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(54) **Focused ultrasound transducers and systems**

Fokussierte Ultraschallwandler und Systeme

Transducteurs et systèmes à ultrasons focalisés

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US-A- 4 248 090 **US-A- 4 572 201**

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to ultrasonic imaging catheters, and more particularly, to ultrasonic transducers providing improved resolution for such catheters.

[0002] Intravascular imaging of blood vessels and surrounding tissues continues to be of great benefit in a wide range of medical fields. US 4 572 201 discloses a probe that is inserted into a lumen of a patient and comprises an elliptical transducer at its tip. A particularly successful design for an intravascular imaging catheter 10 is shown in Figs. 1A and 1B. Catheter 10 employs a rotatable imaging assembly 12 having a distal end 16 and a proximal end. An ultrasound transducer 14 is attached to distal end 16. The proximal end is operably attached to a flexible drive cable (not shown). Transducer 14 typically is elliptical in shape with a flat outer face. The transducer outer face has its major axis aligned with a longitudinal axis 20 of the imaging assembly 12. In other cases, the transducer 14 is round in shape with a flat outer face as shown in Fig. 1C.

[0003] During operation, a flexible sheath 18 is inserted into a patient with the drive cable and imaging assembly 12 disposed within sheath 18. The imaging assembly 12 typically is rotated within sheath 18 during transmission of ultrasound signals into the patient. During rotation of imaging assembly 12, transducer 14 projects ultrasound signals into a 360 degree image plane. The image plane has an in-plane or X-plane component 22 created primarily by the rotation of transducer 14. The image plane also has a cross-plane or Y-plane component 24 created primarily by the length of the major axis of transducer 14 for the transducer shown in Fig. 1B. The transducer element 14 is connected to electronics, typically maintained outside the patient's body, to produce a video image of at least a portion of the image plane by well-known techniques.

[0004] To produce images, it is desirable to have ultrasound signals transmitted by transducer 14 pass through sheath 18 and reflect off of tissue or fluids. However, a portion of the ultrasound signals transmitted by the transducer 14 typically are reflected by the sheath 18. Another portion of the ultrasound signals pass through sheath 18, but are refracted by sheath 18 during passage.

[0005] Due at least in part to the sheath effects on the ultrasound signal and to the shape of the transducer, ultrasound signals typically have a different in-plane profile than a cross plane profile. The in-plane profile typically is narrower or tighter than the cross-plane profile. This can be seen by comparing Fig. 2A (depicting an in-plane profile 26 for a round transducer) with Fig. 2B (depicting a cross-plane profile 28 for a round transducer). Further, the in-plane profile 26 has a focal length that is shorter compared to the focal length in the cross-plane profile

28. As a result, the transducer 14 has better lateral resolution in the in-plane direction 22 than in the cross-plane direction 24.

[0006] It is desirable, therefore, to produce a tighter beam profile in the cross-plane direction so that the focal point is closer to the transducer surface. Improved cross-plane lateral resolution will result. It is further desirable to provide a more circular or symmetrical cross-section for the ultrasound signal profile, so that lateral resolution is similar for both the in-plane and cross-plane.

SUMMARY OF THE INVENTION

[0007] According to the invention, there is provided an ultrasound imaging assembly for an ultrasound imaging catheter, comprising: a housing having a distal end, a proximal end, and a longitudinal axis; and a transducer element having a curved outer face, said outer face having a first radius of curvature in a first plane extending along a first axis and a second radius of curvature in a second plane extending along a second axis; wherein said transducer element is operably attached to said distal end and said first axis is parallel to said longitudinal axis; said second radius of curvature being greater than said first radius of curvature.

[0008] In one embodiment, the first axis is a major axis of the outer face and the second axis is a minor axis of the outer face. Alternatively, the first axis is a minor axis of the outer face and the second axis is a major axis of the outer face. In this manner, elliptical or oval transducers are used. Alternatively, the outer face is generally round.

[0009] In still another embodiment, the transducer element further includes a second face spaced apart from the outer face to define a transducer thickness therebetween. In one embodiment, the second and outer faces are both curved so that the transducer thickness is generally uniform. Alternatively, the transducer thickness varies by having the outer face curved relative to the second face.

[0010] In one embodiment, the imaging assembly further includes a matching layer having first and second faces defining a matching layer thickness therebetween. Matching layer second face is coupled to the transducer element outer face. In one embodiment, the matching layer thickness is generally uniform. Alternatively, the matching layer first face is generally flat so that the matching layer thickness varies. In one particular embodiment, the matching layer thickness increases from a center of the transducer element to a periphery of the transducer element.

[0011] The transducer element may have a generally elliptical outer face.

[0012] The present invention further provides ultrasound imaging catheters having an imaging assembly according to the invention and which include a drive cable coupled to the proximal end and a sheath into which the imaging assembly and drive cable are disposed. In one

particular embodiment, the sheath includes polyethylene.

[0013] Other features and advantages of the invention will appear from the following description in which the preferred embodiment has been set forth in detail in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1A provides a side cross-sectional view of a prior art imaging catheter;

Figs. 1B and 1C provide alternative side cross-sectional views of the prior-art imaging catheter of Fig. 1A.

Figs. 2A-2B depict an in-plane profile and a cross-plane profile, respectively, of the imaging catheter shown in Figs. 1A and 1C.

Fig. 3A depicts a top view of an exemplary imaging assembly according to the present invention;

Figs. 3B-3C depict cross-sectional side and cross-sectional front views, respectively, of the transducer included in the embodiment shown in Fig. 3A;

Fig. 4 depicts the top view of an alternative imaging assembly according to the present invention;

Figs. 5A-5E depict alternative embodiments of a transducer and matching layer package for use in imaging assemblies of the present invention; and

Figs. 6-8 depict exemplary imaging catheters according to the present invention.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

[0015] Fig. 3 depicts an exemplary imaging assembly 50 according to the present invention. Imaging assembly 50 has a distal end 56 and a proximal end 57. Proximal end 57 is adapted to be operably attached to a drive cable (not shown). Exemplary drive cables are described in U.S. Patent Application Serial No. 09/017,578, entitled "Integrated Coaxial Transmission Line and Flexible Drive Cable". The drive cable rotates imaging assembly 50 during operation.

[0016] A transducer element 54 is operably attached to distal end 56. Transducer element 54 may include a backing material (not shown) and one or more matching layers (not shown) operably attached to opposing surfaces of transducer element 54. Transducer element 54 is generally elliptical or oval shaped, and has a major axis 58 and a minor axis 60.

