voltage and a current from the galvanic sensor when the closed circuit is formed.

17. The ultrasound probe of claim **16**, wherein the first material comprises copper.

18. The ultrasound probe of claim **16**, wherein the second material comprises aluminum.

19. The ultrasound probe of claim **1**, further comprising a latch electrically coupled to the sense circuit, wherein the sense circuit triggers the latch to store a state indicating a fluid ingress when the sense circuit detects the change from the first state to the second state.

20. The ultrasound probe of claim **1**, further comprising a clock electrically coupled to the sense circuit, wherein the sense circuit triggers the clock to store a time of a fluid ingress when the sense circuit detects the change from the first state to the second state.

21. An ultrasound imaging system comprising:

an ultrasound probe including a capacitor including a soluble dielectric; and

a dielectric property sensing circuit electrically coupled to the ultrasound probe, wherein the capacitance sensing circuit is configured to detect a change in a dielectric property of the capacitor when at least some of the soluble dielectric reacts.

22. The ultrasound system of claim **21**, wherein the dielectric property sensing circuit is included with the ultrasound probe.

23. The ultrasound system of claim **21**, wherein the capacitor comprises a first plate and a second plate spaced from the first plate, wherein the soluble dielectric coats the first and second plates and fills a space between the first and second plates.

24. The ultrasound system of claim **23**, wherein the first place and second plate form two parallel lines.

25. The ultrasound system of claim **21**, wherein the capacitor is implemented on a printed circuit assembly.

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专利名称(译)	用于超声换能器的流体进入检测的系统，方法和设备		
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摘要(译)

公开了用于检测超声探头中的流体进入的系统，方法和设备。可以通过流体入口检测组件的流体入口检测器的电阻，电容和/或电流的变化来检测流体入口。公开了一种包括可溶性材料的流体进入检测器。公开了一种包括电流传感器的流体进入检测器。流体进入检测器可将指示流体进入的信号提供给超声成像系统和/或维护诊断系统。