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Kuniyasu et al.(10) **Pub. No.: US 2009/0247875 A1**(43) **Pub. Date: Oct. 1, 2009**(54) **ULTRASONIC GENERATOR**(86) PCT No.: **PCT/JP2006/319645**(75) Inventors: **Toshiaki Kuniyasu**, Kanagawa
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(2), (4) Date: **Mar. 29, 2008**(30) **Foreign Application Priority Data**

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A61B 8/00 (2006.01)(52) **U.S. Cl.** **600/459**(57) **ABSTRACT**(73) Assignees: **FUJIFILM Corporation**, Tokyo
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An ultrasonic transducer (20) is enclosed by a cap (19). Inside of the cap (19) is filled with liquid paraffin (25). The liquid paraffin (25) has a maximum molecular weight M1 of $520 \leq M1 \leq 1400$, a peak top molecular weight M2 of $230 \leq M2 \leq 380$, and a kinematic viscosity S (mm²/s) of $4 \leq S \leq 12.5$ at 40° C. This liquid paraffin (25) achieves deeper penetration of the ultrasonic waves into biological tissues and higher receiver sensitivity to the echoes of the ultrasonic waves across a broad frequency range.

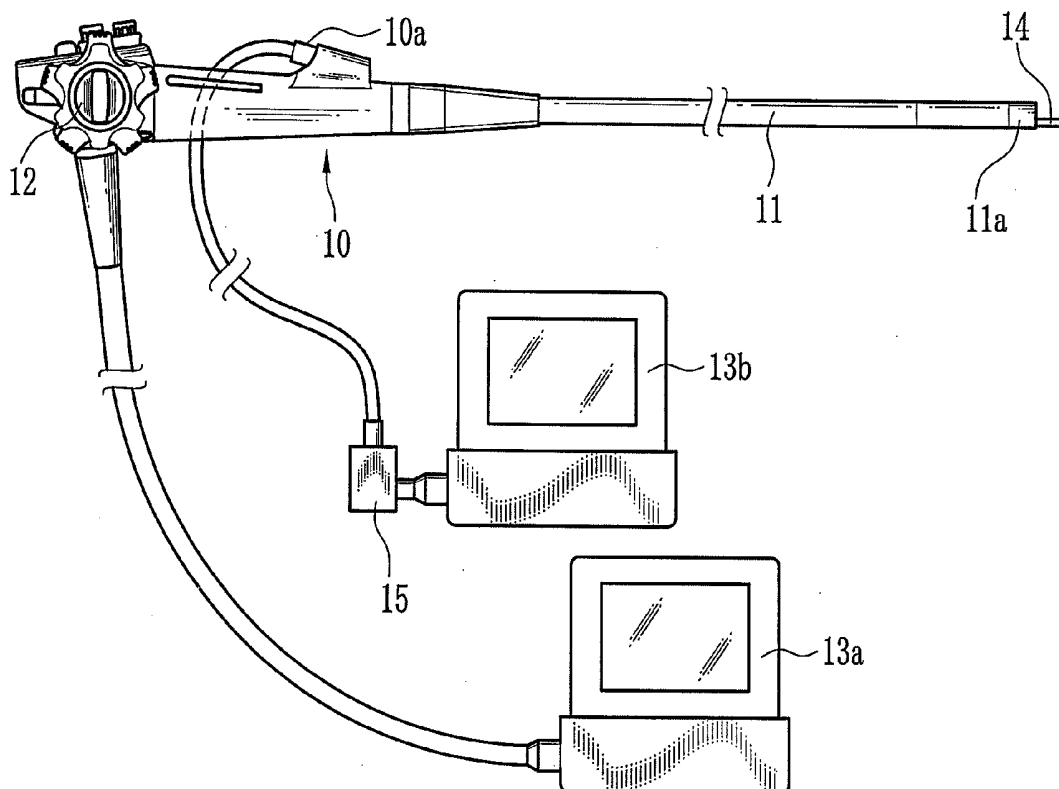
(21) Appl. No.: **12/088,682**(22) PCT Filed: **Sep. 26, 2006**

