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WO 91/14394 A1 WO 91/02489 A1 US 4951677 A

(58) Field of search
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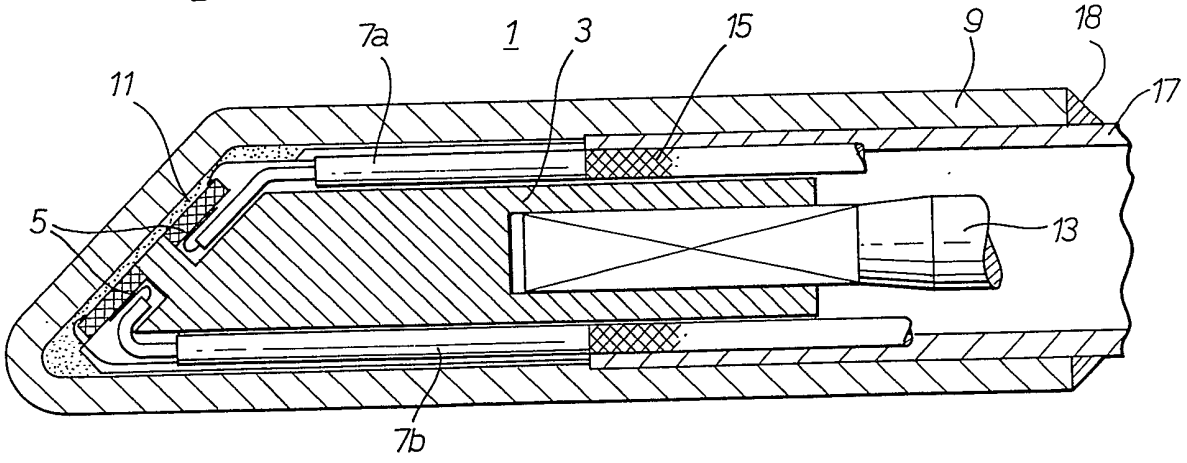
(54) Ultrasonic oesophageal probe

(57) An ultrasonic probe for insertion into a patient, particularly via the oesophagus, comprising emission and reception piezoelectric crystals 5 mounted on a core member 3 at substantially 45 degrees to the longitudinal axis of the core member. A flexible drive member 13 is provided to conduct torque to the core member from the exterior of the patient to enable the orientation of the probe to be controlled. The probe tip is encased in a silicon boot 9 while the flexible drive member and the cables 7a, 7b taking signals to and from the piezoelectric crystals are surrounded by a copper braid 15 and a silicon tube 17. The flexible drive member comprises a soft steel mandrel overwound with two flat spring steel wires wound in opposite senses. Such a member exhibits no hysteresis and has substantially no set.

Fig. 1.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig. 1.

