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(54) **A DEVICE FOR REFLECTOMETRIC EXAMINATION AND MEASUREMENT OF CAVITIES**

VORRICHTUNG ZUR REFLEKTROMETRISCHEN UNTERSUCHUNG UND MESSUNG VON KÖRPERHOHLRÄUMEN

DISPOSITIF D'EXAMEN ET DE MESURE REFLECTOMETRIQUES DE CAVITES

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Description

[0001] The present invention relates to a device for reflectometric examination and measurement of cavities, comprising a signal generator system, a hose with a distal end to be introduced via an entrance to the cavity to be examined, a transmission transducer at a proximal end of the hose connected to the signal generator for transmission of an excitation signal from the signal generator to and through the hose, a reception transducer connected to the hose for reception of response signals from the hose, and a computer adapted for analysis of the response signal in relation to the excitation signal sent to and through the hose.

[0002] For examination and measurement of blockings, deformations, movements etc. in various human and animal cavities, e.g. pharynx, larynx and other air and alimentary passages, blood vessels etc. various methods are known.

[0003] In catheter examinations, balloon-angioplasty etc. it is known to use a probe in the shape of a hose of flexible material.

[0004] Another method is based on measurement of reflection (reflectometry) using an acoustic, transient excitation signal which, through a hose and through the patient's mouth, is sent into the air passages of the patient, cf. e.g. US-A-4.326.416.

[0005] This document discloses a device according to the preamble of claim 1.

[0006] Another method based on the use of a non-transient excitation signal - random or pseudorandom signal - is used in equipment manufactured by the applicant firm, under the commercial designation SRE 2000 and SRE 2000 PC.

[0007] Especially in connection with examination of movements in the air passages and examination of stertorous respiration mainly pressure transducers, placed in or on catheters to be introduced in nose or mouth, have so far been used. This allows for measurement of pressure variations, constrictions, etc. in nose and throat.

[0008] A drawback in this technique is to be seen in that the measurement probe must include a relatively large number of closely located pressure transducers connected to a corresponding apparatus which offers the possibility, on a screen with a sufficient resolution, to determine the position of and pressure at each examined spot.

[0009] Known techniques also include endoscopy by which optical examinations are made of nose, pharynx and other internal organs. However, these examinations have a certain number of limitations, including the clarity and size of the optical image, the size of the catheter and especially the lack of catheter flexibility which makes the catheter unsuitable for examination of e.g. stertorous respiration.

[0010] CT and MRI scanning have been tried, but involves long periods of measuring, which do not give useful measurements and no dynamic measurements at all.

[0011] By using acoustic reflectometry of the above mentioned kind, it is known that it is possible to measure cross-sectional areas in the air passages as a function of the distance from the transducer used for emission the excitation signal, cf. the above patent US-A-4.326.416 or an article: "Airway geometry by analysis of acoustic pulse response measurements" by Andrew C. Jackson et al. in J. Appl. Physiology, 43(3) : 525-536, 1977.

[0012] In direct measuring, the measurements are limited by cross modes, i.e. cross resonance, and by adjacent cavities, which, to a large extent, limits the use of such direct measurements having large differences in the cross-sectional areas as a function of the distance from the signal source.

[0013] Especially when examining stertorous respiration, the use of direct measurements is hampered by the transient or continuous sound influence necessary for the measurements, which affects the sleep state or awakens the patient during the examination phase itself, and also causes measurement errors because of noise from the measuring microphone and a measurement error due to the very large cavity made up by the mouth and throat.

[0014] The invention which is defined in claim 1 aims at remedying the above mentioned disadvantages.

[0015] The invention is based on the recognition that humans have many spots where a pathological change or obstruction in the air passages, urinary system etc. can be difficult to determine, locate and measure with the above mentioned known technique, i.a. because of the common cross resonance in the large or small surrounding cavities at the spot which is to be examined, and that it is particularly suitable to use a very flexible hose, whose wall can be made to abut the side wall in question of the passage or can be deformed by some change e.g. a constriction at the spot in question. By this, the measuring equipment is brought to only "seeing", so to speak, the interior of the hose and clearly measure the least deformation in the inner cross-sectional area of the hose as a function of the distance from the spot in the hose where the excitation signal is emitted onto the spot or spots where a deformation or deformations appear and from where the response signal originates.

[0016] According to a particular appropriate embodiment of the invention the device can be characterised in that the hose has a longitudinal, axially centered lumen surrounded by a ring-shaped wall, and around the ring-shaped wall a number of spaced, longitudinal canals separated from each other by means of essentially radial partitions.

[0017] By combining reflectometric measurements made inside the lumen of the hose and the peripheral canals or chambers it is possible with much greater sensibility to determine the position or measure the areas in the hose which due to some local change or obstruc-

tion in the passage in question (air passage, urinary system etc.) are compressed, as well as the degree of compression.

[0018] Upon insertion of the hose it is possible, with or without positive or negative compressive force in the lumen of the hose and/or the canals, by measuring the inner cross-sectional areas of the hose as a function of the distance, to determine the areas which are most narrow or compress the hose locally.

[0019] In this way it is possible, in balloon examinations and freeing of arteries in case of arteriosclerosis, to check the distension (cross-sectional area/longitudinal distance) of the balloon at the end of a catheter concurrently with the inflation of the balloon.

