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(54) FOCUSED ULTRASOUND TRANSDUCERS AND SYSTEMS

FOKUSSIERTE ULTRASCHALLWANDLER UND SYSTEME

TRANSDUCTEURS ET SYSTEMES A ULTRASONS FOCALISES

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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. 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.

[0007] US 4 572 201 discloses an ultrasound assembly 10 according to the pre-characterising portion of claim 1.

SUMMARY OF THE INVENTION

[0008] In accordance with the present invention, there is provided an ultrasound imaging assembly as defined in the appendant independent claim to which reference should now be made. Embodiments of the present invention are defined in the appendant dependent claims to which reference should also now be made.

[0009] The present invention provides imaging assemblies and catheters employing ultrasound transducers, that provide improved imaging capabilities. In particular, the present invention provides improved lateral resolution as a result of the positioning of the transducer on the imaging assembly. This produces a tighter imaging signal in the cross-plane direction, thereby improving lateral resolution. The curvature profile of the transducer outer face may additionally be configured for improved resolution.

[0010] In one embodiment, the present invention provides an ultrasound imaging assembly. The imaging assembly includes a housing having a distal end, a proximal end, and a longitudinal axis. The assembly includes a transducer element having a generally elliptical outer face which defines a major axis and a minor axis. The transducer element is operably attached to the distal end to position the minor axis to be generally parallel to the longitudinal axis. In this manner, a tighter cross-plane beam profile is produced due to the minor axis being generally parallel to, i.e. generally aligned with, the longitudinal axis of the imaging assembly.

[0011] In one embodiment, the outer face of the transducer element is generally oval shaped. It will be appreciated by those skilled in the art, that other transducer shapes may be used within the scope of the present invention. In another embodiment, the outer face is generally flat.

[0012] In one embodiment, the outer face has a first radius of curvature along the minor axis and a second radius of curvature along the major axis. Preferably, the second radius of curvature is greater than the first radius of curvature. In this manner, the transducer element has a tighter radius of curvature in the cross-plane direction to provide a greater focussing effect in the cross-plane direction compared to the focussing effect in the in-plane direction. A tighter cross-plane beam profile will result compared to the device shown in Fig. 1. Alternatively, the first and second radii of curvature are generally equal.

[0013] In one embodiment, the proximal end is adapted to be coupled to a drive cable. In this manner, the drive cable can operate to rotate the imaging assembly. In another embodiment, a matching layer or multiple matching layers are operably attached to the outer face of the transducer element. In this manner, improved efficiency and band-width can result.

[0014] In one embodiment, the transducer element is a tapered focus transducer element. Alternatively, the transducer element is a true focus transducer element. Preferably, the transducer element is selected from a group of materials consisting of piezoplastics, piezocomposites, and piezoceramics.

[0015] In one particular embodiment, the transducer element is adapted to propagate an ultrasound signal in response to electrical input. The ultrasonic beam includes an in-plane signal component that is generally perpendicular to the longitudinal axis, and a cross-plane signal component that is generally parallel to the longitudinal axis. The in-plane signal component has an in-plane focal length that is generally equal to a cross-plane focal length of the cross-plane signal component. In one embodiment, the in-plane focal length is between about 0.25 mm and about 2.5 mm. Similarly, the cross-plane focal length is between about 0.25 mm and about 2.5 mm. In one particular embodiment, the outer face has a shape and radius of curvature profile so that the ultrasound signal has a generally circular cross-sectional shape at a prescribed distance, for example between about 0.25 mm and about 2.5 mm, from the distal end.

[0016] The present invention further provides ultrasound imaging catheters having an imaging assembly as previously described. The catheter includes a drive cable coupled to the proximal end and a sheath into which the imaging assembly and drive cable are disposed. In one particular aspect, the sheath includes polyethylene.

[0017] 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

[0018]

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 imaging assembly which is not part of the present invention

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

Fig. 4 depicts the top view of an 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 imaging catheters which are not part of the present invention.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

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[0019] Fig. 3 depicts an imaging assembly 50 which is not part of the present invention having a distal end 56 and a proximal end 57. Proximal end 57 is adapted to be operably attached to a drive cable (not shown). The drive cable rotates imaging assembly 50 during operation.

[0020] 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.

[0021] 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.

[0022] As shown in Figs. 3B and 3C, transducer element 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.

[0023] 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.

[0024] 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.

[0025] Turning now to Fig. 4, an 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 7.4×10^{-4} m (0.029 inches) and minor axis 110 is about 6.4×10^{-4} m (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.

[0025] 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.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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).

[0031] 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, as described in further detail in U.S. Application Serial No. US 6,406,433, (Attorney Reference. No. 12553-009500), entitled "Off-Aperture Electrical Connect Transducer and Methods of Making,".

[0032] Turning now to Fig. 6, an imaging catheter 200, which is not part of 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 hav-

ing 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 which is not part of the present invention.

[0033] 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 version, 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.

[0034] In one 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.

[0035] 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.

[0036] 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.

[0037] 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 de-

scription 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. Therefore, the scope and content of this invention are not limited by the foregoing description. Rather, the scope is defined by the following claims.

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Claims

1. An ultrasound imaging assembly (100) for an ultrasound imaging catheter, comprising:

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a housing having a distal end (106), a proximal end, and a longitudinal axis; and a transducer element (104) operably attached to said distal end, said transducer element having a substantially elliptical outer face defining a major axis (108) and a minor axis (110); said transducer element being operably attached to said distal end (106); **characterised in that** said minor axis (110) is substantially parallel to said longitudinal axis.