FIG. 1

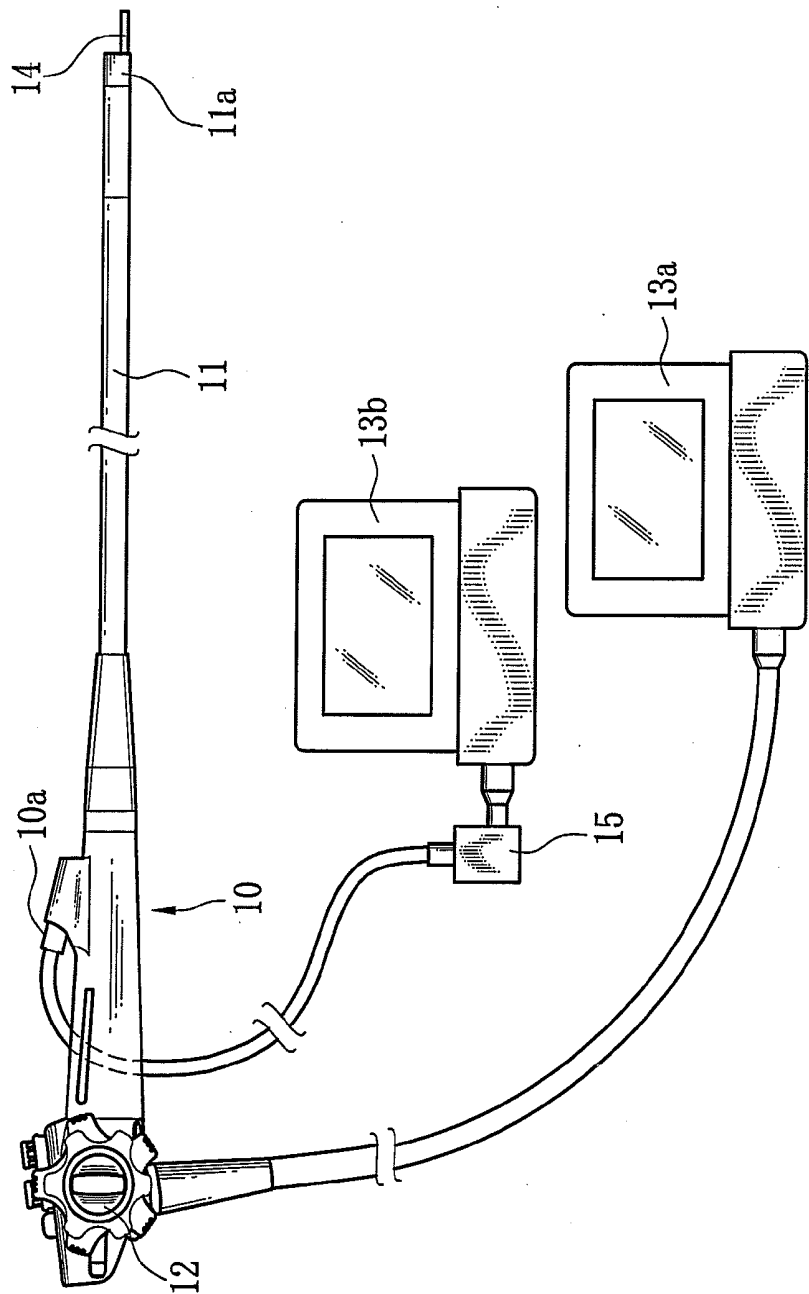


FIG. 2

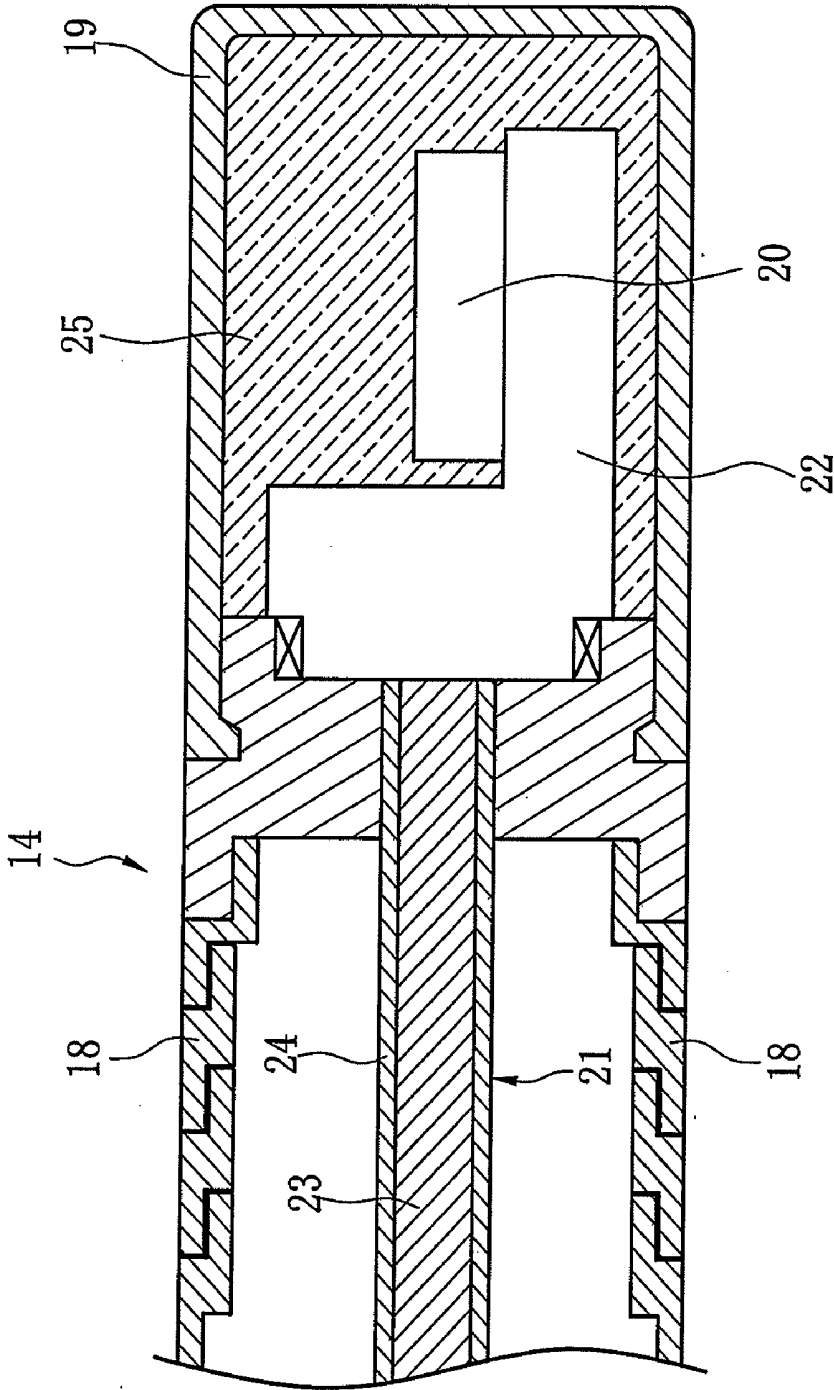


FIG. 3A

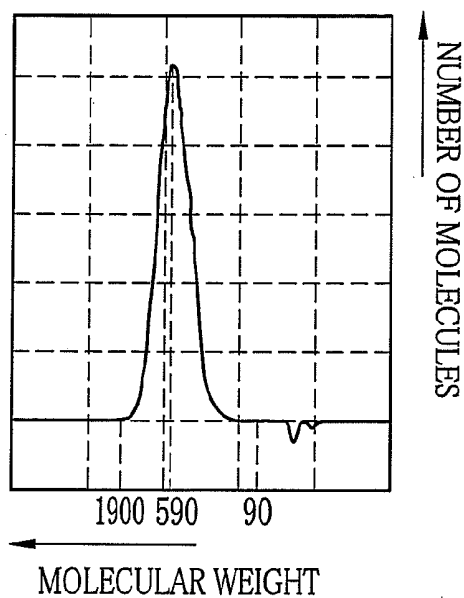


FIG. 3B

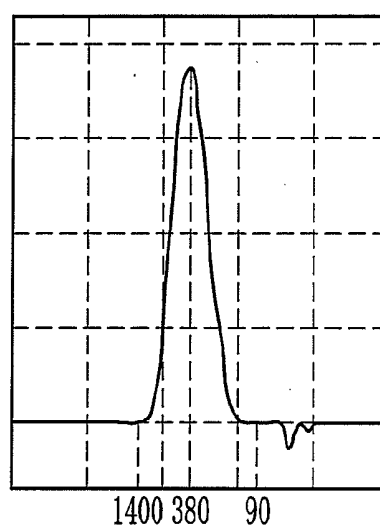


FIG. 3C