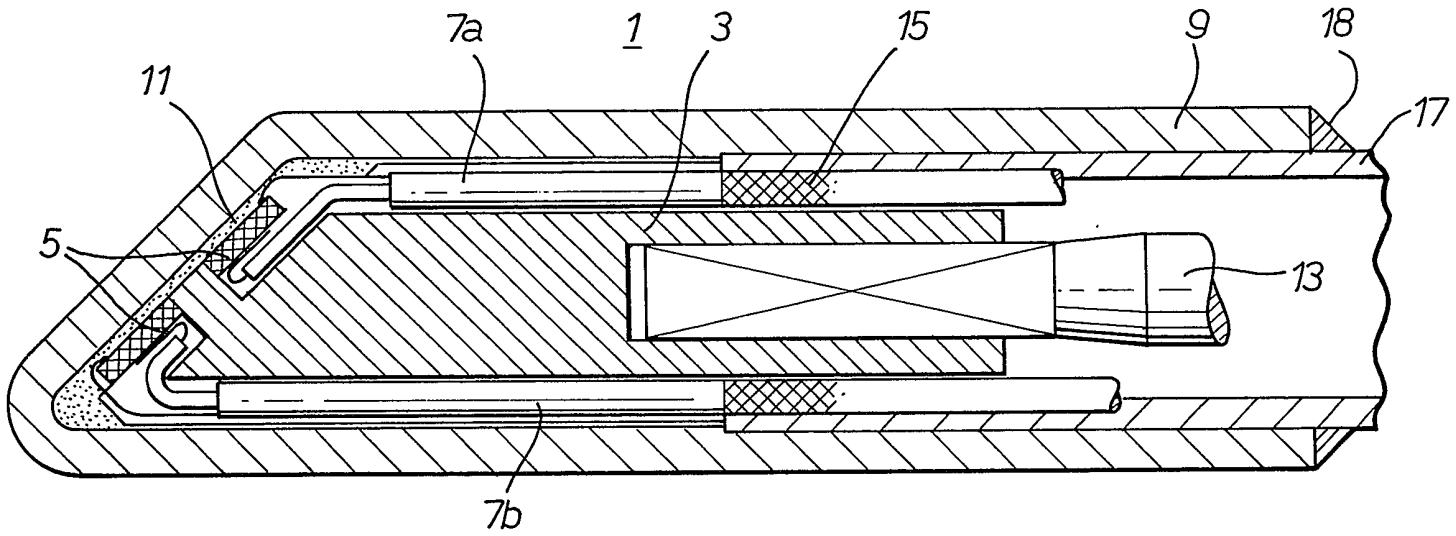

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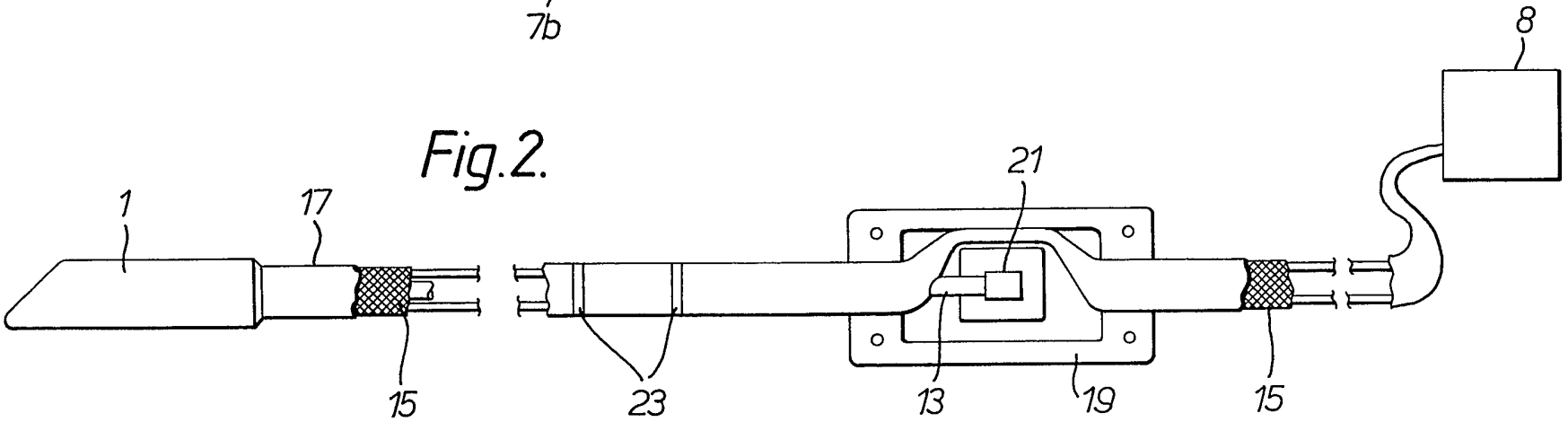
Fig. 2.



ULTRASONIC OESOPHAGEAL PROBE

The present invention relates to an ultrasonic probe and particularly to probes which may be used internally of a patient.

Ultrasound is widely used to investigate, in a non-destructive manner, circumstances prevailing within the human or animal body. An ultrasonic signal, either pulsed or continuous, is emitted from a piezoelectric crystal into the body and returning echoes are picked up by the same or another piezoelectric crystal which converts them into electrical signals which may then be analysed. Conventionally, such piezoelectric crystals are encased in de-gassed epoxy resins, such as Araldite (TM), to protect the crystal and to provide a good acoustic coupling between the crystal and the human or animal body. However, such probes suffer from a number of disadvantages; they are expensive to make as the process of de-gassing the Araldite (TM), which is necessary to prevent spurious reflections from air bubbles within it, is time consuming. Also, the Araldite (TM) encased crystals form a hard and rigid lump which is not suitable for insertion into the patient via, for example, the oesophagus as it is likely to damage or irritate the delicate internal tissues of the patient.

Problems have also been experienced in the prior art in ensuring that the probe lies at the correct orientation within the patient since it cannot be directly manipulated when in

place.

According to the present invention there is provided an ultrasonic probe for use internally of a patient, the probe comprising:

a core member having mounted thereon at least one piezoelectric crystal for emitting an ultrasonic signal and receiving returning echoes;

cable means for conducting electrical signals between the or each piezoelectric crystal and an apparatus external to the patient; and

flexible drive means for transmitting a torque to said core member, said drive means having substantially no set and exhibiting substantially no hysteresis.