[0017] During rotation of imaging assembly 50, transducer 54 projects ultrasound signals into a 360 degree image plane. The image plane has an in-plane or X-plane component 62 created primarily by the rotation of transducer 54. The image plane also has a cross-plane or Y-plane component 64 created primarily by the length of major axis 58 of transducer 54.

[0018] As shown in Figs. 3B and 3C, transducer ele-

ment 54 has a first radius of curvature (ROC) 68 along major axis 58, and a second ROC 66 along minor axis 60. As shown, ROC 68 is smaller than ROC 66. In other words, the radius of curvature along minor axis 60 is greater than the radius of curvature along major axis 58. As a result, major axis 58 has a tighter focus due to the smaller radius of curvature. In one particular arrangement, ROC 68 is about 2.5 millimeters mm and ROC 66 is about 4.0 mm, although other ROCs may be used.

[0019] Similarly, transducer 54 has a focal length 70 for X-plane component 62 and a focal length 72 for Y-plane component 64. Typically the focal length of a transducer element is a function of the transducer element size and the frequency of signals transmitted therefrom. Curving transducer element 54 provides a focusing effect. By having a tighter radius of curvature along major axis 58, the focal length of transducer 54 in the cross-plane and in-plane can be generally equal notwithstanding the larger major axis length. In one arrangement, the cross-plane and in-plane focal lengths are between about 0.25 mm and about 2.5 mm. As a result, the imaging profile in both the cross-plane and in-plane are similar to that depicted in Fig. 2A.

[0020] Turning now to Fig. 4, another exemplary embodiment of the present invention will be described. Fig. 4 depicts an imaging assembly 100 with a transducer element 104 operably attached to a distal end 106 of the imaging assembly 100. Transducer element 104 has a major axis 108 and a minor axis 110. In one embodiment, major axis 108 is about 0.74 mm (0.029 inches) and minor axis 110 is about 0.64 mm (0.025 inches), although other dimensions may be used within the scope of the present invention. Transducer element 104 has a generally flat outer face.

[0021] Imaging assembly 100 is rotated by a drive cable (not shown) as previously discussed. During rotation of imaging assembly 100, transducer 104 projects ultrasound signals into a 360 degree image plane. The image plane has an in-plane or X-plane component 112 created primarily by the rotation of transducer 104, and a cross-plane or Y-plane component 114 created primarily by the length of minor axis 110. In this embodiment, major axis 108 is aligned with in-plane 112, and minor axis 110 is aligned with cross-plane 114. Aligning the shorter, minor axis 110 of transducer 104 with the cross-plane compensates for at least some of the refractory effects of the sheath (not shown). As a result, ultrasound signals propagated into cross-plane 114 will have a tighter profile and a shorter focal length compared to those depicted in Fig. 2B. Hence, assembly 100 produces a more symmetrical beam profile than that depicted in Fig. 2.

[0022] In another embodiment, transducer 104 has a curved outer face. For example, transducer 104 can have a relatively uniform radius of curvature throughout. As with the embodiment described above with the flat transducer outer face, this embodiment relies primarily on the coaxial alignment of minor axis 110 with the imaging assembly longitudinal axis to provide improved cross-plane

resolution. Further, the beam profile is narrowed in both the in-plane and cross-plane directions by having a curved transducer outer face with a relatively uniform radius of curvature, compared to transducer 104 having a flat outer face.

[0023] In still another embodiment, transducer 104 has a radius of curvature profile similar to that described in conjunction with Fig. 3. In this embodiment, however, minor axis 110 has a tighter radius of curvature than the major axis 108 radius of curvature. In this manner, the cross-plane component 114 of the image plane has improved resolution due to minor axis 110 being generally aligned with the imaging assembly 100 longitudinal axis, and also due to minor axis 110 having a tighter radius of curvature profile.

[0024] Turning now to Figs. 5A-5E, exemplary transducer elements and matching layers for use with the present invention will be described. Figs. 5A-5C depict a tapered focus transducer package 150. Transducer package 150 includes a transducer 152 having an outer face 154 and a second face 156. Outer face 154 and second face 156 are spaced apart to create a transducer thickness 158. As shown in Figs. 5A-5C, outer face 154 is curved relative to second face 156. As a result, transducer thickness 158 varies across the transducer. Transducers of this type show an increase in bandwidth as compared to similar transducers of uniform thickness. Figs. 5A-5C further include a matching layer 160 having a matching layer first face 162 and a matching layer second face 164. Matching layer second face 164 is operably attached to transducer outer face 154 using epoxy or the like.

[0025] In the embodiment shown in Fig. 5A, matching layer 160 has a generally uniform thickness. In this manner, matching layer first face 162 and matching layer second face 164 have a similar curvature to that of transducer outer face 154. Alternatively, and as shown in Fig. 5B, matching layer first face 162 is generally flat. As a result, matching layer 160 thickness varies, with matching layer 160 being thickest near the center. Due to the diminutive sizes of transducer 152 and matching layer 160 for imaging catheters, a variable thickness matching layer 160 will likely not have severe detrimental effects to imaging performance as a result of varying thickness across matching layer 160. Further, it may be easier to manufacture matching layer first face 162 to be flat. Another embodiment, as shown in Fig. 5C, has matching layer 160 which is tapered and increases in thickness from the center of transducer element 152 towards the edge or periphery of transducer element 152 in the same fashion as the thickness of transducer element 152. The thickness of matching layer 160 varies in this embodiment so that the ratio of the matching layer 160 thickness to the thickness of transducer element 152 remains generally constant, or close to constant, throughout the transducer face 154.

[0026] As shown in Figs. 5D-5E, a true focus transducer package 170 can be used with the imaging assemblies

of the present invention, including imaging assemblies 50, 100. Figs. 5D-5E depict a true focus transducer 172 having an outer face 174 and a second face 176. Faces 174, 176 are spaced apart from one another to define a transducer thickness 178. For true focus transducer package 170, transducer thickness 178 is generally uniform across transducer 172. Figs. 5D and 5E further include a matching layer 180 having a matching layer first face 182 and a matching layer second face 184. Matching layer second face 184 is operably attached to transducer outer face 174 using an epoxy or the like. Again, matching layer 180 may have a uniform thickness (as shown in Fig. 5D) or a variable thickness (as shown in Fig. 5E).

[0027] Matching layers 160, 180 may comprise a wide range of materials, and preferably have an acoustic impedance less than the acoustic impedance of transducer 162, 172, respectively. Such matching layers 160, 180 help facilitate acoustic coupling with the tissue or fluid to be imaged. Matching layers of the present invention also may include a thermoplastic.

[0028] Turning now to Fig. 6, an exemplary imaging catheter 200 according to the present invention will be described. Catheter 200 includes an imaging assembly as previously described. Catheter 200 is depicted with imaging assembly 50, including transducer element 54 having a radius of curvature profile as previously described. However, it will be appreciated by those skilled in the art that imaging assembly 100, and other imaging assemblies, may be used with catheter 200 within the scope of the present invention.