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2. An imaging assembly (100) as in claim 1, wherein said outer face is substantially oval - shaped.

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3. An imaging assembly (100) as in claim 1, wherein said outer face is substantially flat.

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4. An imaging assembly (100) as in claim 1, wherein said outer face has a first radius of curvature in a first plane extending along said minor axis and a second radius of curvature in a second plane extending along said major axis.

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5. An imaging assembly (100) as in claim 4 wherein said second radius of curvature is greater than said first radius of curvature.

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6. An imaging assembly (100) as in claim 4, wherein said second radius of curvature is generally equal to said first radius of curvature.

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7. An imaging assembly (100) as in claim 1, wherein said proximal end is adapted to be coupled to a drive cable.

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8. An imaging assembly (100) as in claim 1, further comprising a matching layer operably attached to said outer face.

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9. An imaging assembly (100) as in claim 1, wherein said transducer element (104) comprises a tapered focus transducer element.

10. An imaging assembly (100) as in claim 1, wherein said transducer element (104) comprises a true focus transducer element.

11. An imaging assembly (100) as in claim 1, wherein said transducer element (104) comprises a material selected from a group of materials consisting of piezoplastics, piezocomposites and piezoceramics.

12. An imaging assembly (100) as in claim 1, wherein said transducer element (104) is adapted to propagate an ultrasound signal in response to electrical input, said signal comprising an in-plane signal component that is generally perpendicular to said longitudinal axis and a cross-plane signal component that is generally parallel to said longitudinal axis, said in-plane signal component having an in-plane focal length that is generally equal to a cross-plane focal length of said cross-plane signal component.

13. An imaging assembly (100) as in Claim 12, wherein said in plane focal length is between about 0.25 mm and about 2.5 mm, and said cross-plane focal length is between about 0.25 mm and about 2.5 mm.

14. An imaging assembly (100) as in claim 12, wherein said outer face has a shape and a radius of curvature profile so that said ultrasound signal has a generally circular cross sectional shape at a prescribed distance from said distal end.

15. 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.

16. An imaging catheter (200) in claim 15, wherein said sheath (220) comprises polyethylene.

Patentansprüche

1. Ultraschallbildgebungsanordnung (100) für einen Ultraschallbildgebungskatheter mit:
 einem Gehäuse, das ein distales Ende (106), ein proximales Ende und eine Längsachse hat, und
 einem betriebsfähig an dem distalen Ende befestigten Wandlerelement (104), wobei das Wandlerelement eine im Wesentlichen elliptische Außenfläche hat, die eine Hauptachse (108) und eine Nebenachse (110) festlegt, wobei das Wandlerelement betriebsfähig an dem distalen Ende (106) befestigt ist, dadurch gekennzeichnet, dass die Nebenachse (110) im Wesentlichen parallel zur Längsachse ist.

5 2. Bildgebungsanordnung (100) nach Anspruch 1, bei der die Außenfläche im Wesentlichen oval geformt ist.

10 3. Bildgebungsanordnung (100) nach Anspruch 1, bei der die Außenfläche im Wesentlichen eben ist.

15 4. Bildgebungsanordnung (100) nach Anspruch 1, bei der die Außenfläche in einer sich entlang der Nebenachse erstreckenden ersten Ebene einen ersten Krümmungsradius und in einer sich entlang der Hauptachse erstreckenden zweiten Ebene einen zweiten Krümmungsradius hat.

20 5. Bildgebungsanordnung (100) nach Anspruch 4, bei der der zweite Krümmungsradius größer als der erste Krümmungsradius ist.

25 6. Bildgebungsanordnung (100) nach Anspruch 4, bei der der zweite Krümmungsradius allgemein gleich dem ersten Krümmungsradius ist.

30 7. Bildgebungsanordnung (100) nach Anspruch 1, bei der das proximale Ende mit einem Antriebskabel gekuppelt zu werden vermag.

35 8. Bildgebungsanordnung (100) nach Anspruch 1, ferner umfassend eine betriebsfähig auf der Außenfläche befestigte Anpassungsschicht.

9. Bildgebungsanordnung (100) nach Anspruch 1, bei der das Wandlerelement (104) ein Wandlerelement mit konischem Fokus umfasst.

40 10. Bildgebungsanordnung (100) nach Anspruch 1, bei der das Wandlerelement (104) ein Wandlerelement mit echtem Fokus umfasst.

11. Bildgebungsanordnung (100) nach Anspruch 1, bei der das Wandlerelement (104) ein Material ausgewählt aus einer Materialgruppe bestehend aus Piezokunststoffen, Piezoverbundwerkstoffen und Piezokeramiken umfasst.

45 50 12. Bildgebungsanordnung (100) nach Anspruch 1, bei der das Wandlerelement (104) als Antwort auf einen elektrischen Eingang ein Ultraschallsignal zu propagieren vermag, wobei das Signal eine In-Ebene-Signalkomponente umfasst, die allgemein rechtwinklig zur Längsachse ist, und eine Signalkomponente quer zur Ebene, die allgemein parallel zur Längsachse ist, wobei die In-Ebene-Signalkomponente eine In-Ebenen-Brennweite hat, die allgemein

gleich einer Quer-zur-Ebenen-Brennweite der Signalkomponente quer zur Ebene ist.