The present invention also provides an ultrasonic probe for use internally of a patient, the probe comprising:

a core member having mounted thereon at least one piezoelectric crystal for emitting an ultrasonic signal and receiving returning echoes;

cable means for conducting signals between the or each piezoelectric crystal and an apparatus external to the patient; and

cover means surrounding the core member, the or each piezoelectric crystal and at least that part of said cable means to be inserted into the patient, said cover means comprising a flexible elastomeric compound.

Because the flexible drive means exhibits no hysteresis rotation of it outside the patient is directly transmitted to the probe so that the user can exert direct control over the orientation of the piezoelectric crystals within the patient. Because the flexible drive means exhibit substantially no set the user can be confident that rotation of the flexible drive means will cause the core member to rotate about its own axis rather than performing an orbital motion which would damage the patient.

Because the cover means are made of a flexible elastomeric compound they are not damaging to the patient being biologically acceptable and relatively soft so as to cause neither physical damage nor irritation to the patient.

The velocity of sound in the cover means is preferably in the range of from 1200 to 1600 m/s, most preferably near 1500 m/s, the approximate velocity of sound in the human body. The cover means should preferably have a breakdown voltage in excess of 4 kV and preferably a dielectric strength of at least 10 kV/mm, most preferably 20 kV/mm or more.

Preferably, the covering is in close contact with the piezoelectric crystals, the space between being substantially

filled with an adhesive which doesn't require degassing and preferably is not brittle, e.g. a silicon based adhesive. This ensures that the ultrasonic signal emitted from the crystals is transmitted into the patient without undue attenuation or scattering.

The present invention will be further described hereinafter with reference to the follow description of an exemplary embodiment and the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a probe end according to the present invention; and

Figure 2 is a partial cross-sectional view of a probe and associated cable according to the invention.

Figure 1 shows, in cross-section, a probe tip 1 which is formed about a central plastics slug 3. Piezoelectric crystals 5a,b are mounted on the end of the slug 3 with their emission and receiving faces at an angle of 45 degrees to the longitudinal axis of the slug 3. The faces of the crystals 5a,b are silver plated and have the inner conductor and screen from coaxial cables 7a & 7b soldered to respective faces. The crystals are bonded to the face of the slug with a small amount of adhesive, and a projection is provided from the face of the slug to separate them and prevent crosstalk between them.

Cables 7a & 7b carry a drive signal from an external apparatus 8 and signals representing received echoes to the apparatus.

The cables are preferably coaxial to prevent crosstalk between the two crystals.

A silicon boot 9 is slid over the end of the slug and crystals and the space between the crystals and the silicon boot is filled with a small amount of silicon adhesive to ensure that there are no air gaps between the crystals and the silicon boot. The silicon boot seals and insulates the probe tip and its exterior surface is smooth.

A flexible drive shaft 13 comprising a soft steel mandrel overwound with two flat spring steel wires is set into a square socket in the rear of the slug. The spring steel wires are wound in opposite directions so that the flexible drive has equal torque characteristics for both clockwise and counter clockwise rotation. In use it exhibits no hysteresis and has substantially no set, i.e. lies straight when unstressed.

The two coaxial wires 7a, 7b and the flexible drive shaft 13 are both surrounded by a high quality silver plated copper braid 15 which both protects the coaxial signal wires and electrically screens them. The copper braid extends into the silicon boot and is pulled tight around the drive shaft 13 and coaxial cables 7a, b. The braid is grounded to ensure that if the patient bites through the silicon outer 13 he/she does not contact any live wires.

A silicon tube 13 surrounds the copper braid and is also inserted into the silicon boot to which it is hermetically

sealed by adhesive 18. The silicon tube 17 insulates the cable and provides a soft and biologically acceptable outer covering to the cable. Circumferential markings 23 are provided on the outer covering at predetermined distances, usually 350 and 400 mm, from the end of the probe to assist the user in judging how far the probe has been inserted. Further up the cable, preferably at least 500 mm from the probe end, the flexible drive shaft terminates and protrudes through the silicon tube 17. The end of the flexible drive shaft is mounted in a manipulator block 19 while the braid and cables are taken around the termination and continue to an external monitoring apparatus (not shown). The manipulator block 19 lies outside the patient and is shaped to enable the user to easily control the depth of insertion of the probe and its orientation.

The silicon rubber of the boot is chosen to provide good bonding properties, a velocity of sound as close as possible to that of water (approximately 1500 metres per second) and high electrical insulation. The silicon rubber of the tube need not have particular acoustic properties but it is important that it is biologically acceptable and has good electrical insulation properties. It is also advantageous that the rear of the silicon boot is tapered to prevent damage to the soft oesophageal tissue on withdrawal of the probe.