[0029] Imaging assembly 50, as described hereinbefore in greater detail, is operably attached to a drive cable 210 for rotation of imaging assembly 50. Imaging assembly 50 and drive cable 210 are disposed within a sheath 220. In one embodiment, sheath 220 comprises polyethylene of high density, low density, combinations thereof, and the like. Preferably, sheath 220 has an acoustic impedance similar to the surrounding tissue or fluids being imaged to reduce the effects of reflected signals off of sheath 220. Drive cable 210 rotates during operation of transducer 54, as shown by an arrow 230. Transducer 54 propagates ultrasound signals into an image plane having an in-plane component 62 and a cross-plane component 64. Due in part to transducer 54 having a tighter radius of curvature in the cross-plane direction, the cross-plane component 64 has improved lateral resolution compared to the assembly depicted in Figs. 1A-1B.

[0030] Alternatively, in another embodiment, catheter 200 includes imaging assembly 100 as described in conjunction with Fig. 4. In this manner, catheter 200 has improved cross-plane lateral resolution, compared to the assembly depicted in Figs. 1A-1B, due to the alignment of transducer 104 minor axis 110 with the longitudinal axis of catheter 200. By also providing transducer 104 with a tighter ROC in the cross-plane direction than in the in-plane direction, cross-plane lateral resolution is further improved.

[0031] As shown in Fig. 7, the use of imaging assembly

50 having transducer 54 with the desired radius of curvature profile results in a generally circular focal plane 250. More specifically, the tighter radius of curvature of transducer 54 in the cross-plane direction, and/or having the minor axis of the transducer being parallel to the longitudinal axis of the catheter, tightens the cross-plane ultrasound profile a sufficient amount so that the focal length in the cross-plane direction and the focal length in the in-plane direction are generally equal. As a result, a tighter and more uniform ultrasound beam profile is produced.

[0032] Fig. 8 depicts still another embodiment of the present invention. Fig. 8 depicts an imaging catheter 80, ostensibly as described in conjunction with Figs. 6 and 7, except catheter 80 has a transducer element 82 having a generally round outer face. In this arrangement, transducer element 82 has a tighter radius of curvature in the cross-plane direction 84 than in the in-plane direction 86. The beam profile generated by transducer element 82 is narrowed in the cross-plane direction a sufficient amount to compensate for at least some of the beam profile widening effects of a sheath 88. In this manner, catheter 80 produces a beam profile having a generally circularly cross sectional shape at a focal plane 90.

[0033] The invention has now been described in detail. However, it will be appreciated that certain changes and modifications may be made. For example, the above description involves single transducer element imaging assemblies when the present invention is not so limited. Those skilled in the art will recognize that imaging assemblies having multiple transducer elements, including annular arrays, are within the scope of the present invention. Exemplary annular arrays are described in U.S. Patent Application Serial No. 09/017,581. Therefore, the scope and content of this invention are not limited by the foregoing description. Rather, the scope is defined by the following claims.

Claims

1. An ultrasound imaging assembly (50) for an ultrasound imaging catheter, comprising:

a housing having a distal end (56), a proximal end (57), and a longitudinal axis; and
a transducer element (54) having a curved outer face, said outer face having a first radius of curvature (68) in a first plane extending along a first axis (58) and a second radius of curvature (66) in a second plane extending along a second axis (60);
wherein said transducer (54) element is operably attached to said distal end (56) and said first axis is parallel to said longitudinal axis;
characterized in that
said second radius of curvature (66) is greater than said first radius of curvature (68).

2. An imaging assembly as in claim 1, wherein said first axis (58) is a major axis of said outer face and said second axis (60) is a minor axis of said outer face.

3. An imaging assembly as in claim 1, wherein said first axis (58) is a minor axis of said outer face and said second axis (60) is a major axis of said outer face.

4. An imaging assembly as in claim 1, wherein said outer face is generally round.

5. An imaging assembly as in claim 1, wherein said transducer element (54) further comprises a second face spaced apart from said outer face, said outer face and second face defining a transducer thickness therebetween.

6. An imaging assembly as in claim 5, wherein said outer face and said second face are both curved so that said transducer thickness is generally uniform.

7. An imaging assembly as in claim 5, wherein said outer face is curved relative to said second face so that said transducer thickness varies.

8. An imaging assembly as in claim 1, further comprising a matching layer (160) having first and second faces (162; 164) defining a matching layer thickness therebetween, said matching layer second face being coupled to said transducer element outer face.

9. An imaging assembly as in claim 8, wherein said matching layer first face (162) is generally flat so that said matching layer thickness varies.

10. An imaging assembly as in claim 8, wherein said matching layer first face (162) is curved so that said matching layer thickness is generally uniform.

11. An imaging assembly as in claim 8, wherein said matching layer is concave and said matching layer thickness increases from a center of said transducer element towards a periphery of said transducer element.

12. An ultrasound imaging assembly as in claim 1 wherein said transducer element has an elliptical outer face.

13. An ultrasound imaging catheter (200) comprising:
an ultrasound imaging assembly (50; 100) according to any preceding claim;
a drive cable (210) coupled to said proximal end (57); and
a sheath (220) into which said imaging assembly (50; 100) and drive cable (210) are disposed.

14. An imaging catheter as in claim 13, wherein said sheath comprises polyethylene.

Patentansprüche

1. Ultraschall-Abbildungsanordnung (50) für einen Ultraschall-Abbildungskatheter, welche aufweist:

ein Gehäuse mit einem distalen Ende (56), einem proximalen Ende (57) und einer Längsachse; und
ein Wandlerelement (54) mit einer gekrümmten äußeren Fläche, welche äußere Fläche einen ersten Krümmungsradius (68) in einer ersten Ebene, die sich entlang einer ersten Achse (58) erstreckt, und einen zweiten Krümmungsradius (66) in einer zweiten Ebene, die sich entlang einer zweiten Achse (60) erstreckt, hat;
wobei das Wandlerelement (54) betriebsfähig an dem distalen Ende (56) angebracht ist und die erste Achse parallel zu der Längsachse ist;
dadurch gekennzeichnet, dass
der zweite Krümmungsradius (66) größer als der erste Krümmungsradius (68) ist.

2. Abbildungsanordnung nach Anspruch 1, bei der die erste Achse (58) eine Hauptachse der äußeren Fläche ist und die zweite Achse (60) eine Nebenachse der äußeren Fläche ist.