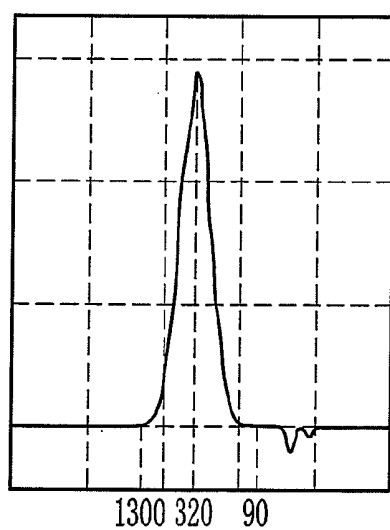


FIG. 3D

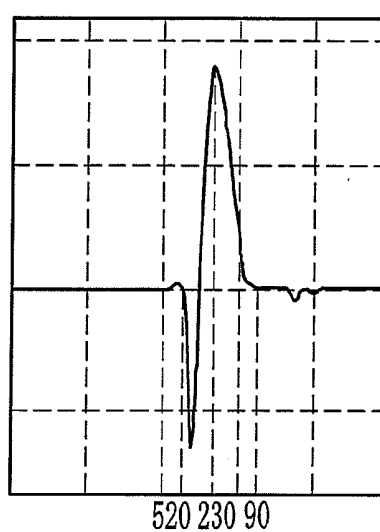


FIG. 4

	KINEMATIC VISCOSITY (mm ² /s)			NUMBER AVERAGE MOLECULAR WEIGHT	WEIGHT AVERAGE MOLECULAR WEIGHT	DISPERSITY	PEAK TOP MOLECULAR WEIGHT	MAXIMUM MOLECULAR WEIGHT
	30°C	40°C	50°C					
A	60.93	38.84	25.88	490	570	1.2	590	1900
B	17.55	12.52	8.119	340	400	1.2	380	1400
C	13.08	9.506	7.136	300	350	1.2	320	1300
D	5.660	4.401	3.968	—	—	—	230	520