13. Bildgebungsanordnung (100) nach Anspruch 12, bei der die In-Ebenen-Brennweite zwischen ungefähr 0,25 mm und ungefähr 2,5 mm beträgt und die Quer-zur-Ebenen-Brennweite zwischen ungefähr 0,25 mm und ungefähr 2,5 mm beträgt. 5

14. Bildgebungsanordnung (100) nach Anspruch 12, bei der die Außenfläche eine Gestalt und einen Krümmungsprofilradius derart hat, dass das Ultraschallsignal in einer vorgeschriebenen Entfernung von dem distalen Ende eine allgemein kreisförmige Querschnittsform hat. 10

15. Ultraschallbildgebungskatheter (200), mit:
 einer Ultraschallbildgebungsanordnung (50) (100) gemäß irgendeinem vorhergehenden Anspruch,
 einem mit dem proximalen Ende (57) gekoppelten Antriebskabel (210), und
 einer Ummantelung (220), in der die Bildgebungsanordnung (50) (100) und das Antriebskabel (210) angeordnet sind. 15

16. Bildgebungskatheter (200) nach Anspruch 15, bei dem die Ummantelung (220) Polyethylen umfasst. 20

Revendications

1. Ensemble d'imagerie à ultrasons (100) pour un cathéter d'imagerie à ultrasons, comprenant : 35
 un logement présentant une extrémité distale (106), une extrémité proximale et un axe longitudinal ; et
 un élément transducteur (104) lié de manière fonctionnelle à ladite extrémité distale, ledit élément transducteur présentant une face externe essentiellement elliptique définissant un axe majeur (108) et un axe mineur (110) ;
 ledit élément transducteur étant lié de manière fonctionnelle à ladite extrémité distale (106), **caractérisé en ce que** ledit axe mineur (110) est essentiellement parallèle audit axe longitudinal. 40

2. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ladite face externe est essentiellement de forme ovale. 45

3. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ladite face externe est essentiellement plate. 50

4. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ladite face externe présente un premier rayon de courbure dans un premier plan s'étendant le long dudit axe mineur et un deuxième rayon de courbure dans un second plan s'étendant le long dudit axe majeur. 5

5. Ensemble d'imagerie (100) selon la revendication 4, dans lequel ledit deuxième rayon de courbure est supérieur audit premier rayon de courbure. 10

6. Ensemble d'imagerie (100) selon la revendication 4, dans lequel ledit deuxième rayon de courbure est généralement égal audit premier rayon de courbure. 15

7. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ladite extrémité proximale est adaptée de façon à être couplée à un câble conducteur. 20

8. Ensemble d'imagerie (100) selon la revendication 1, comprenant en outre une couche d'appariement liée de manière fonctionnelle à ladite face externe. 25

9. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ledit élément transducteur (104) comprend un élément transducteur à foyer conique. 30

10. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ledit élément transducteur (104) comprend un élément transducteur à foyer réel. 35

11. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ledit élément transducteur (104) comprend un matériau choisi dans un groupe de matériaux constitués de piézoplastiques, de piézocomposites et de piézocéramiques. 40

12. Ensemble d'imagerie (100) selon la revendication 1, dans lequel ledit élément transducteur (104) est adapté de façon à propager un signal ultrasonore en réponse à une impulsion électrique, ledit signal comprenant un élément de signal au même plan qui est généralement perpendiculaire audit axe longitudinal et un élément de signal en plan croisé qui est généralement parallèle audit axe longitudinal, ledit élément de signal au même plan présentant une longueur focale en plan qui est généralement égale à la longueur focale en plan croisé dudit élément de signal en plan croisé. 45

13. Ensemble d'imagerie (100) selon la revendication 12, dans lequel ladite longueur focale en plan est d'environ 0,25 mm à environ 2,5 mm et ladite longueur focale en plan croisé est d'environ 0,25 mm à environ 2,5 mm. 50

14. Ensemble d'imagerie (100) selon la revendication 12, dans lequel ladite face externe a une forme et 55

un rayon de profil de courbure tel que ledit signal ultrasonore présente généralement une forme de section circulaire à une distance prescrite de ladite extrémité distale.

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15. Cathéter d'imagerie ultrasonore (200) comprenant :

un ensemble d'imagerie à ultrasons (50) (100)
selon l'une quelconque des revendications
précédentes ;
un câble conducteur (210) couplé à ladite extré-
mité proximale (57) ; et
une gaine (220) dans laquelle ledit ensemble
d'imagerie (50) (100) et le câble conducteur
(210) sont disposés.