3. Abbildungsanordnung nach Anspruch 1, bei der die erste Achse (58) eine Nebenachse der äußeren Fläche ist und die zweite Achse (60) eine Hauptachse der äußeren Fläche ist.

4. Abbildungsanordnung nach Anspruch 1, bei der die äußere Fläche im Allgemeinen rund ist.

5. Abbildungsanordnung nach Anspruch 1, bei der das Wandlerelement (54) weiterhin eine zweite Fläche aufweist, die im Abstand von der äußeren Fläche angeordnet ist, wobei die äußere Fläche und die zweite Fläche eine Wandlerdicke zwischen sich definieren.

6. Abbildungsanordnung nach Anspruch 5, bei der die äußere Fläche und die zweite Fläche jeweils so gekrümmt sind, dass die Wandlerdicke im Allgemeinen gleichförmig ist.

7. Abbildungsanordnung nach Anspruch 5, bei der die äußere Fläche relativ zu der zweiten Fläche so gekrümmt ist, dass die Wandlerdicke variiert.

8. Abbildungsanordnung nach Anspruch 1, weiterhin aufweisend eine Anpassungsschicht (160) mit einer ersten und einer zweiten Fläche (162; 164), die eine

Anpassungsschichtdicke zwischen sich definieren, wobei die zweite Fläche der Anpassungsschicht mit der äußeren Fläche des Wandlerelements gekoppelt ist.

9. Abbildungsanordnung nach Anspruch 8, bei der die erste Fläche (162) der Anpassungsschicht im Allgemeinen flach ist, so dass die Anpassungsschichtdicke variiert.

10. Abbildungsanordnung nach Anspruch 8, bei der die erste Fläche (162) der Anpassungsschicht so gekrümmt ist, dass die Anpassungsschichtdicke im Allgemeinen gleichförmig ist.

11. Abbildungsanordnung nach Anspruch 8, bei der die Anpassungsschicht konkav ist und die Anpassungsschichtdicke von der Mitte des Wandlerelements aus zu einer Peripherie des Wandlerelements hin zunimmt.

12. Ultraschall-Abbildungsanordnung nach Anspruch 1, bei der das Wandlerelement eine elliptische äußere Fläche hat.

13. Ultraschall-Abbildungskatheter (200), welcher aufweist:

eine Ultraschall-Abbildungsanordnung (50; 100) gemäß jedem der vorhergehenden Ansprüche;
ein mit dem proximalen Ende (57) gekoppeltes Antriebskabel (210); und
eine Hülle (220), in der die Abbildungsanordnung (50; 100) und das Antriebskabel (210) angeordnet sind.

14. Abbildungskatheter nach Anspruch 13, bei dem die Hülle Polyethylen aufweist.

Revendications

1. Assemblage imageur à ultrasons (50) pour un cathéter imageur à ultrasons, comprenant :

un boîtier ayant une extrémité distale (56), une extrémité proximale (57) et un axe longitudinal ;
et
un élément transducteur (54) ayant une face externe incurvée, ladite face externe ayant un premier rayon de courbure (68) dans un premier plan s'étendant le long d'un premier axe (58) et un second rayon de courbure (66) dans un second plan s'étendant le long d'un second axe (60) ;
dans lequel ledit élément transducteur (54) est fonctionnellement attaché à ladite extrémité dis-

tale (56) et ledit premier axe est parallèle audit axe longitudinal ;

caractérisé en ce que :

- ledit second rayon de courbure (66) est plus grand que ledit premier rayon de courbure (68). 5
2. Assemblage imageur selon la revendication 1, dans lequel ledit premier axe (58) est un grand axe de ladite face externe et ledit second axe (60) est un petit axe de ladite face externe. 10
 3. Assemblage imageur selon la revendication 1, dans lequel ledit premier axe (58) est un petit axe de ladite face externe et ledit second axe (60) est un grand axe de ladite face externe. 15
 4. Assemblage imageur selon la revendication 1, dans lequel ladite face externe est de façon générale ronde. 20
 5. Assemblage imageur selon la revendication 1, dans lequel ledit élément transducteur (54) comprend en outre une seconde face espacée de ladite face externe, ladite face externe et ladite seconde face définissant entre elles une épaisseur de transducteur. 25
 6. Assemblage imageur selon la revendication 5, dans lequel ladite face externe et ladite seconde face sont toutes deux incurvées de telle sorte que ladite épaisseur de transducteur soit de façon générale uniforme. 30
 7. Assemblage imageur selon la revendication 5, dans lequel ladite face externe est incurvée par rapport à ladite seconde face de telle sorte que ladite épaisseur de transducteur varie. 35
 8. Assemblage imageur selon la revendication 1, comprenant en outre une couche d'adaptation (160) ayant des première et seconde faces (162 ; 164) définissant entre elles une épaisseur de couche d'adaptation, ladite seconde face de couche d'adaptation étant couplée à ladite face externe d'élément transducteur. 40 45
 9. Assemblage imageur selon la revendication 8, dans lequel ladite première face de couche d'adaptation (162) est de façon générale plane de telle sorte que ladite épaisseur de couche d'adaptation varie. 50
 10. Assemblage imageur selon la revendication 8, dans lequel ladite première face de couche d'adaptation (162) est incurvée de telle sorte que ladite épaisseur de couche d'adaptation soit de façon générale uniforme. 55

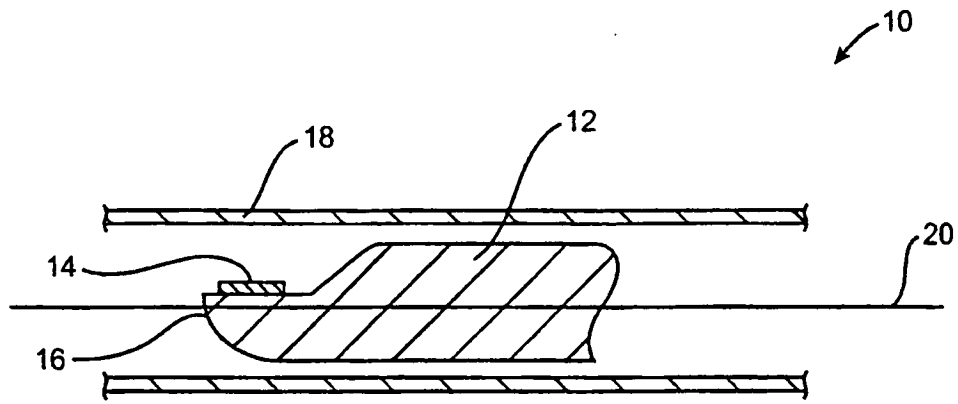
11. Assemblage imageur selon la revendication 8, dans lequel ladite couche d'adaptation est concave et ladite épaisseur de couche d'adaptation augmente depuis un centre dudit élément transducteur en direction d'une périphérie dudit élément transducteur.

