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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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(54) Title: MATRIX ULTRASOUND PROBE WITH PASSIVE HEAT DISSIPATION

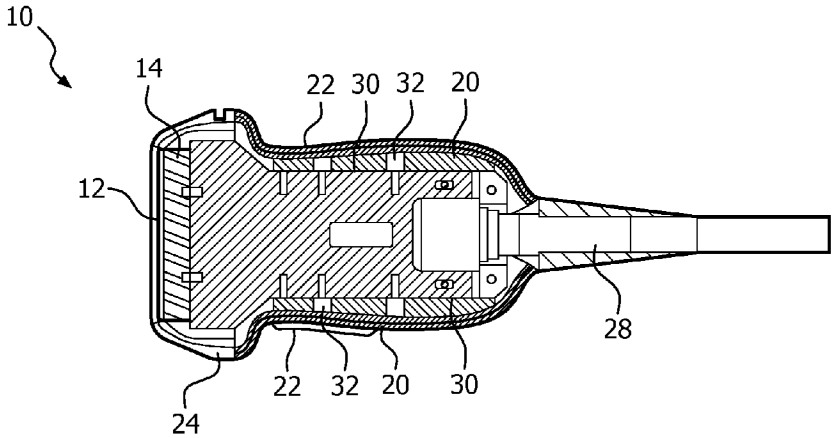

FIG. 2

(57) Abstract: A matrix array ultrasound probe passively dissipates heat developed by the matrix array transducer and beamformer ASIC away from the distal end of the probe. The heat developed in the transducer stack is coupled to a metallic frame inside the handle of probe. A metallic heatspreader is thermally coupled to the probe frame to convey heat away from the frame. The heatspreader surrounds the inside of the probe handle and has an outer surface which is thermally coupled to the inner surface of the probe housing. Heat is thereby coupled evenly from the heatspreader into the housing without the development of hotspots in the housing which could be uncomfortable to the hand of the sonographer.

WO 2012/156886 A1

MATRIX ULTRASOUND PROBE WITH PASSIVE HEAT DISSIPATION

This invention relates to medical diagnostic systems and, in particular, to matrix array transducer probes with passive heat dissipation.

Conventional one dimensional (1D) array transducer probes for two dimensional (2D) imaging are actuated by transmit drive circuitry located in the system mainframe. The probe cable is plugged into the system mainframe and the transducer elements of the array at the probe face are driven for transmission by the drive circuitry in the mainframe system. While the heat generated by piezoelectric actuation of the transducer elements must be dissipated by the probe, the heat generated by the high voltage drive circuitry in the system mainframe can be relatively easily dissipated by the system. However, solid-state 3D imaging probes have a two dimensional matrix of transducer elements numbering in the thousands, and a cable with thousands of coaxial drive signal conductors is impractical. Consequently a beamformer ASIC (microbeamformer) is employed in the probe with integrated drive circuitry and receive circuitry for the transducer elements in the probe itself. The beamformer ASIC controls and performs at least part of the transmit and receive beamforming so that only a relatively few signal path conductors are needed in the cable, enabling the use of a practical, thin cable for the 3D imaging probe.

With the transmit beamforming ASIC and drive circuitry in the probe, the heat generated by this circuitry must now be dissipated from the probe, not the system mainframe. Since the beamforming ASIC is attached directly behind the transducer array, the heat of the transducer stack and ASIC is now at the front of the probe, just behind the lens which contacts the patient. Various approaches have been taken in the past to dissipate heat from the front of an ultrasound probe. One approach shown in US Pat. 5,213,103 (Martin et al.) is to use a heatsink extending from the transducer at the front of the probe to the cable braid at the back. Heat is conducted away from the transducer by the heatsink and into the cable braid, from which it dissipates through the cable and the probe housing. Martin et al. are only transporting the heat from the piezoelectric transducer without the drive circuitry, as the drive circuitry for the Martin et al. probe is presumably in the system mainframe. A more aggressive approach to cooling is to use active cooling as described in US Pat. 5,560,362 (Sliwa, Jr. et al.) or a thermoelectric cooler as described in US Pat. pub. no. US 2008/0188755 (Hart). Active cooling with a coolant requires the necessary space and apparatus to circulate the coolant as well as the hazard of coolant leaks, and both approaches complicate the component complexity and spacing inside the probe. What is needed is a passive cooling technique which is more effective than that of Martin et al. and without the complications of the active cooling approaches. It is further desirable for such a passive cooling technique to avoid the development of hotspots in the probe which can concentrate heat at a specific point or points of the probe case and hence into the hand of the probe user.