FIG. 5

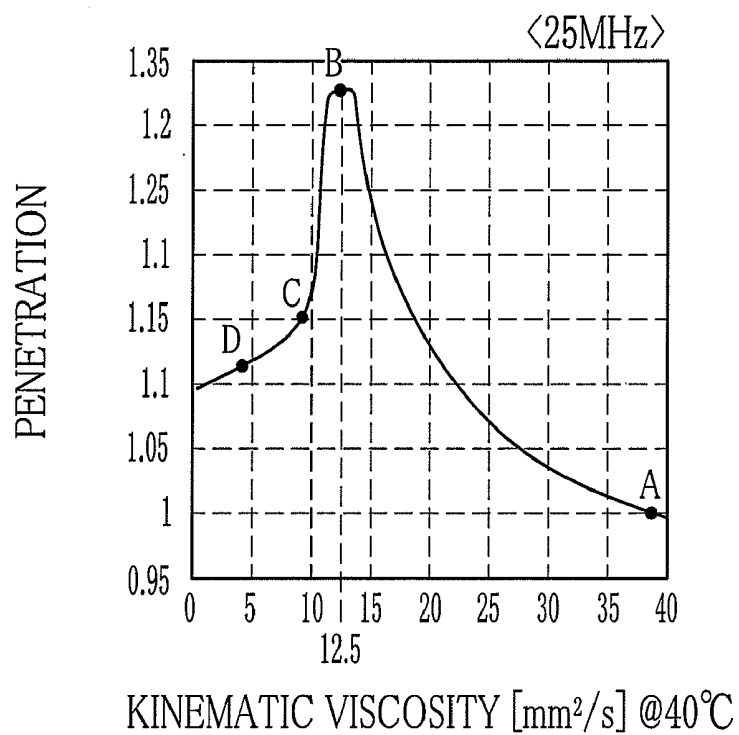
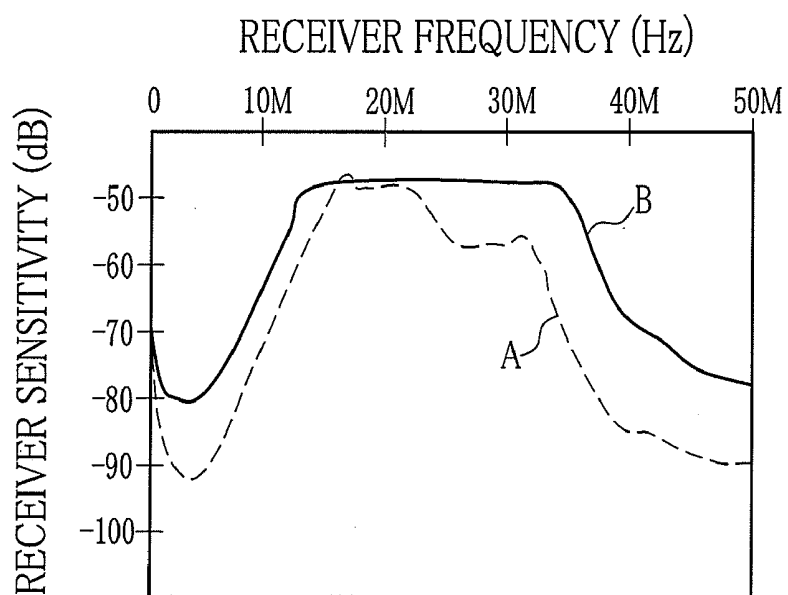


FIG. 6



ULTRASONIC GENERATOR

TECHNICAL FIELD

[0001] The present invention generally relates to an ultrasonic generator used in ultrasonic probes, and more particularly to an ultrasonic generator with improved ultrasonic transfer characteristics.

BACKGROUND ART

[0002] Some medical electronic endoscopes have both a CCD camera for observation of an organ surface and an ultrasonic probe for observation inside the tissues of the organ. The ultrasonic probe sends ultrasonic waves into a biological tissue of interest and receives echoes of the ultrasonic waves. The received echoes of the ultrasonic waves bear tomographic information of the biological tissue, and it is possible to produce a tomographic image of the biological tissue based on these echoes. The combination of the ultrasonic image inside the biological tissue by the ultrasonic probe and an optical image of the biological tissue by the CCD camera enables accurate diagnosis as to existence of a disease and progress of the disease.

[0003] The ultrasonic probe has one or more ultrasonic transducers as a source of ultrasonic wave. The ultrasonic transducer is composed of a piezoelectric element, and typically contained in a cavity filled with ultrasonic transmission fluid medium so that the ultrasonic waves are effectively transmitted to the target body. One variety of such transmission fluid medium is liquid paraffin, a kind of hydrocarbon oils (see, for example, Japanese patent laid-open publication No. 05-176931). Also, Japanese laid-open publication No. 2001-299748 discloses an ultrasonic probe using the liquid paraffin having a kinematic viscosity of less than $20 \text{ mm}^2/\text{s}$. This liquid paraffin provides better transfer efficiency to high frequency components of the ultrasonic waves.

[0004] It becomes known, however, that the ultrasonic transfer characteristics of the liquid paraffin depends on molecular weight distribution of the paraffin molecules. Namely, if the molecular weight of the paraffin molecule is changed, the liquid paraffin has different ultrasonic transfer characteristics even with the same kinematic viscosity. It is therefore understood that the composition of the liquid paraffin must be considered for a good ultrasonic transfer characteristics.

[0005] In view of the foregoing, an object of the present invention is to provide an ultrasonic generator which incorporates the liquid paraffin with an excellent ultrasonic transfer characteristics.