12. Assemblage imageur à ultrasons selon la revendication 1, dans lequel ledit élément transducteur a une face externe elliptique.

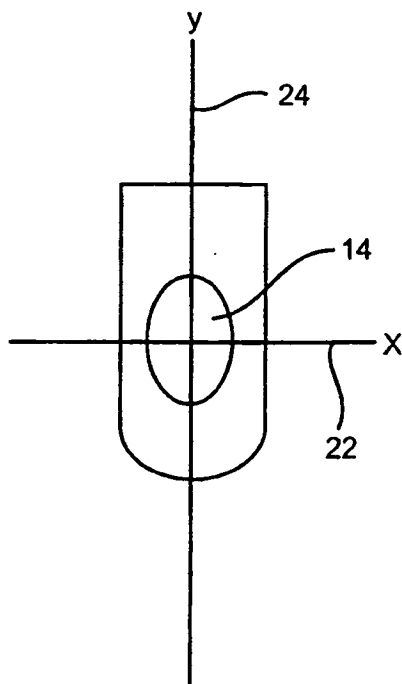
13. Cathéter imageur à ultrasons (200) comprenant :

un assemblage imageur à ultrasons (50 ; 100) selon l'une quelconque des revendications précédentes ;
un câble de commande (210) couplé à ladite extrémité proximale (57) ; et
une gaine (220) dans laquelle ledit assemblage imageur (50 ; 100) et ledit câble de commande (210) sont disposés.

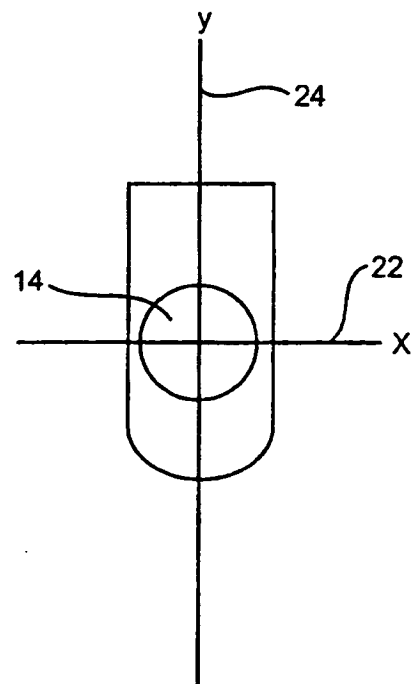
14. Cathéter imageur selon la revendication 13, dans lequel ladite gaine comprend du polyéthylène.