In accordance with the principles of the present invention, a matrix array ultrasound probe is described which uses passive heat dissipation to dissipate heat generated by a matrix array transducer and ASIC. The heat generated by these elements is conducted to a heat spreader which distributes the heat through a surface area beneath the probe housing. The distribution of heat by the heat spreader prevents the buildup of hotspots at a particular point or points of the handle portion of the probe housing. The distributed heat is then dissipated through the probe housing and probe cable.

In the drawings:

FIGURE 1 illustrates a first cross-sectional view of matrix array ultrasound probe constructed in accordance with the principles of the present invention.

FIGURE 2 illustrates a second cross-sectional view, orthogonal to FIGURE 1, of a matrix array probe constructed in accordance with the principles of the present invention.

FIGURE 3 is a quarter-section cross sectional view of the matrix array probe of FIGURES 1 and 2.

FIGURE 4 illustrates a matrix array transducer stack, ASIC, and backing block mounted on a thermally conductive probe frame.

FIGURE 5 is a perspective view of one-half of a heat spreader for a matrix array probe.

FIGURE 6 illustrates the matrix array probe of the previous drawings assembled with one-half of the probe housing removed.

FIGURE 7 illustrates a probe housing which is molded around one-half of a heat spreader.

FIGURE 8 is an exploded assembly drawing of the major component parts of the matrix array probe of FIGURES 1-6.

Referring first to FIGURE 1, a matrix array ultrasound probe 10 constructed in accordance with the principles of the present invention is shown in cross-section. The probe 10 has an outer case 22 which forms the handle portion of the probe which is held by a sonographer when using the probe. The distal end of the probe is enclosed by a nosepiece housing 24. Behind a lens 36 covering the distal end is a matrix array transducer backed by an ASIC, both of which are indicated at 12. The integrated circuitry of the ASIC controls transmission by the transducer elements and performs both transmit and receive beamforming of signals transmitted and received by the array. An interposer can be employed if desired to couple the elements of the transducer array to the circuitry of the ASIC. One such interposer is described in international patent pub. WO 2009/083896 (Weekamp et al.), for instance. Behind the matrix array transducer and ASIC is a graphic backing block 14 which attenuates acoustic reverberations from the back of the matrix array and conducts heat developed in the matrix array and ASIC away from the distal end of the probe. Further details of the graphic backing block may be found in co-pending U.S. patent application no. 61/453,690, filed March 17, 2011. An aluminum or magnesium probe frame 16 is in thermally conductive contact with the back of the graphite backing block to conduct heat further away from the distal end of the probe. The frame 16 also mounts electrical components of the probe which themselves are mounted on two printed circuit boards and occupy the space inside the probe indicated by 18. At the back of the probe and extending from the proximal end of the probe is a probe cable 28. The cable 28 is clamped to the rear of the frame by a clamp 26.

Surrounding the frame 16 in the handle portion of the probe is a heatspreader 20. The heatspreader is in thermally conductive contact with the two sides of the frame 16 as shown in FIGURE 2. This thermal contact is promoted by a thermal gasket such as one formed with thermally conductive tape or a thermal compound (putty) where the heatspreader 20 contacts the sides of the frame 16 at 30. The heatspreader 20 is held in place against the frame 16 and its thermal coupling by screws at 32. FIGURE 3 is a one-quarter cross-sectional view of the probe of FIGURES 1 and 2 showing a printed circuit board 34 on top of the frame 16 and the heatspreader 20 surrounding the frame 16 and printed circuit boards in the handle portion of the probe.

FIGURE 4 is a perspective view of one embodiment of the frame 16 with the graphite backing block 14 and matrix array transducer and ASIC 12 mounted on top of the frame and in thermally conductive contact with the frame. In this embodiment there are flanges 38 on the sides of the frame 16 to which the heatspreader is attached for efficient heat conduction from the frame to the heatspreader.