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**16. Cathéter d'imagerie (200) selon la revendication 15,
dans lequel ladite gaine (220) comprend du polyé-
thylène.**

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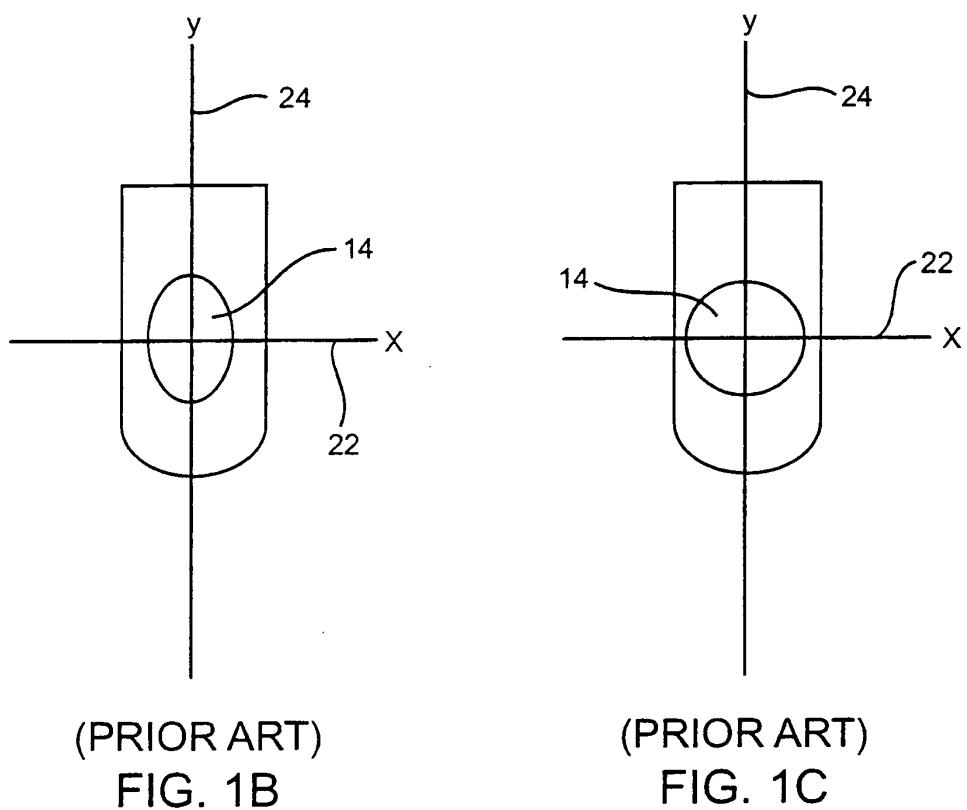