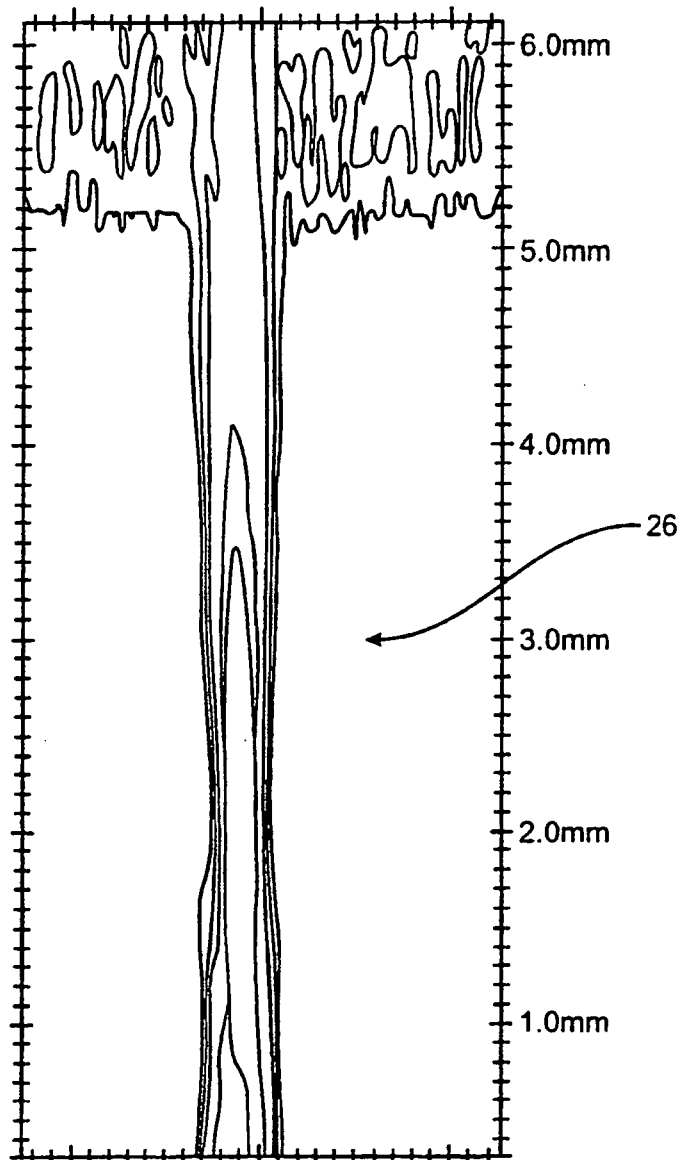
(PRIOR ART)
FIG. 1A



(PRIOR ART)
FIG. 1B

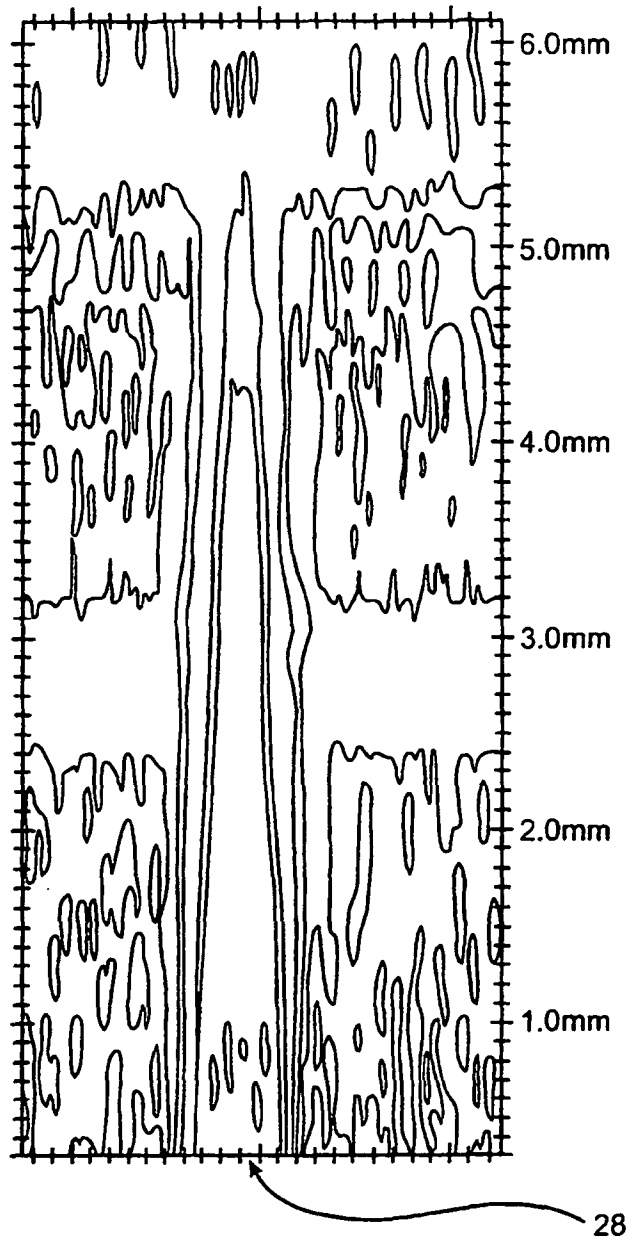


(PRIOR ART)
FIG. 1C



In-plane (x)
 Peak = 0.046 Vpp
 Focal Width = 0.14 mm; Focal Length ≥ -46.85 mm
 Scan starts at 0.30 mm

FIG. 2A



Cross - Plane (Y)
 Peak = 0.02414 Vpp
 Focal Width = 0.26 mm; Focal Length \geq -2.20 mm
 Scan starts at 0.30 mm