FIGURE 5 illustrates one implementation of a heatspreader 20. In this implementation the heatspreader is formed as two clamshell halves which fit together at diagonally located edges. The half illustrated in the view of FIGURE 5 surrounds the inside of the handle portion of the housing 22 on the back and top, and its mating half surrounds the front and bottom of the handle interior. Visible in this view are two holes through which screws are inserted to fasten the heatspreader to one side of the frame 16.

FIGURE 7 illustrates another implementation of the heatspreader in which the housing 22 is molded around the metal heatspreader. In this implementation the handle portion 22 and the nosepiece 24 are molded as a single housing 22′ which is formed around the heatspreader 20′ so that the heatspreader 20′ surrounds not only the volume inside the handle, but also extends forward to surround the transducer stack in the distal end of the housing. The heatspreader 20′ will thus be in direct thermally conductive contact with the graphite backing block which carries heat away from the matrix array and ASIC 12. Heat in the distal end of the probe will therefore be carried to the rear of the probe and dissipated by both the probe frame 16 and the heatspreader 20′.

FIGURE 6 is a plan view of an assembled probe 10 of the present invention with the nosepiece and half of the housing 22 removed. This view shows the heatspreader 20 completely enclosing the frame 16 and printed circuit boards inside the handle portion of the housing 22. The heatspreader 20 conducts heat over its entire area, avoiding the buildup of hotspots at particular points inside the housing. The development of such hotspots can be felt by the hand of the sonographer using the probe and, while they may not be sufficient to pose a danger, they can make use of the probe uncomfortable. A benefit of the present invention is that heat is distributed throughout the heatspreader inside the housing and individual hotspots will not develop. The heat conducted by the heatspreader is conducted from the outer surface of the heatspreader 20 to the inner surface of the housing 22 from which it dissipates through the housing and into the air. To promote the transfer of heat into the housing 22 from the heatspreader 20, a layer of thermal putty may be spread between the heatspreader and the housing, carrying heat into the housing over its entire inner surface area and further preventing the buildup of hotspots in the housing.

FIGURE 8 is an exploded view showing the assembly of a probe 10 of the present invention including many of the components described above. The transducer stack, including the matrix array transducer and beamformer ASIC 12 and the graphite backing block 14 (not shown in this drawing) are fastened to the top of the probe frame 16 as shown in previous drawings. Printed circuit boards 18a and 18b are fastened to opposite sides of the frame 16. Wires from the cable 28 are connected to connectors on the printed circuit boards and a clamp 26a and 26b is clamped around the strain relief and braid of the cable 28 and the clamp is also clamed to two rails 17a and 17b extending from the proximal end of the frame 16. This coupling of the proximal end of the frame 16 to the cable braid promotes the transfer of heat from the frame into the cable braid and away from the probe. A thermal gasket or thermal putty covers the surfaces of the flanges 38 of the frame 16 and the two halves 20a and 20b of the heatspreader are fastened to the flange sides of the frame 16 with screws. The nosepiece 24 and lens 36 are placed on the distal end of the assembly over the transducer stack. The outer surface of the assembled heatspreader (or the inner surfaces of the housing halves) are coated with thermal putty and the housing is put in place around and in contact with the heatspreader and thermal putty with the seams of the housing and nosepiece sealed to prevent fluid ingress. The assembled probe is now ready for final testing and delivery to a user.

WHAT IS CLAIMED IS:

1. An ultrasonic transducer array probe comprising:

a transducer stack having an array of transducer elements coupled to an application specific integrated circuit (ASIC) for a transducer array;

a thermally conductive frame which is thermally coupled to the transducer stack;

a housing forming a probe handle and enclosing at least a portion of the frame; and

a thermally conductive heatspreader which is thermally coupled to the frame and exhibits an outer surface area which aligns with and is thermally coupled to an inner surface area of the housing to prevent the development of hotspots in the housing.

2. The ultrasonic transducer array probe of Claim 1, wherein the array of transducer elements further comprises a two dimensional matrix array of transducer elements.

3. The ultrasonic transducer array probe of Claim 2, wherein the ASIC further comprises a beamformer ASIC which at least partially beamforms transmit beams from the matrix array and echo signal received by elements of the matrix array.

4. The ultrasonic transducer array probe of Claim 1, wherein the transducer stack further comprises a thermally conductive backing block located between the ASIC and the frame.

