(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 142 862**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 84114041.1

(22) Date of filing: 20.11.84

(51) Int. Cl.[4]: G 10 K 11/00

(30) Priority: 21.11.83 JP 218908/83

(43) Date of publication of application:
29.05.85 Bulletin 85/22

(84) Designated Contracting States:
DE FR GB

(71) Applicant: Matsushita Electric Industrial Co., Ltd.
1006, Oaza Kadoma
Kadoma-shi Osaka-fu, 571(JP)

(72) Inventor: Muramatsu, Fumio
1158, Tsumada
Atsugi-shi Kanagawa-ken(JP)

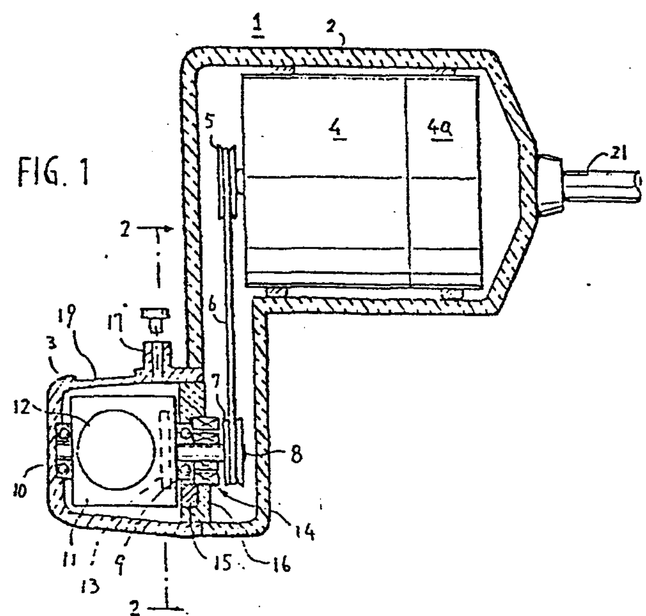
(72) Inventor: Kawabuchi, Masami
2710-157, Miho-cho Midori-ku
Yokohama(JP)

(74) Representative: Bühling, Gerhard, Dipl.-Chem. et al,
Patentanwaltsbüro Tiedtke-Bühling-Kinne
Grupe-Pellmann-Grams-Struif Bavariaring 4
D-8000 München 2(DE)

(54) Ultrasonic probe having a liquid-containing housing formed of polymethylpentene resin.

(57) Disclosed is an ultrasonic probe having a transducer submerged in an acoustic transmitting liquid medium contained in a housing. The housing is formed of polymethylpentene resin having an acoustic impedance approximately equal to that of the human body. Multiple reflections and transmission loss of acoustic energy are minimized to ensure high quality tomographic images.

FIG. 1



EP 0 142 862 A2

Croydon Printing Company Ltd.

0142862

TITLE OF THE INVENTION

"Ultrasonic Probe having a Liquid-Containing Housing Formod of Polymethylpentene Resin"

BACKGROUND OF THE INVENTION

The present invention relates to ultrasonic probes particularly for medical diagnostic purposes, and more particularly to ultrasonic probes of the type wherein piezoelectric transducer is submerged in a liquid medium.

Ultrasonic probes for medical purposes require that in order to obtain a high quality tomographic image there be a minimum amount of energy loss and a minimum number of reflections of acoustic energy between piezoelectric transducer and human body. Impedance match between them is important in this regard and attempts have been made to seek a material that can be used to match in acoustic impedace with that of the human body. Ultrasonic probes of the mechanical scan type wherein the transducer is submerged in a transmitting liquid medium contained in a housing, the material of the housing determines the degree of impedance match. The housing is further required to have a sufficient degree of insulation to prevent leakage of electricity, have sufficient mechanical strength and required to be inactive to chemicals, available at low cost and have a sufficient thermal plasticity to lend itself to extrusion process while at the same time it is sufficiently resistive to heat generated during use.