FIG. 2B

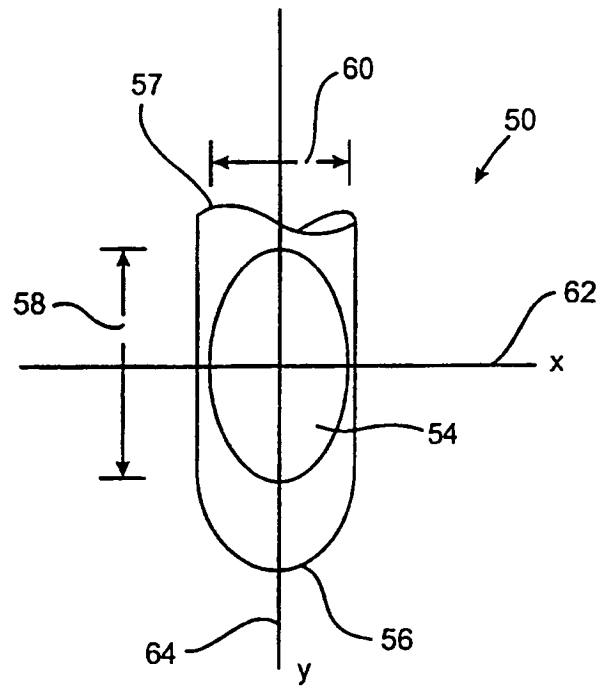


FIG. 3A

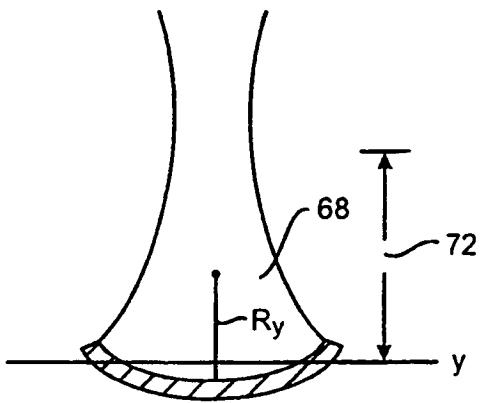


FIG. 3B

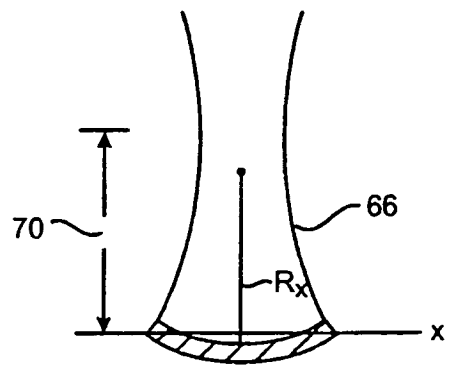


FIG. 3C

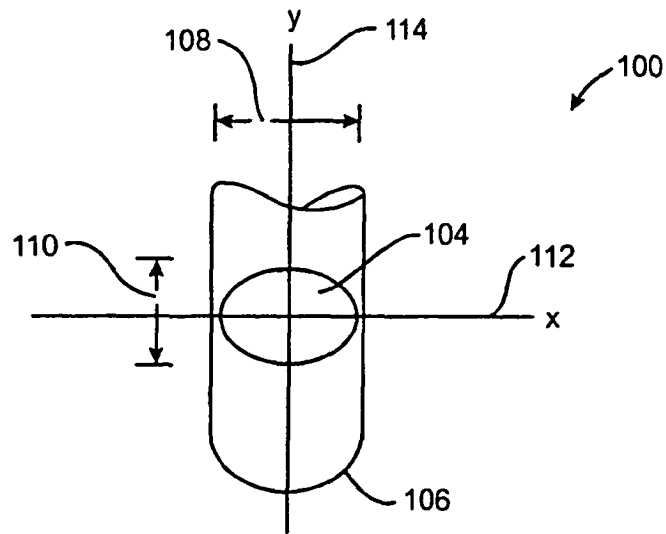


FIG. 4

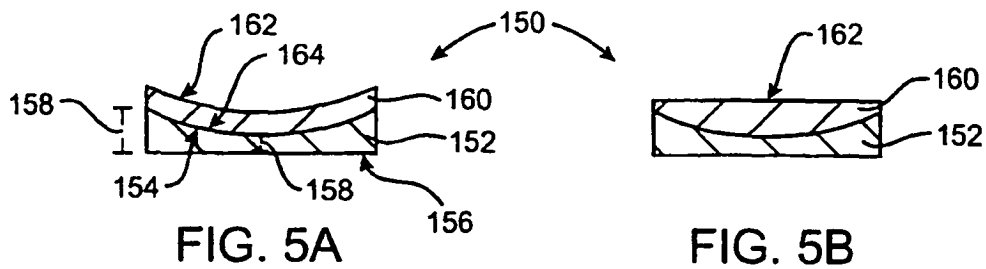


FIG. 5A

FIG. 5B

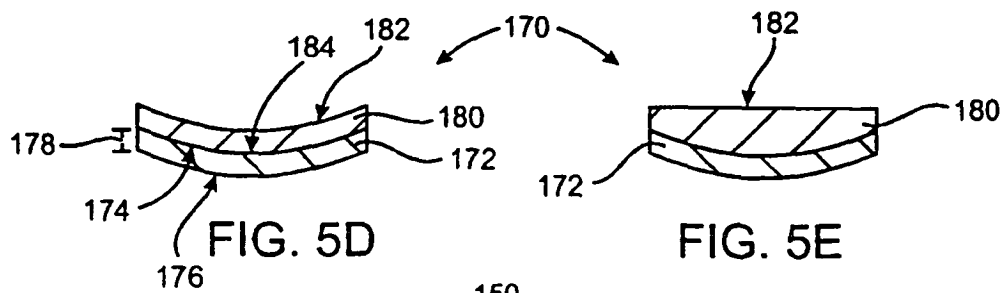


FIG. 5D

FIG. 5E

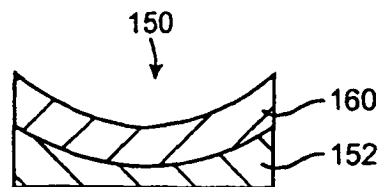
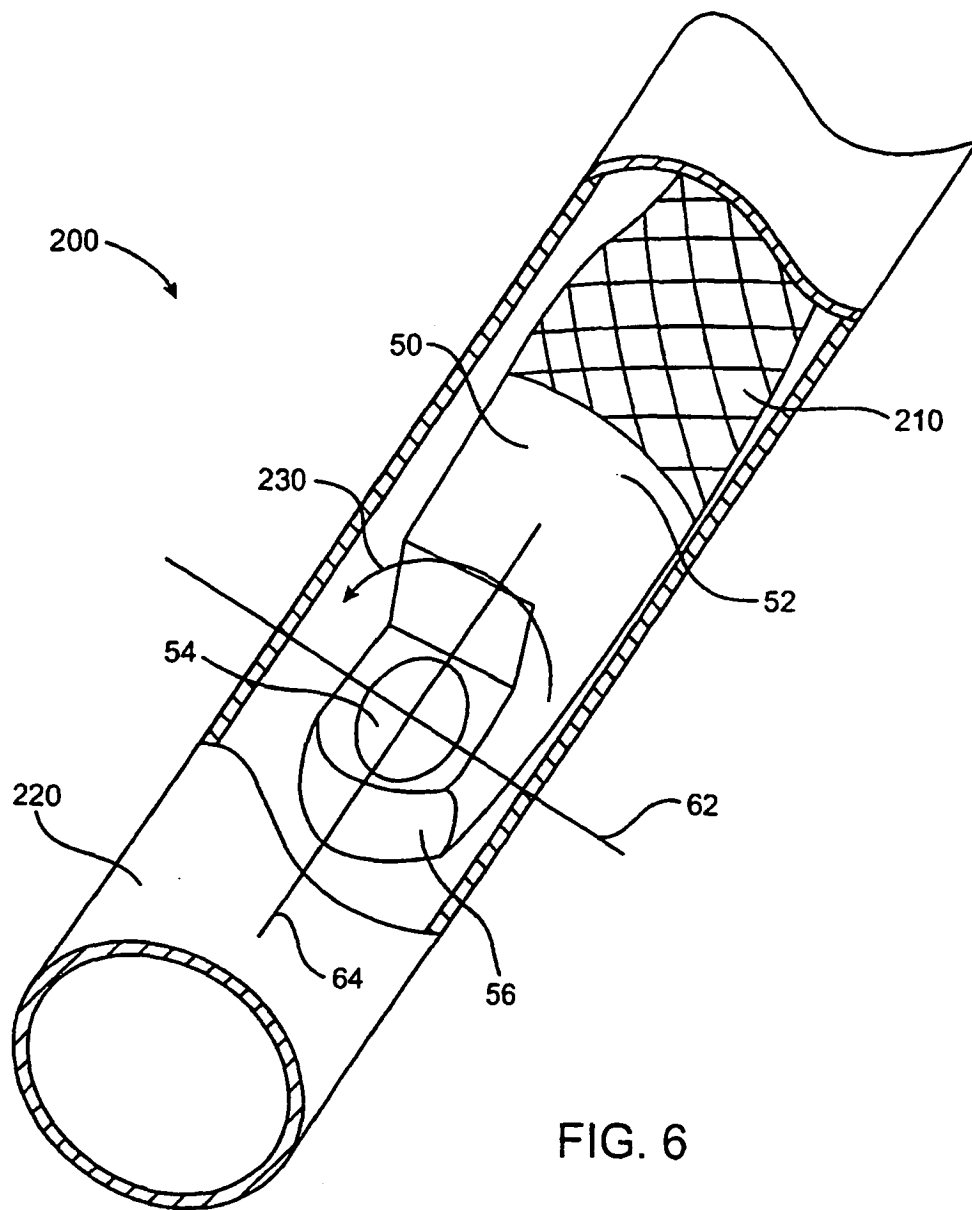