5. The ultrasonic transducer array probe of Claim 1, further comprising a thermal gasket or

thermal putty which provides thermal coupling between the frame and the heatspreader.

6. The ultrasonic transducer array probe of Claim 5, wherein the frame has side flanges, and wherein the heatspreader is fastened in thermally conductive contact with the side flanges of the frame.

7. The ultrasonic transducer array probe of Claim 6, wherein the heatspreader is screwed or bolted to the side flanges of the frame.

8. The ultrasonic transducer array probe of Claim 1, further comprising a thermal gasket or thermal putty which provides thermal coupling between the heatspreader and the housing.

9. The ultrasonic transducer array probe of Claim 1, wherein the transducer stack further comprises a thermally conductive backing block located between the ASIC and the frame,

wherein the heatspreader is directly thermally coupled to the backing block.

10. The ultrasonic transducer array probe of Claim 1, further comprising a printed circuit board fastened to the frame.

11. The ultrasonic transducer array probe of Claim 1, further comprising a probe cable having a metallic braid,

wherein the frame is further thermally coupled to the metallic braid of the cable.

12. The ultrasonic transducer array probe of Claim 1, wherein the heatspreader is made of aluminum or magnesium.

13. The ultrasonic transducer array probe of Claim 12, wherein the frame is made of aluminum or magnesium.

14. The ultrasonic transducer array probe of Claim 1, wherein at least a portion of the housing is molded around at least a portion of the heatspreader to form a one-piece unit.