SUMMARY OF THE INVENTION

The present invention is therefore to provide an ultrasonic probe having a piezoelectric transducer submerged in a liquid contained in a probe housing having properties which satisfy the requirements imposed upon it.

According to the invention, use is made of polymethylpentene resin to form at least a part of the probe housing, or acoustic window, which is brought into contact with the human skin. Polymethylpentene resin has a number of advantageous physical and chemical properties among which the acoustic impedance value, which is most important, is approximately equal to that of the human body. The use of polymethylpentene resin is particularly beneficial to ultrasonic probes of the mechanical scan type of either sector or linear format.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described in further detail with reference to the accompanying drawings, in which:

Fig. 1 is a longitudinal cross-sectional view of an ultrasonic probe of a mechanical sector scan type;

Fig. 2 is a transverse cross-sectional view taken along the line 2 of Fig. 1;

Fig. 3 is a circuit diagram of the sector scan probe of Fig. 1;

Figs. 4 and 5 are illustrations of alternative embodiment; and

Fig. 6 is a cross-sectional view of a probe of a mechanical linear scan type.

DETAILED DESCRIPTION

A mechanical sector-scan ultrasonic probe shown in Fig. 1 comprises a housing 1 which is divided into a hand grip portion 2 and a cylindrical head portion 3. An electric motor 4, accommodated in the hand grip portion 2, has a pulley 5 which is connected by a belt 6 to a driven pulley 7 which in turn drives a rotary shaft 8 supported by bearings 9 and 10 fixed on front and rear walls of the head portion. The instantaneous angular position of motor 4 is detected and controlled by a position encoder 4a which is also mounted in the grip portion 2. On the rotary shaft 8 are mounted an insulative block 11 of a triangular cross-section (Fig. 2) and the inner winding 14b of a rotary transformer 14. Piezoelectric transducers 12a, 12b, 12c are fixedly secured to the sides of block 11. As shown in Fig. 3, first electrodes of transducers 12a, 12b, 12c are coupled together to one terminal of the inner winding 14a of transformer 14 and their second electrodes are coupled to the opposite terminal of the inner winding 14a via reed switches 13a, 13b and 13c, respectively, which are embedded in the rotary block 11 in locations spaced 120 degrees apart as shown in Fig. 2. A permanent magnet 15 is mounted on the rear wall 16 adjacent to the lower arc of a circular path followed by rotating reed switches in order to successively close their contacts as each piezoelectric transducer rotates over a lower arc of its path.

The head portion 3 is provided with a liquid inlet port 17 and a cap 18 therefor to fill the head portion 3 with a liquid which provides low-loss propagation of acoustic waves. If the liquid contains bubbles, acoustic transmission is adversely affected. To prevent this, the inlet port has a sufficient cross-section to allow bubbles in liquid to escape therethrough while the liquid is being supplied. Preferably, an air vent port 20 with a cap 21 may be provided.

Ultrasonic burst pulses are supplied from a drive circuit, not shown, through a cable 21 to the outer winding 14b of rotary transformer 14. Pulses are induced in the inner winding 14a and coupled to the piezoelectric transducer by the associated reed switch which is following the lower half of its circular path near the permanent magnet 15, transmitting acoustic energy. Each reed switch remains closed to allow the transmitted energy to be steered in a sector format and during this period short-duration bursts are sequentially transmitted at intervals sufficient to receive echos returning from different tissues of a body under examination. The received energy is converted to electrical signals which are coupled through the rotary transformer 14 to a processing circuit to obtain a tomographic ultrasound image of a sector field. As reed switches 13a, 13b, 13c are sequentially closed, piezoelectric transducers 12a, 12b, 12c are likewise energized to effect the transmission and reception of acoustic energy.

According to the invention, the head portion 3 of the housing is formed of polymethylpentene resin. To make the inside of the housing portion 3 invisible from the outside, a coloring agent is mixed with the resin. However, the top wall of housing portion 3 has a reduced thickness as shown at 19 to make the inside visible to allow observation of bubbles in the liquid.