FIG. 5C



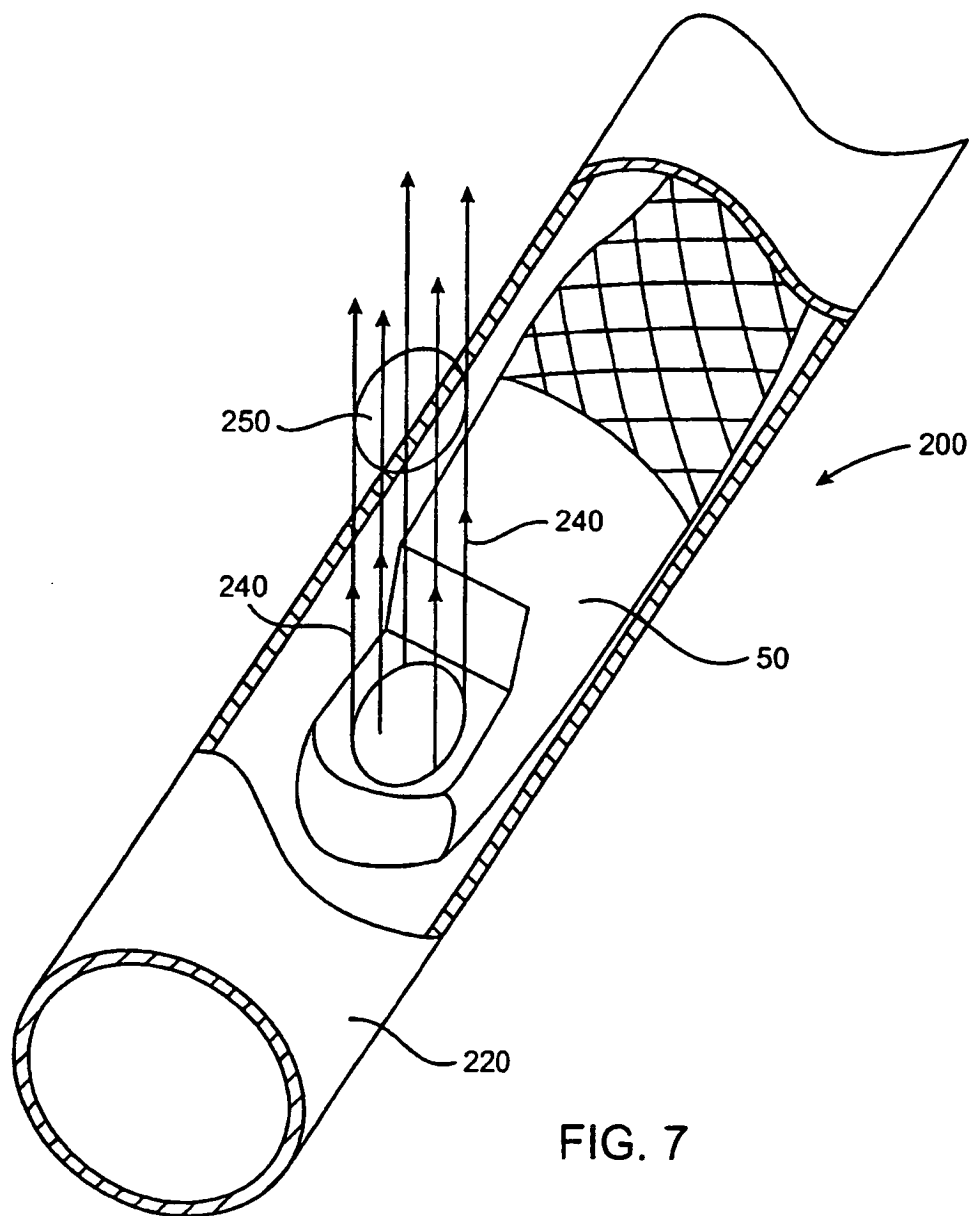
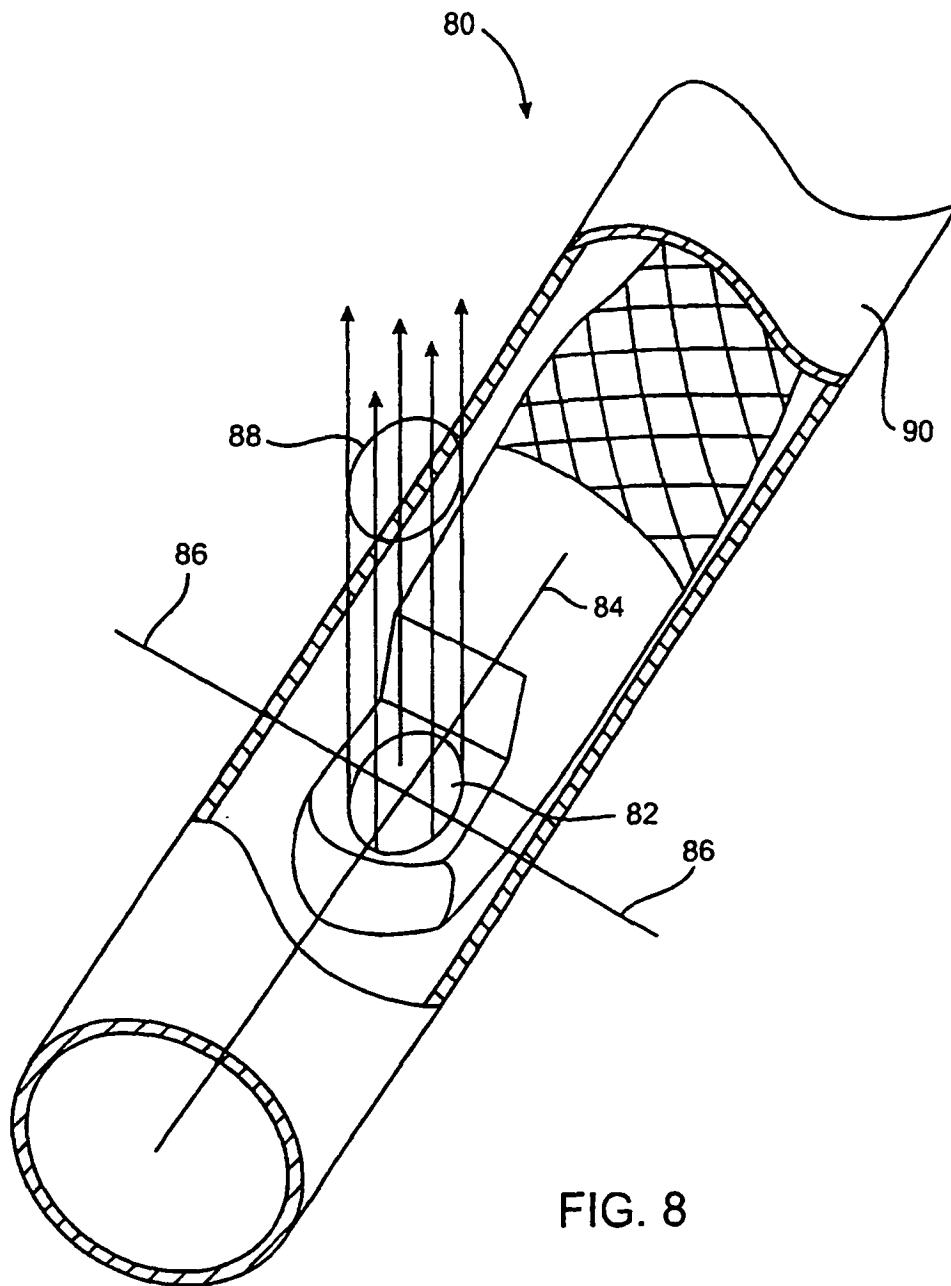


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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专利名称(译)	聚焦超声换能器和系统		
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摘要(译)

本发明提供了超声换能器，以及采用这种换能器的成像组件和导管，其提供了改进的成像能力。在一个实施例中，超声成像组件（50）包括壳体，壳体具有远端（56），近端（57）和纵向轴线。包括具有外表面的换能器元件（54）。外表面沿第一轴具有第一曲率半径，沿第二轴具有第二曲率半径。换能器元件可操作地连接到远端，以将第一轴线定位成大致平行于纵向轴线，以提供改善的跨平面分辨率。