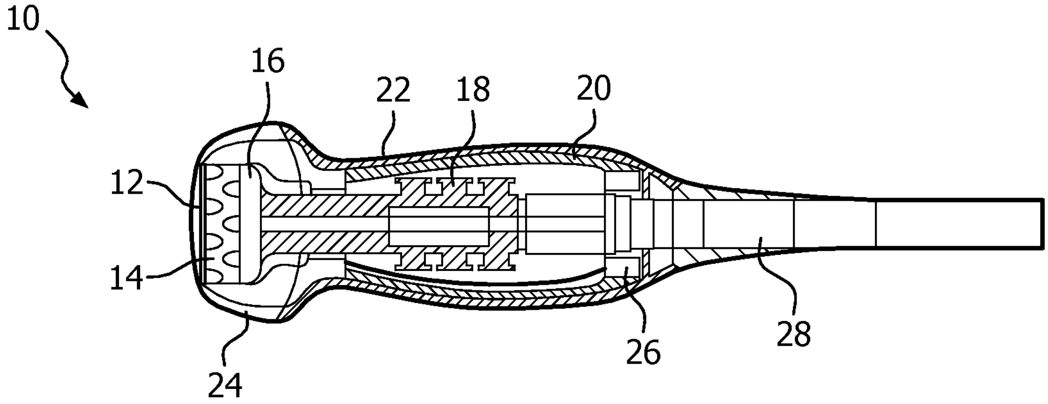

FIG. 1

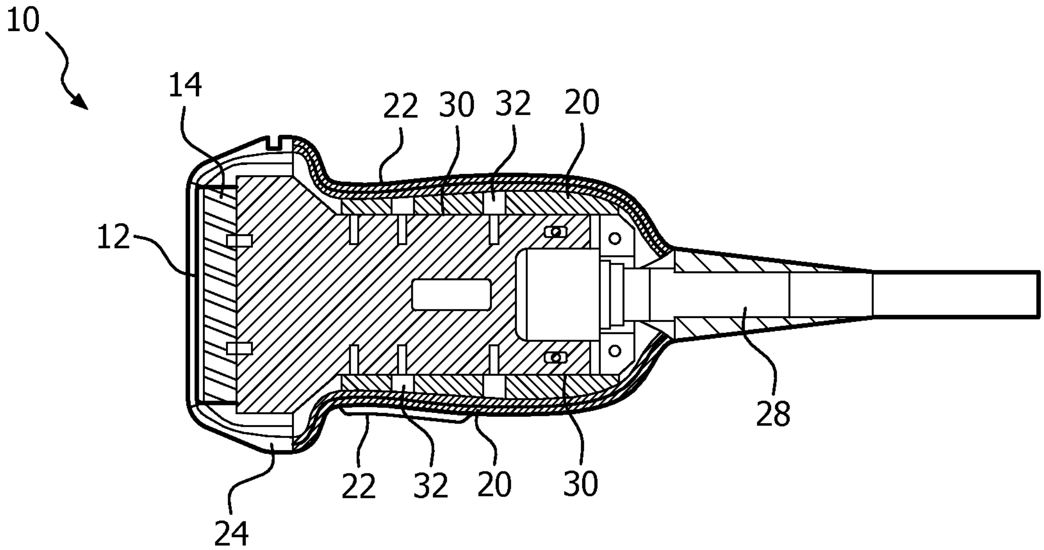

FIG. 2

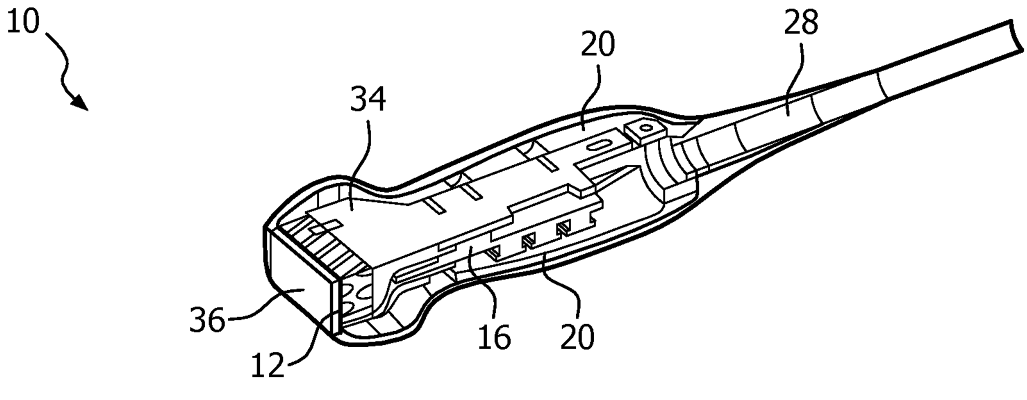

FIG. 3

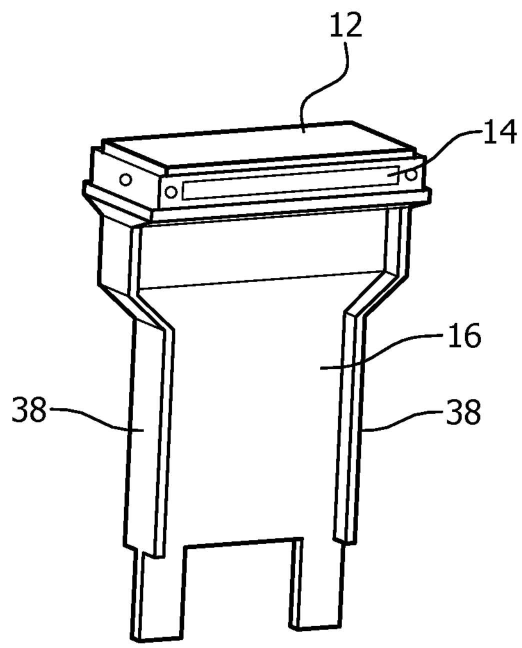

FIG. 4

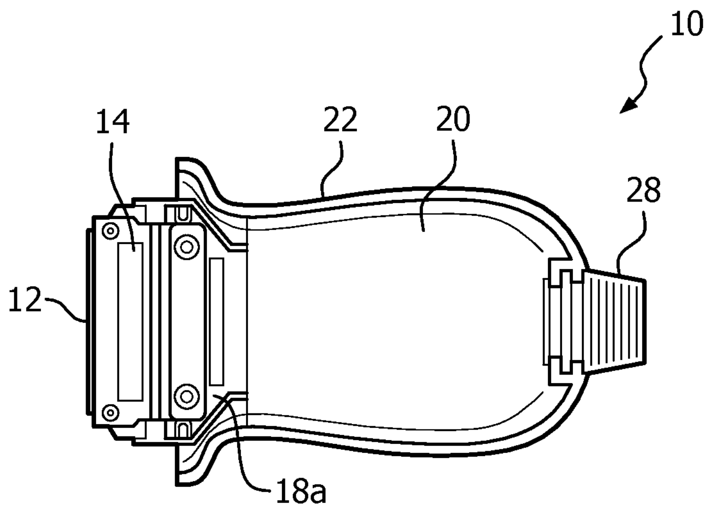

FIG. 6

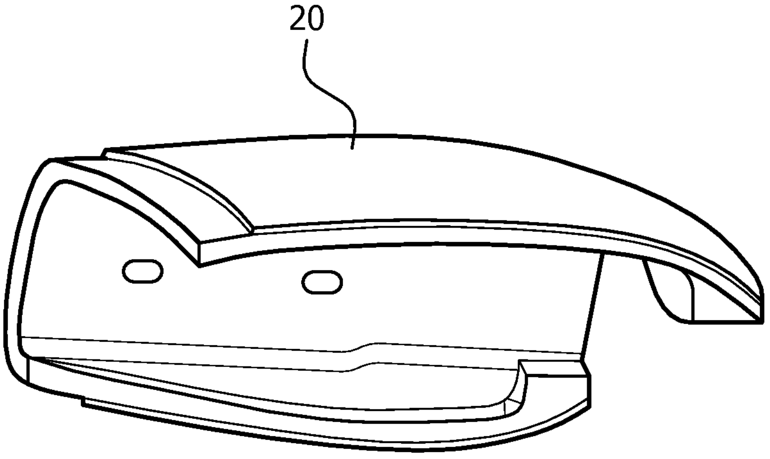

FIG. 5

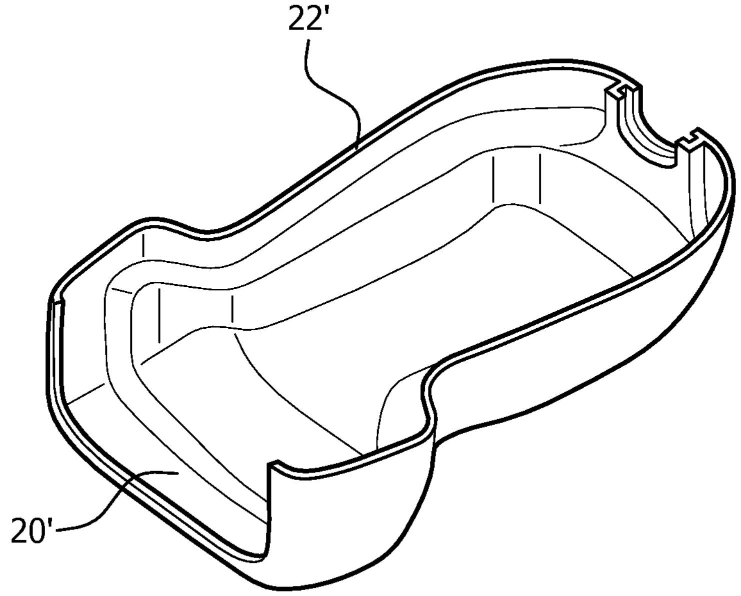

FIG. 7

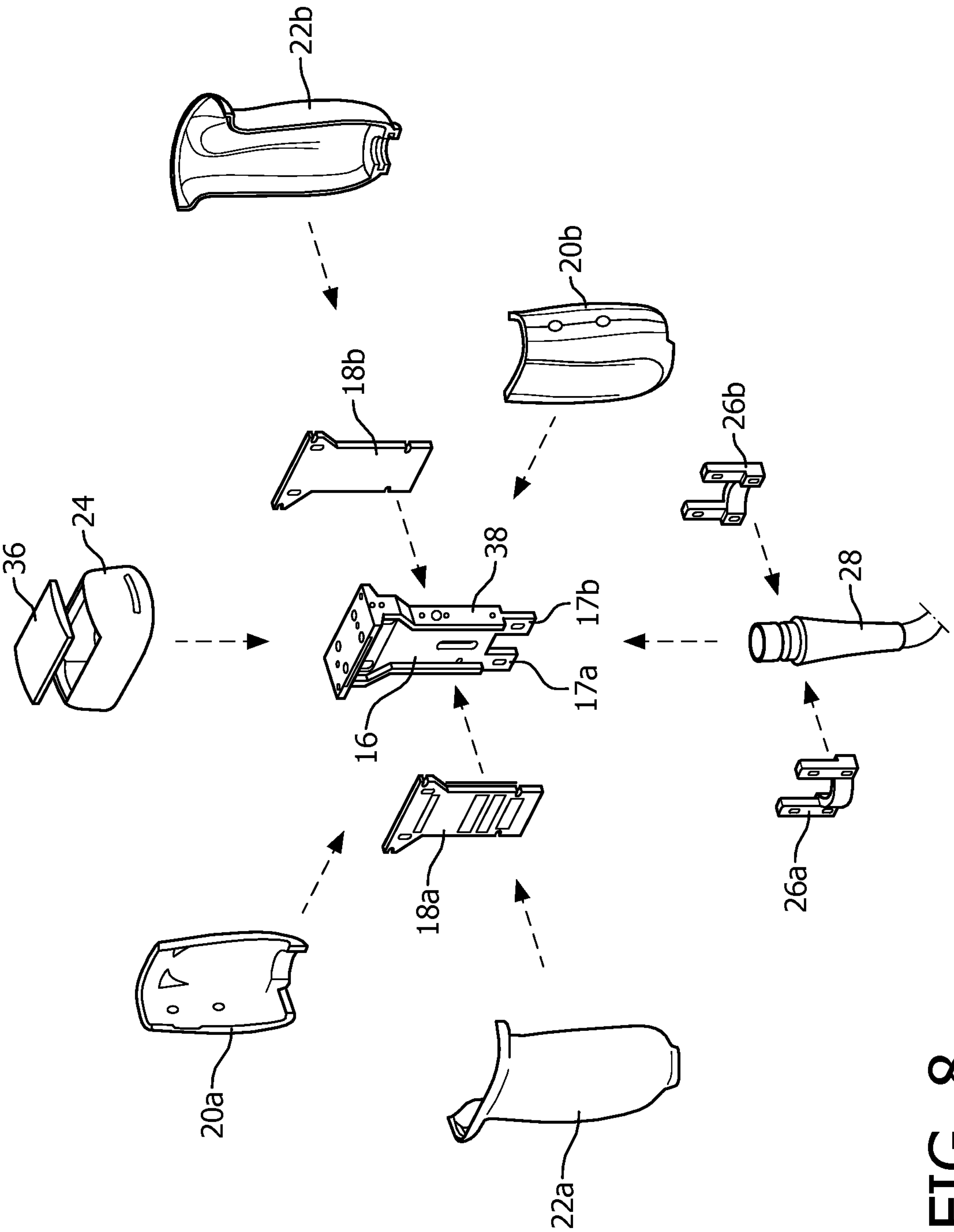

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/052364

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B8/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 652 476 A2 (TOSHIBA KK [JP]; TOSHIBA MEDICAL SYS CORP [JP]) 3 May 2006 (2006-05-03)	1-3,7, 10,13,14
Y	fig. 10, (48), (50), (47), (45), (52) paragraph 87 & 93 & 94 & 90	7

Y	EP 1 671 588 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 21 June 2006 (2006-06-21) figure 8	7

X	US 2009/227910 A1 (PEDERSEN LAUST G [US] ET AL) 10 September 2009 (2009-09-10) (16); paragraphs [0079], [0081]; figure 8	1-3,10, 14

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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Date of the actual completion of the international search	Date of mailing of the international search report
18 July 2012	26/07/2012