DISCLOSURE OF INVENTION

[0006] In order to achieve the above object and other objects, an ultrasonic generator according to the present invention includes liquid paraffin, as an ultrasonic transmission medium, whose maximum molecular weight $M1$ is $520 \leq M1 \leq 1400$. Contained in a space filled with this liquid paraffin is an ultrasonic transducer which generates ultrasonic waves.

[0007] In addition, the liquid paraffin has a peak top molecular weight $M2$, where the number of molecules is greatest, of $230 \leq M2 \leq 380$.

[0008] Furthermore, the liquid paraffin has a kinematic viscosity S (mm^2/s) of $4 \leq S \leq 12.5$.

[0009] It is preferable that the liquid paraffin has the maximum molecular weight $M1$ of $1300 \leq M1 \leq 1400$.

[0010] It is also preferable that the liquid paraffin has the peak top molecular weight $M2$ of $320 \leq M2 \leq 380$.

[0011] It is further preferable that the liquid paraffin has the kinematic viscosity S of $9 \leq S \leq 12.5$.

[0012] According to the present invention, the liquid paraffin is improved in the ultrasonic transfer characteristics. This enables deep penetration of the ultrasonic waves into the biological tissue and high receiver sensitivity across a broad frequency range. It is therefore possible to obtain high definition, high contrast ultrasonic images of deep part of a biological tissue.

Brief Description of Drawings

[0013] FIG. 1 is a schematic view of an electronic endoscope having an ultrasonic probe according to the present invention;

[0014] FIG. 2 is a cross sectional view of the ultrasonic probe;

[0015] FIGS. 3A to 3D are graphs showing molecular weight distribution of four types of liquid paraffin;

[0016] FIG. 4 is a table showing representative values for kinematic viscosity at different temperatures and the molecular weight distribution of the four types of liquid paraffin;

[0017] FIG. 5 is a graph showing the kinematic viscosity at 40°C . and penetration of the four types of liquid paraffin; and

[0018] FIG. 6 is a graph showing receiver sensitivities of an optimal liquid paraffin and a conventional liquid paraffin at each frequency.

BEST MODE FOR CARRYING OUT THE INVENTION

[0019] Referring to FIG. 1, an electronic endoscope 10 has a flexible insertion section 11 to be inserted into a living body and an operating section 12 for operation of the insertion section 11. A distal end 11a of the insertion section 11 has a CCD camera (not shown). The electronic endoscope 10 is connected to monitors 13a and 13b, and the images captured with the CCD camera are displayed on the monitor 13a. At the time of an ultrasonic diagnosis, an ultrasonic probe 14 is inserted into an instrument inlet port 10a. The ultrasonic probe 14 passes through a forceps channel (not shown) running inside the insertion section 11, and projects outwardly from a forceps opening provided on the distal end 11a. The ultrasonic images obtained with the ultrasonic probe 14 are displayed on the monitor 13b.

[0020] As shown in FIG. 2, the ultrasonic probe 14 includes a flexible pipe section 18 constituted of a plurality of sheaths 18a interlocked with one another and a polyethylene cap 19 attached to the front end of the pipe section 18. Enclosed inside the cap 19 is an ultrasonic transducer 20 which generates ultrasonic waves and receives the echoes of the ultrasonic waves that reflected off the organs. The ultrasonic transducer 20 is mounted on a base 22, which is connected to a control cable 21. The control cable 21 is composed of a flexible shaft 23 and a flexible tube 24 to enclose the flexible shaft 23. One end of the flexible shaft 23 is connected to the base 22, and the other end thereof is connected to a translator 15 (see, FIG. 1). The translator 15 has a built-in motor, and the drive of this motor leads the flexible shaft 23 to rotate around its axial direction. Accordingly, the base 22 rotates together with the ultrasonic transducer 20 on the flexible shaft 23. Rotating the

ultrasonic transducer 20 enables radial scanning of the biological tissues with the ultrasonic waves to produce the ultrasonic images. It is understood that the flexible shaft 23 houses a plurality of electric wires for transmittal of drive signals to the ultrasonic transducer 20 and echo signals from the ultrasonic transducer 20.