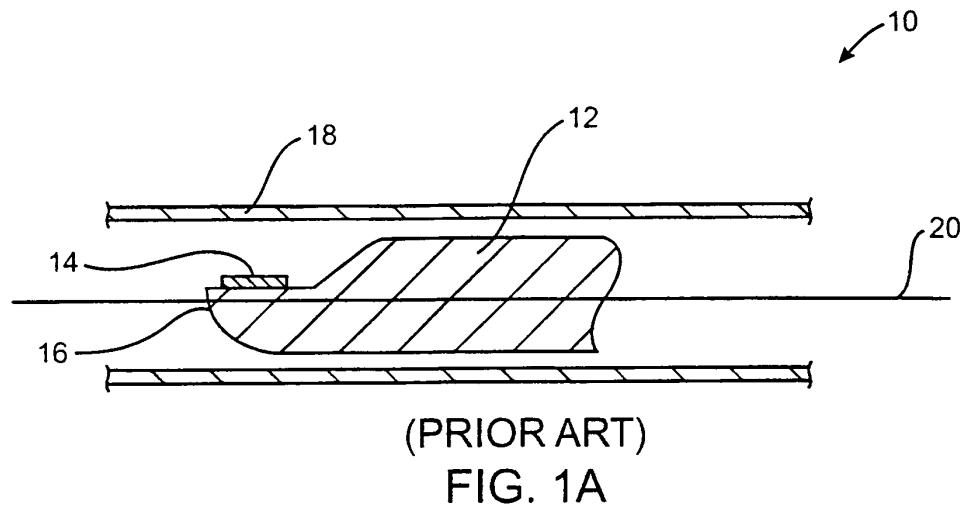
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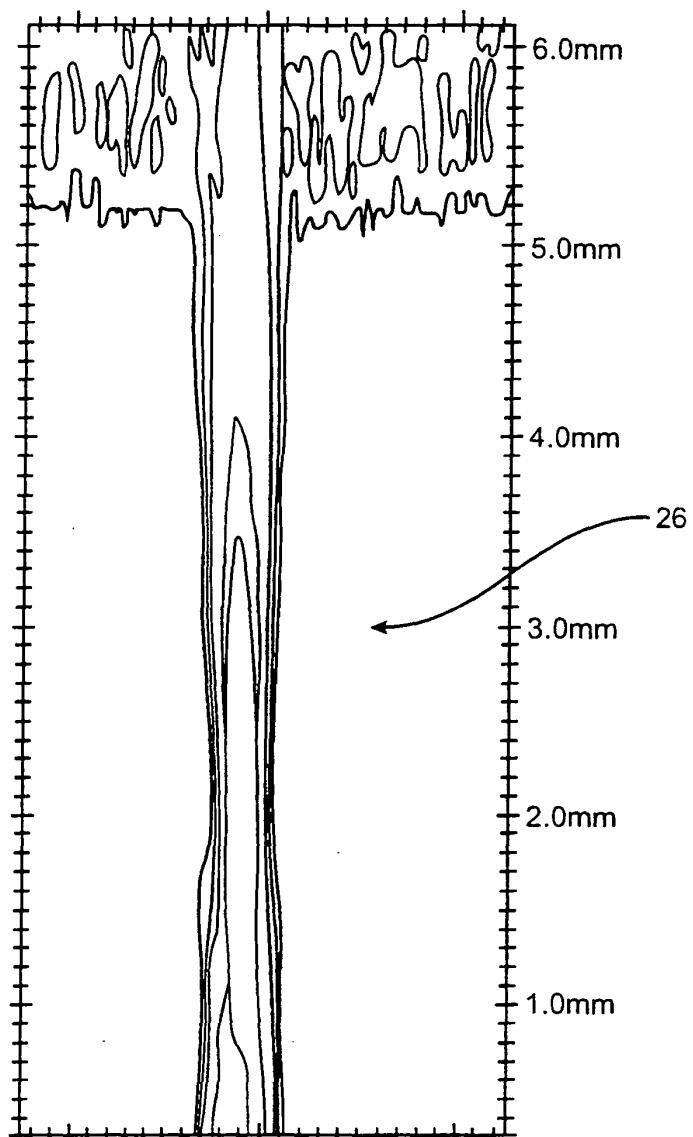
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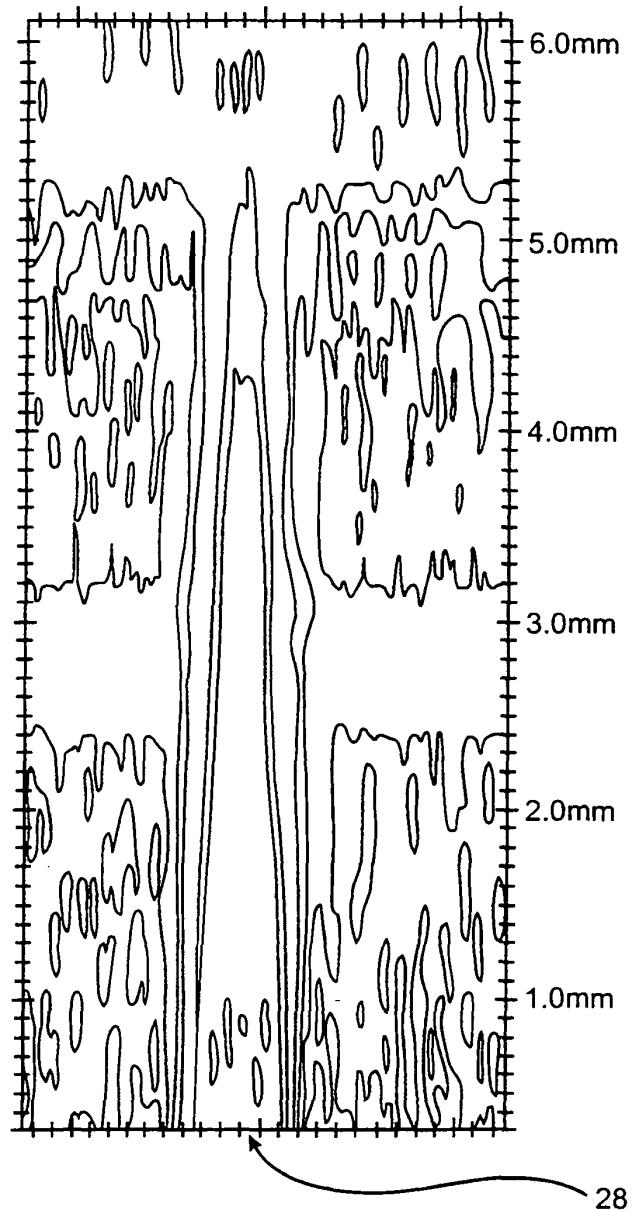
55