The polymethylpentene resin having recurring units of the formula

$$\left(\underset{\lfloor CH_2-CH(CH_3)_2}{CH}-CH_2 \right)_n$$

has the following advantageous properties:

TABLE

Density	: 0.833 g/cm^3
Melting point	: 240°C
Acoustic impedance	: approx 1.66×10^5 $g/cm^3\cdot sec$

Acoustic propagation loss	: approx 0.4 dB/mm at 3.5 MHz
Bending strength	: 360 kg/cm^2
Thermally deformable temperature	: 90°C
Volume resistivity	: more than 10^{16} ohm·cm

Since the acoustic impedance of polymethylpentene resin is very close to that of the human body which is approximately 1.54×10^5 $g/cm^2 \cdot sec$, it is possible to minimize the effect of multiple reflections of acoustic energy which would otherwise occur between the inner wall of head portion 3 and each piezoelectric transducer. Experiments confirmed that tomographic images obtained by the probe of the invention showed no trace of multiple reflections. The propagation loss value of about 0.4 dB/mm at 3.5 MHz does not materially affect the sensitivity performance of the ultrasound probe. The mechanical and thermal characteristics of polymethylpentene resin also are satisfactory for the purpose of the present invention. A further advantageous characteristic of polymethylpentene resin is that its volume resistivity falls within the range of insulators and guarantees excellent protection against current leakage. The chemical inactive nature of this material also makes it ideal for use in environment where the ultrasound probe is likely to be stained by chemicals. Another advantage is that the thermoplastic nature of the resin lends itself to extrusion process.

Figs. 4 and 5 show an alternative embodiment in which the lower half part of the probe head 3, or window 30 may be formed of polymethylpentene resin and the remainder part 31 may be formed of an opaque plastic material which is molded to create an opening to which the polymethslpentene-resin made window 30 is adhesively fitted.

Fig. 6 shows a linear scan ultrasound probe. A piezoelectric transducer 40 of a rectangular or disc shape is fitted below a block 41 threadably mounted on a horizontal drive shaft 42 rotatably mounted on bearings 43, 44 which are secured on opposite walls of a housing 45 formed of polymethylpentene resin. A position encoder 53 slidably mounted on a guide shaft 54 is connected to block 41. The housing 45 is provided with a bubble check window 46 if it is formed of an opaque polymethylpentene resin. Drive shaft 42 is connected to pulley 47 connected by a belt 48 and pulley 49 to a revesible motor 50 which is secured to the housing 45. Transducer 40 is driven to reciprocate along a straight line to steer transmitted energy to obtain a tomographic image of a rectangular format. All the component parts of the probe are accommodated in an opaque insulative casing 51 to which cable 52 is terminated. Flexible wire connection, not shown, is made from cable 52 to the transducesr 40.

Although the use of polymethylpentene resin is also applicable to electronically scanned ultrasound probe, the present invention is particularly advantageous to the mechanically scanned probe as described above since this type of probes necessitates an acoustic low-loss propagation liquid medium which must be contained in a housing.

What is claimed is:

1. An ultrasonic probe comprising:

a housing having an acoustic window for passing acoustic energy therethrough, said acoustic window being formed of polymethylpentene resin;

an acoustic energy propagating liquid in said housing; and

a piezoelectric transducer in said liquid for transmitting and receving acoustic energy through said window.

2. An ultrasonic probe as claimed in claim 1, wherein said housing is entirely formed of said polymethylpentene resin.

3. An ultrasonic probe as claimed in claim 1, wherein said housing is provided with a window through which said liquid is made visible from the outside.

4. An ultrasonic probe as claimed in claim 1, further comprising means for repetitively moving said transducer over a predetermined path to steer said acoustic energy.

5. An ultrasonic probe as claimed in claim 4, wherein said predetermined path is a part circular path to scan said

energy in a sector format.