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/052364

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/083896 A2 (KONINKL PHILIPS ELECTRONICS NV [NL]; WEEKAMP JOHANNES WILHELMUS [NL];) 9 July 2009 (2009-07-09) (18); page 11, lines 8-10; figures 1A, 1B, 1C, -----	1-4,9,10
X	WO 2010/150539 A1 (TOSHIBA KK [JP]; TOSHIBA MEDICAL SYS CORP [JP]; MIYAJIMA YASUO [JP]) 29 December 2010 (2010-12-29) (202), (204); paragraphs [0016] - [0017] -----	1,3,4,9
X	US 5 545 942 A (JASTER HEINZ [US] ET AL) 13 August 1996 (1996-08-13) (22), (4), (6),(26), (18); column 4, lines 2-47; figure 3 -----	1,3-6,8, 9,11,12, 14
X	JP 2006 025892 A (TOSHIBA CORP; TOSHIBA MEDICAL SYS CORP) 2 February 2006 (2006-02-02) (3a) -----	1,3
A	US 5 213 103 A (MARTIN GLENN [US] ET AL) 25 May 1993 (1993-05-25) (54); column 4, lines 18-29 -----	1
A,P	EP 2 366 430 A1 (ENRAF NONIUS B V [NL]) 21 September 2011 (2011-09-21) the whole document -----	1
A	JP 2 203846 A (ALOKA CO LTD) 13 August 1990 (1990-08-13) abstract -----	1
A	US 5 961 465 A (KELLY JR WALTER PATRICK [US] ET AL) 5 October 1999 (1999-10-05) figures 7a,7b -----	1
A	US 2005/075573 A1 (PARK WILLIAM J [US] ET AL) 7 April 2005 (2005-04-07) (15); paragraph [0019] -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2012/052364

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1652476 A2	03-05-2006	CN 102068278 A	25-05-2011
		EP 1652476 A2	03-05-2006
		EP 1792571 A1	06-06-2007
		EP 1806097 A1	11-07-2007
		US 2006100513 A1	11-05-2006
EP 1671588 A1	21-06-2006	CN 1859871 A	08-11-2006
		EP 1671588 A1	21-06-2006
		JP 4624659 B2	02-02-2011
		JP 2005103078 A	21-04-2005
		US 2007276248 A1	29-11-2007
		WO 2005030055 A1	07-04-2005
US 2009227910 A1	10-09-2009	NONE	
WO 2009083896 A2	09-07-2009	CN 101911178 A	08-12-2010
		US 2012143060 A1	07-06-2012
		WO 2009083896 A2	09-07-2009
WO 2010150539 A1	29-12-2010	CN 102223844 A	19-10-2011
		JP 2011004868 A	13-01-2011
		KR 20110069162 A	22-06-2011
		US 2011230767 A1	22-09-2011
		WO 2010150539 A1	29-12-2010
US 5545942 A	13-08-1996	NONE	
JP 2006025892 A	02-02-2006	JP 4602013 B2	22-12-2010
		JP 2006025892 A	02-02-2006
US 5213103 A	25-05-1993	DE 69327413 D1	03-02-2000
		DE 69327413 T2	07-09-2000
		EP 0553804 A2	04-08-1993
		JP 6022955 A	01-02-1994
		US 5213103 A	25-05-1993
EP 2366430 A1	21-09-2011	EP 2366430 A1	21-09-2011
		US 2011230794 A1	22-09-2011
JP 2203846 A	13-08-1990	JP 2065214 C	24-06-1996
		JP 2203846 A	13-08-1990
		JP 7106201 B	15-11-1995
US 5961465 A	05-10-1999	DE 29822346 U1	25-02-1999
		JP 3061292 U	17-09-1999
		US 5961465 A	05-10-1999
US 2005075573 A1	07-04-2005	DE 102005001673 A1	13-10-2005
		US 2005075573 A1	07-04-2005

patsnap

专利名称(译)	具有被动散热的矩阵式超声探头		
公开(公告)号	EP2709530A1	公开(公告)日	2014-03-26
申请号	EP2012726216	申请日	2012-05-11
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	DAVIDSEN RICHARD EDWARD FREEMAN STEVEN RUSSELL SAVORD BERNARD JOSEPH		
发明人	DAVIDSEN, RICHARD, EDWARD FREEMAN, STEVEN, RUSSELL SAVORD, BERNARD, JOSEPH		
IPC分类号	A61B8/00		
CPC分类号	A61B8/4209 A61B8/546 G01S7/5208 G01S7/52096 G01S15/8925 A61B8/4444 A61B8/4494		
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摘要(译)

矩阵阵列超声探头被动地消散由矩阵阵列换能器和波束形成器ASIC产生的热量远离探头的远端。在换能器叠层中产生的热量耦合到探针手柄内的金属框架。金属散热器热耦合到探头框架以将热量传递离开框架。散热器围绕探头手柄的内部并具有外表面，该外表面热耦合到探头外壳的内表面。因此，热量从散热器均匀地耦合到壳体中，而不会在壳体中产生热点，这对于超声波检查者的手来说可能是不舒服的。