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

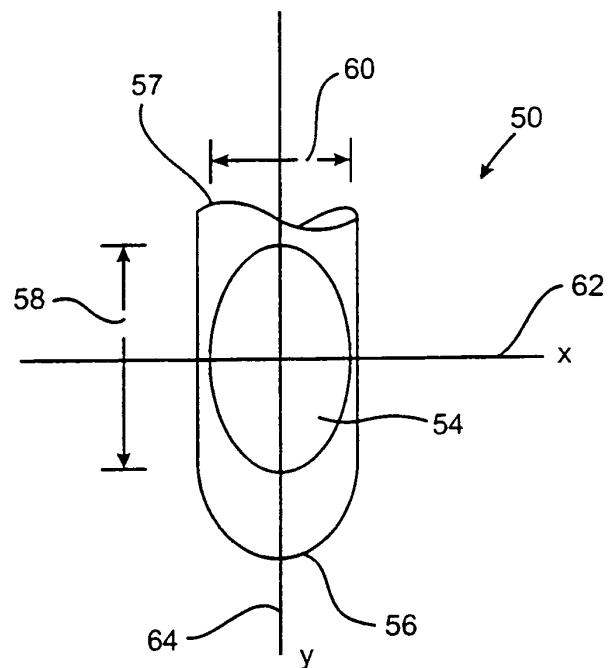


FIG. 3A

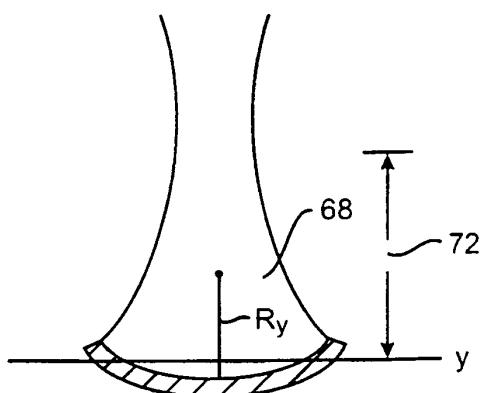


FIG. 3B

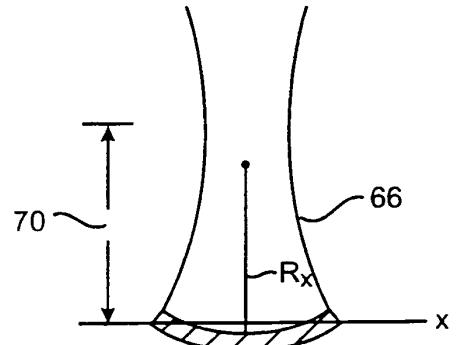