[0021] Inside the cap 19 to contain the ultrasonic transducer 20 is filled with liquid paraffin 25 serving as an ultrasonic transmission medium. The liquid paraffin 25 improves transfer efficiency of the ultrasonic waves generated by the ultrasonic transducer 20 and the echoes of the ultrasonic waves reflected off the biological tissue. Also, the liquid paraffin 25 serves as a lubricant to allow smooth rotation of the ultrasonic transducer 20. The liquid paraffin 25, a kind of hydrocarbon oil, is superior in lubricity and electrical insulation property, and harmless to the living body.

[0022] Next, the ultrasonic transfer characteristics was compared between four types of liquid paraffin A to D (from Wako pure chemical industries, ltd) having different compositions. The liquid paraffin A is the one used in conventional ultrasonic probes. The liquid paraffin B has a density of 0.825 to 0.850 g/ml. The liquid paraffin C has a density of 0.815 to 0.840 g/ml. The liquid paraffin D has a density of 0.795 to 0.830 g/ml. The molecular weight distribution of each liquid paraffin was measured, and the results of the measurement are shown on graphs of FIGS. 3A to 3D where the vertical axis represents the number of paraffin molecules and the horizontal axis represents the molecular weight of paraffin. In addition, a table of FIG. 4 shows kinematic viscosity of these liquid paraffin measured at different temperatures and representative values of the molecular weight distribution.

[0023] The molecular weight was measured by a gel permeation chromatography method (GPC method). Used in the measurement were LC-10 from Shimadzu corporation as the analytical instrument, PLgel MIXD-E columns, chloroform (1 ml/min) as the elution solution, a differential refractive index detector, and polystyrene as a reference material. The values of each molecular weight are expressed in terms of polyethylene equivalent. The kinematic viscosity was measured under JIS K2283 (crude petroleum and petroleum products—Determination of kinematic viscosity and calculation of viscosity index from kinematic viscosity).

[0024] As shown in FIGS. 3A to 3B, the liquid paraffin A used in the conventional ultrasonic probes showed a minimum molecular weight of approximately 90 and a maximum molecular weight of approximately 1900. Additionally, a peak top molecular weight, where the molecule number is largest, was 590, and a number averaged molecular weight, or the central value was 490. A weight averaged molecular weight was 570. The liquid paraffin B showed the minimum molecular weight of approximately 90 and the maximum molecular weight of approximately 1400. The peak top molecular weight was 380, and the number averaged molecular weight was 340. The weight averaged molecular weight was 400. The liquid paraffin C showed the minimum molecular weight of approximately 90 and the maximum molecular weight of approximately 1300. The peak top molecular weight was 320, and the number averaged molecular weight was 300. The weight averaged molecular weight was 350. The liquid paraffin D showed the minimum molecular weight of approximately 90 and the maximum molecular weight of approximately 1900. The peak top molecular weight was 230 while the number averaged molecular weight and the weight averaged molecular weight were immeasurable.

[0025] Recognized in FIG. 4 is that the liquid paraffin with higher values of the maximum, average, and peak top molecular weights has higher kinematic viscosity whereas the liquid paraffin with lower values of the maximum, average, and peak top molecular weights has lower kinematic viscosity. Next, the ultrasonic probes having one of the liquid paraffin A to D were prepared to measure a penetration of a 25 MHz ultrasonic wave from these ultrasonic probes into a biological tissue. The measurement result is shown in FIG. 5.

[0026] As shown in FIG. 5, the liquid paraffin B showed by far greater penetration than the other liquid paraffin. This means that the liquid paraffin B enables to produce tomographic images of deeper part of a biological tissue. While being inferior to the liquid paraffin B, the liquid paraffin C and D were superior to the liquid paraffin A, proving to achieve a practically admissible level of penetration. These results lead to arrive the conclusion that an ever better penetration of the ultrasonic waves is achieved by the liquid paraffin having the kinematic viscosity S of $4 \leq S \leq 12.5$ at 40°C ., i.e., about the temperature of body. Specifically, the penetration becomes excellent when the kinematic viscosity S is $9 \leq S \leq 12.5$ at 40°C .