6. An ultrasonic probe as claimed in claim 4, wherein said predetermined path is a straight line path to scan said energy in a rectangular format.

7. An ultrasonic probe as claimed in claim 1, wherein said housing is provided with an inlet port through which said liquid is supplied to said housing and an air vent port through which bubbles in said liquid is allowed to escape to the outside.

8. An ultrasonic probe as claimed in claim 4, further comprising a second piezoelectric transducer, wherein said mechanically moving means comprises a permanent magnet, means for rotatably supporting the first and second transducers in angularly spaced apart relationship to each other, means for rotating said support, and first and second reed switches connected respectively to said first and second transducers and mounted on said supporting means in an angularly spaced apart relationship to each other to sequentially establish connection from an acoustic energy source to the first and second transducers under the influence of an electromagnetic field generated by said permanent magnet.

9. An ultrasonic probe as claimed in claim 4, wherein said mechanically moving means comprises means for reciprocating said transducer along a linear path.

0142862

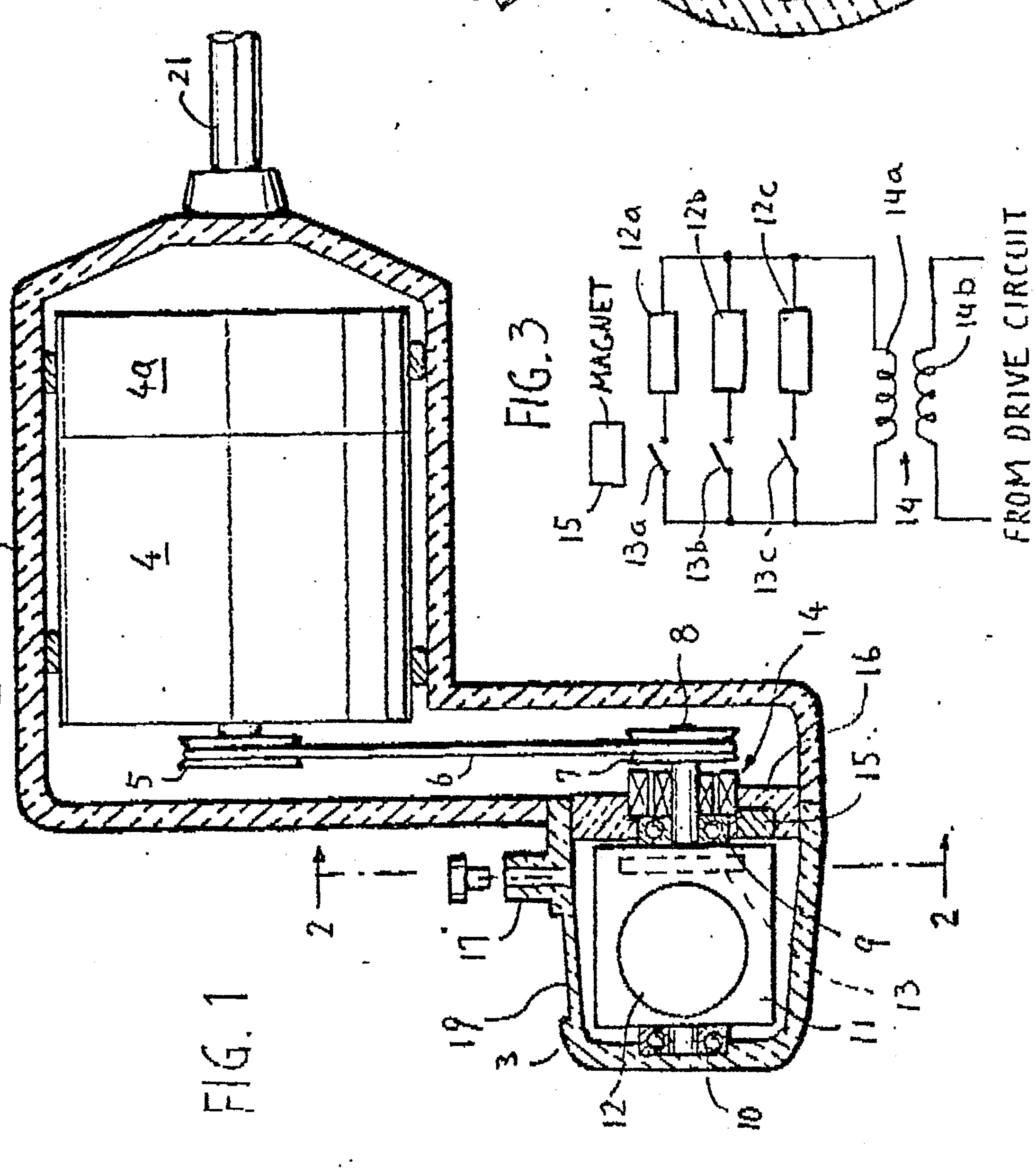


FIG. 1

FIG. 3

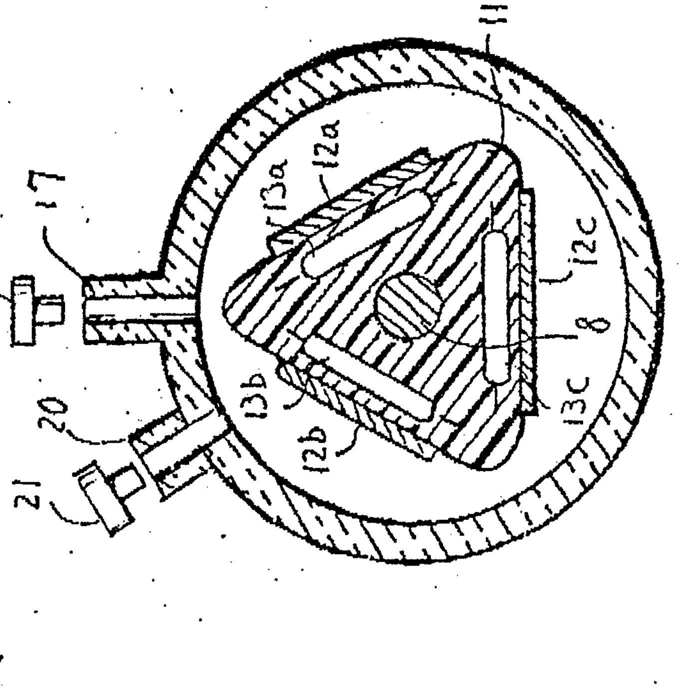


FIG. 2

FIG. 4

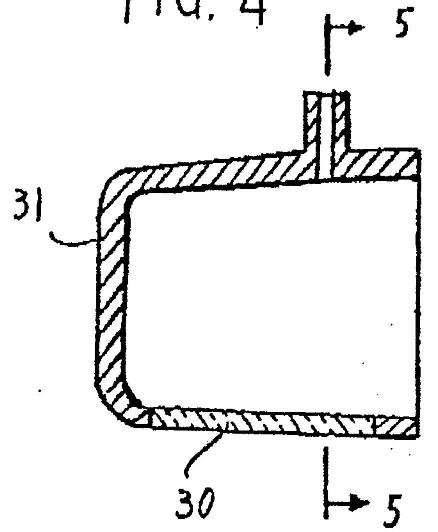


FIG. 5

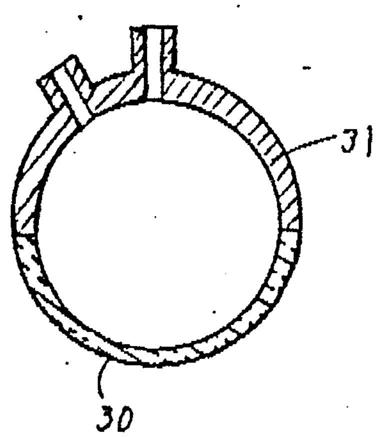


FIG. 6