FIG. 3C

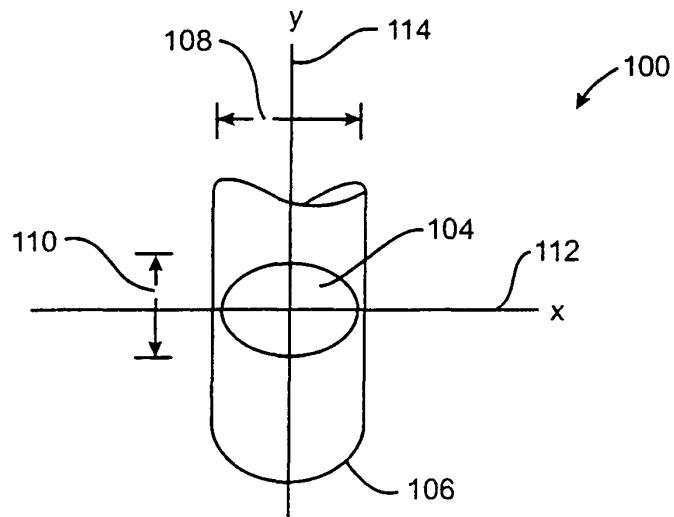


FIG. 4

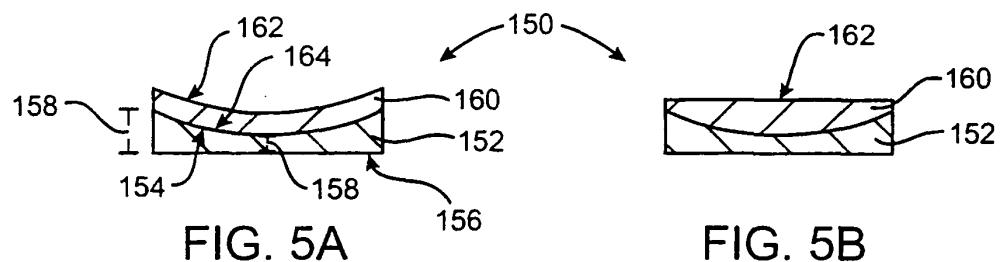


FIG. 5A

FIG. 5B

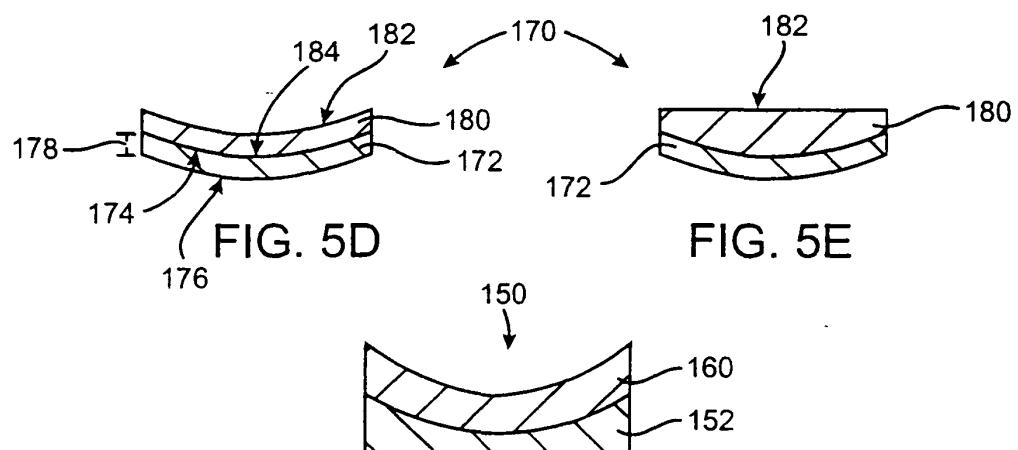
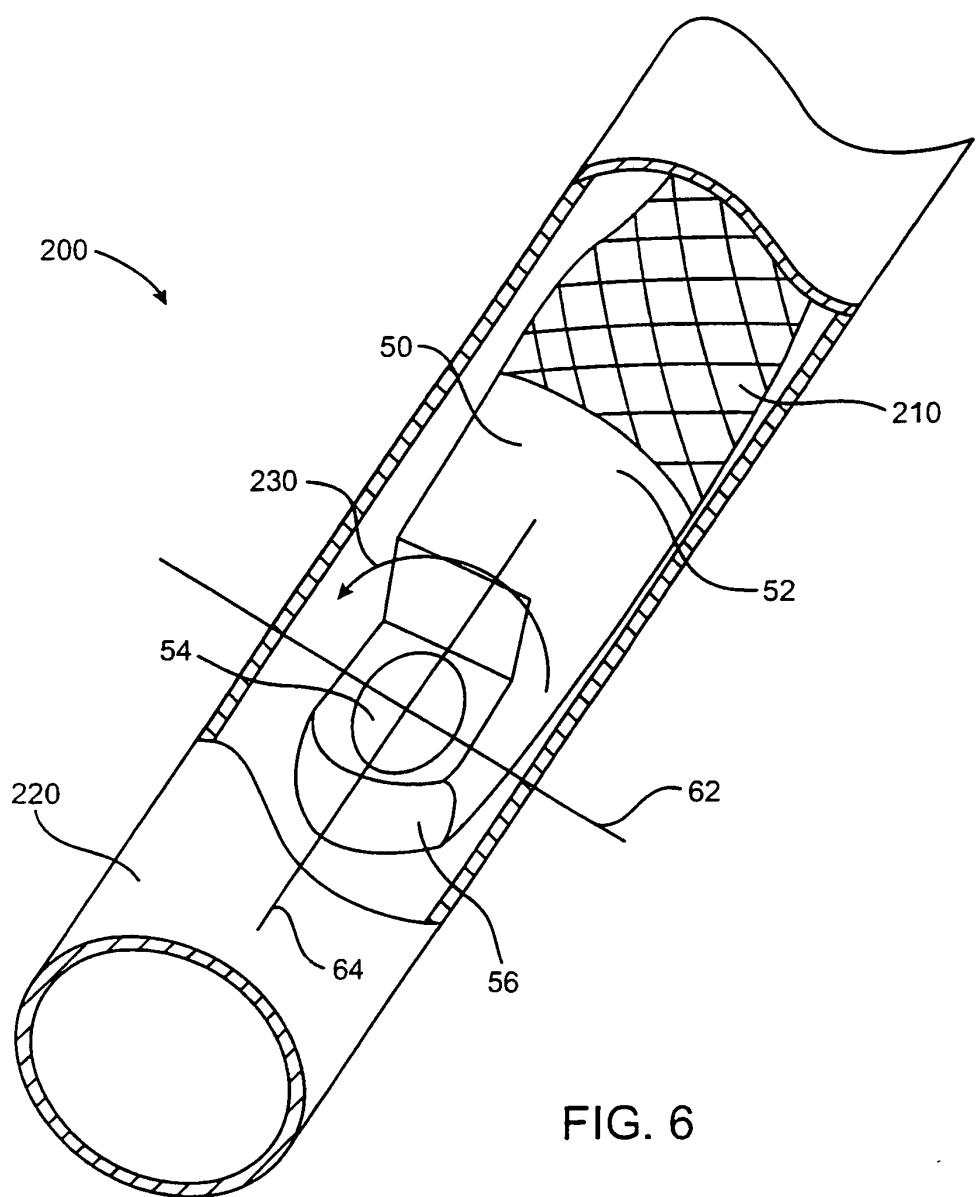