[0027] FIG. 6 has a graph showing a measurement result of receiver sensitivity at each frequency. The dashed line represents the conventional liquid paraffin A, and the solid line represents the liquid paraffin B which showed the best penetration among the others. The liquid paraffin A shows its best receiver sensitivity of -50 dB at around 20 MHz and the receiver sensitivity of -60 dB at around 15 MHz and 30 MHz. The liquid paraffin B, on the other hand, shows good receiver sensitivity of -50 dB across a broad frequency range stretching from around 12 MHz to around 35 MHz, proving to have by far greater receiver sensitivity than the liquid paraffin A. This means that the ultrasonic probes with the liquid paraffin B are able to produce high definition, high contrast ultrasonic images. Furthermore, the resolving power becomes excellent with the liquid paraffin B.

[0028] Based on the results of the above experiment, it is discovered that the ever better ultrasonic transfer characteristics can be obtained with the liquid paraffin having the maximum molecular weight of less than 1900 and in the range of 520 to 1400, and with the peak top molecular weight of less than 590 and in the range of 230 to 380. If the liquid paraffin is conditioned to have the maximum molecular weight of in the range of 1300 to 1400 and the peak top molecular weight of in the range of 320 to 380, an excellent or good ultrasonic transfer characteristics such as of the liquid paraffin B or C can be obtained.

[0029] The ultrasonic generator of the present invention is not limited to the medical electronic endoscopes having a CCD camera, but applicable to medical ultrasonic apparatuses of external type. Furthermore, the ultrasonic generator of the present invention is not limited to the medical endoscopes, but applicable to the industrial-use inspection apparatuses which work in the same frequency range of ultrasonic wave as the medical endoscopes.

INDUSTRIAL APPLICABILITY

[0030] The ultrasonic generator of the present invention is suitably applied to medical diagnosis apparatuses and industrial-use inspection apparatuses.

1. An ultrasonic generator comprising:
an ultrasonic transducer for generating ultrasonic waves;
a cap for enclosing said ultrasonic transducer; and

liquid paraffin filled in said cap and having a maximum molecular weight M1 of $520 \leq M1 \leq 1400$.

2. An ultrasonic generator described in claim 1, wherein said liquid paraffin has a peak top molecular weight M2 with a largest molecule number of $230 \leq M2 \leq 380$.

3. An ultrasonic generator described in claim 1, wherein said liquid paraffin has a kinematic viscosity S (mm^2/s) of $4 \leq S \leq 12.5$ at 40°C .

4. An ultrasonic generator described in claim 1, wherein said maximum molecular weight M1 is $1300 \leq M1 \leq 1400$.

5. An ultrasonic generator described in claim 2, wherein said peak top molecular weight M2 is $320 \leq M2 \leq 380$.

6. An ultrasonic generator described in claim 3, wherein said kinematic viscosity S is $9 \leq S \leq 12.5$ at 40°C .

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专利名称(译)	超声波发生器		
公开(公告)号	US20090247875A1	公开(公告)日	2009-10-01
申请号	US12/088682	申请日	2006-09-26
[标]申请(专利权)人(译)	富士胶片株式会社 富士写真光机株式会社		
申请(专利权)人(译)	富士胶片株式会社 FUJINON CORPORATION		
当前申请(专利权)人(译)	富士胶片株式会社 FUJINON CORPORATION		
[标]发明人	KUNIYASU TOSHIAKI TANAKA TOSHIZUMI ITOI HIROMU		
发明人	KUNIYASU, TOSHIAKI TANAKA, TOSHIZUMI ITOI, HIROMU		
IPC分类号	A61B8/00		
CPC分类号	A61B8/12 A61B8/4281 G10K11/02 A61B8/4461 A61B8/445		
优先权	2005286116 2005-09-30 JP		
外部链接	Espacenet USPTO		

摘要(译)

超声换能器 (20) 由帽 (19) 包围。盖子 (19) 的内部充满液体石蜡 (25) 。液体石蜡 (25) 的最大分子量M1为 $520 \leq M1 \leq 1400$ ，峰顶分子量M2为 $230 \leq M2 \leq 380$ ，运动粘度S (mm² / s) 为 $4 \leq S \leq 12.5$ ，40该液体石蜡 (25) 实现了超声波更深地穿透到生物组织中，并且在宽频率范围内对超声波的回波具有更高的接收器灵敏度。