CLAIMS

1. An ultrasonic probe for use internally of a patient, the probe comprising:

a core member having mounted thereon at least one piezoelectric crystal for emitting an ultrasonic signal and receiving returning echoes;

cable means for conducting electrical signals between the or each piezoelectric crystal and an apparatus external of the patient; and

flexible drive means for transmitting a torque to said core member said drive means having substantially no set and exhibiting substantially no hysteresis.

2. An ultrasonic probe for use internally of a patient, the probe comprising:

a core member having mounted thereon at least one piezoelectric crystal for emitting an ultrasonic signal and receiving returning echoes;

cable means for conducting signals between the or each piezoelectric crystal and an apparatus external to the patient; and

cover means surrounding the core member, the or each piezoelectric crystal and at least that part of said cable means to be inserted into the patient, said cover means comprising a flexible elastomeric compound.

3. A probe according to claim 2, wherein said flexible elastomeric compound has a dielectric strength of at least 10

kV/mm.

4. A probe according to claim 2 or 3, wherein the velocity of sound in said flexible elastomeric compound is in the range of from 1200 to 1600 m/s.

5. A probe according to claim 2, 3 or 4, wherein said flexible elastomeric compound is silicon rubber.

6. A probe according to any one of claims 2 to 5, wherein said cover means comprises a first part surrounding said core member and the or each piezoelectric crystal and a tube hermetically sealed thereto surrounding said cable means.

7. A probe according to any one of claims 2 to 6, wherein the thickness of said cover means adjacent said piezoelectric crystals is substantially constant.

8. A probe according to any one of claims 2 to 7, wherein the exterior of said cover means is substantially smooth.

9. A probe according to any one of claims 2 to 8, wherein the space between the or each piezoelectric crystal and said cover means is substantially filled with a silicon adhesive.

10. A probe according to any one of claims 2 to 9 wherein the space between the or each piezoelectric crystal and said cover means is substantially free of gas bubbles.

11. A probe according to any one of claims 2 to 10 further comprising a braided sheath within said cover means and surrounding at least a part of said cable means.

12. A probe according to claim 11 wherein said braided sheath is conductive.

13. A probe according to any one of claims 2 to 12 further comprising:

flexible drive means for transmitting torque to said core member from the exterior of said patient, said drive means having substantially no set and exhibiting substantially no hysteresis.

14. A probe according to claim 13 wherein said flexible drive means is within said cover means.

15. A probe according to claim 13 or 14 when appendant on claim 9 wherein said flexible drive means is within said braided sheath.

16. A probe according to any one of claims 1 or 13 to 15 wherein said flexible drive means comprises a soft steel mandrel overwound with two flat spring steel wires.

17. A probe according to claim 16 wherein said flat wires are wound in opposite senses.

18. A probe according to any one of claims 1 or 13 to 17

further comprising a manipulator member positioned, in use, external to the patient and connected to said flexible drive means to enable application of a torque to said flexible drive means.

19. A probe according to any one of the preceding claims, wherein the or each emission/absorption surface of the or each piezoelectric crystal is positioned at a predetermined angle to the longitudinal axis of said core member.

20. A probe according to claim 19 wherein said predetermined angle is substantially 45 degrees.

21. A probe according to any one of the preceding claims, comprising separate piezoelectric crystals for emitting ultrasonic signals and for receiving returning echoes.

22. A probe according to claim 21 wherein said cable means comprises a coaxial cable for conducting a drive signal to the emission crystal or crystals and a coaxial cable for conducting signals representing returning echoes from the reception crystal or crystals.

23. A probe according to any one of the preceding claims further comprising at least one marking on the exterior of the probe at a predetermined distance or distances from the piezoelectric crystals.

24. An ultrasonic probe constructed and arranged to operate

substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number: 9208812.9

Relevant Technical fields

(i) UK Cl (Edition K) G1G (GEEH, GEEM)

(ii) Int Cl (Edition 5) A61B; A61M

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner: D C SUMMERHAYES

Date of Search: 21 JULY 1992

Documents considered relevant following a search in respect of claims 1

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	WO 91/14394 A1	(CARDIOVASCULAR) - see whole document, particularly page 9 line 34 to page 10 line 28	1
X	WO 91/02489 A1	(INTERTHERAPY) - see whole document, particularly page 20 line 19 to page 24 line 15	1
X	US 4951677	(CROWLEY) - see whole document, particularly column 8 line 18 to column 10 line 46	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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