FIG. 5D

FIG. 5E

FIG. 5C



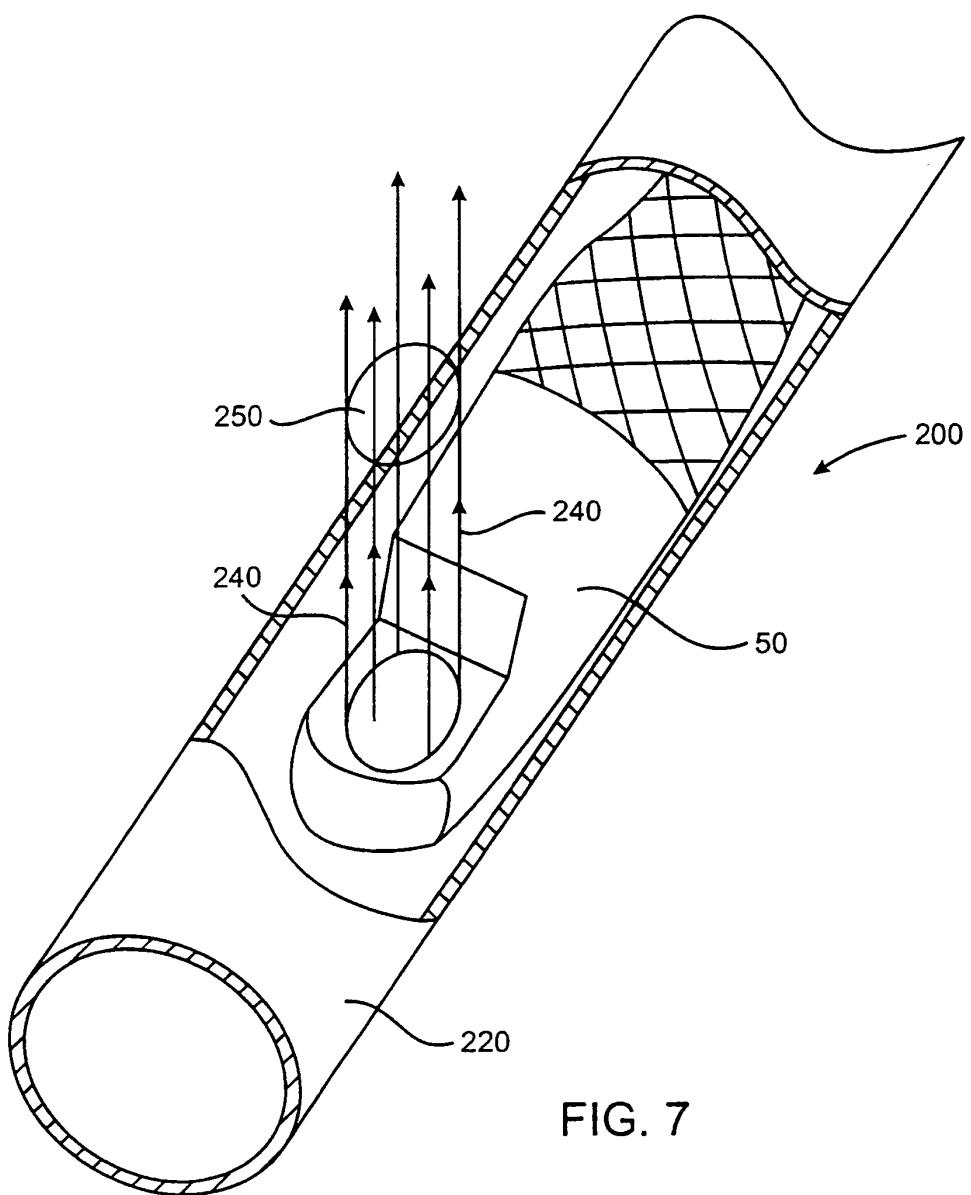


FIG. 7

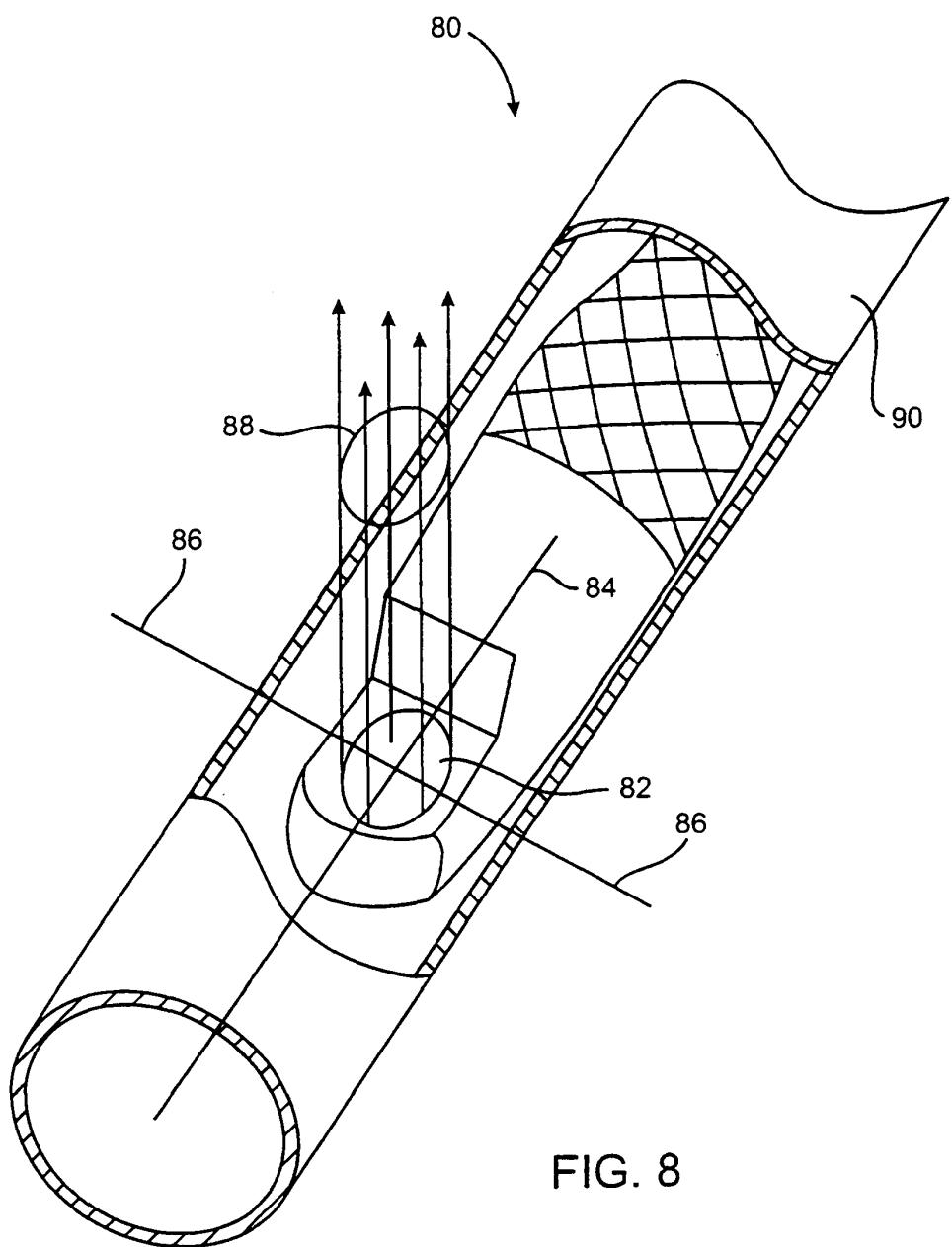


FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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EP1196091A1

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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。