[0020] The invention is explained in detail below, with reference to the schematic drawings, where

Fig. 1 shows a block diagram of the basic layout of the device according to the invention,
Fig. 2 is a perspective drawing of part of the hose according to the invention, at the spot where the measurement is made,
Fig. 3 is a perspective drawing of part of the hose in another embodiment of the invention,
Fig. 4 is a sectional view of the hose according to Fig. 3 in a sectional plane at right angles to the axis of the hose,
Fig. 5 illustrates the placing of a hose according to the invention in the upper air passages with a patient being examined for tongue-fallback,
Fig. 6 illustrates the placing of a hose according to the invention in the upper air passages with a patient being examined for stertorous respiration, and
Fig. 7 shows a diagram of a hose with a balloon for a catheter examination in a blood vessel.

[0021] Fig. 1 shows the basic layout of the device according to the invention.

[0022] At 1 there is shown a hose the design of which will be explained below. At its proximal end A the hose 1 is in a manner known *per se*, not illustrated, connected to auxiliary equipment used for inserting the hose in e. g. the air passages of a patient, e.g. through the mouth or the nostrils, or in the urinary system or a blood vessel. At B is shown the distal end of the hose which after insertion of the hose will be present in the cavity of the patient who undergoes an examination.

[0023] At 2 is shown an electronic signal generator adapted to deliver an activation signal to a transducer 3 connected to the hose 1. The signal generator 2 delivers the same signal to a signal analysis processor 4. At 5 is shown a transducer connected to the hose 1. When an excitation signal is transferred from the signal generator 2, via the transducer 3, to the interior of the hose 1, this signal will propagate in the hose, on to the distal end of the hose, from where a response signal is sent back and received by the transducer 5 and from there led to the signal analysis processor 4.

[0024] The signal analysis processor 4 is connected to a computer 6 by means of which it is possible, on a screen 7 to present an image which illustrates the results of the examination and measurements made.

[0025] The transducer 3 can be an arbitrary type known *per se*, e.g. an electromagnetic transducer, an electrostatic transducer, a piezo-electric transducer, etc. Its task is to transform the electronic signal from the signal generator 2 into an excitation signal in the interior of the hose 1.

[0026] The transducer 5 can also be of the above mentioned arbitrary type, e.g. a microphone, the purpose of which is to receive an acoustic response signal from the distal end of the hose and to transform this response signal into an electric signal which is led to the signal analysis processor 4.

[0027] The excitation signal can be a transient signal in the low frequency band, as known from e.g. the above US-A-4.326.416 or from the Jackson article. It can also be a non-transient excitation signal - a random or pseudo-random signal, as used in the above-mentioned pieces of equipment SRE 2000 and SRE 2000 PC.

[0028] The invention is a very important contribution to determination of the exact position of the obstruction and to measure when and for how long the obstruction will last. It is thus possible to connect an alarm system to the measuring equipment which gives an alarm when the probe has been compressed for a certain fixed period of time.

[0029] The analysis itself of the response signal in relation to the excitation signal belongs to a technique known *per se*.

[0030] Fig. 2 shows part of the hose 1 in the zone G of the hose. The characteristic of the hose according to the invention is that, at least in its zone G at the distal end it is thin-walled. The hose according to Fig. 2 is a simple hose, i.e. a hose with only one lumen 19.

[0031] If the hose 1, as will be explained later, locally, i.e. in the mentioned zone G, is exposed to an external mechanical influence (as indicated at the arrow F), due to a constriction in the air passage, the oesophagus or a blood vessel of the patient, the reduction of the cross-section of the hose in said zone G will consequently bring about a modification of the response signal, a modification which can be seen in the picture analysis and on the screen. This modification expresses the change that might be present in the patient, e.g. a constriction.

[0032] Fig. 3 shows a further embodiment of a hose according to the invention. The hose 10 has a central lumen 11 and three peripheral annular canals or chambers 12, 13, and 14. Such a hose can be made by extrusion of a soft plastics material or elastomer. The outer diameter of the hose can vary from e.g. 1 mm to e.g. 3-4 mm, according to the intended use. The wall 15 around the central lumen 11 is continuous in the longitudinal direction of the hose and it separates the lumen 11 from the three peripheral chambers 12, 13, 14. The chambers

themselves which are also continuous in the longitudinal direction of the hose are separated from each other by means of radial partitions 16, 17, 18.

[0033] Fig. 4 shows a cross-sectional view of the hose in a plane at right angles to the axis of the hose.

[0034] A transducer 20 has been introduced from the outside through the outer chamber 12 and through the wall 15 so that the response signal receiving end 21 of the transducer 20 is located in the lumen 11.

[0035] Fig. 4 also shows two transducers 22, 23, which are introduced from the outside into the outer wall of the hose 11 and whose response signal receiving ends 24, 25 respectively are located in a peripheral chamber, e.g. chamber 14.

[0036] While the sectional view in Fig. 4 shows the two transducers placed in the sectional plane (the plane of the diagram) it should be understood that they do not need be it and that e.g. transducers 23 can be placed axially displaced from the transducer 22.

[0037] Fig. 5 illustrates the use of the hose in order to determine the position of and measure the so-called tongue fallback with a patient, i.e. the situation where the patient's tongue narrows the upper air passages.

[0038] Here the hose has been introduced through the nostrils and into the air passage. Part of the hose is compressed by the rear end of the tongue in the zone D.

[0039] Fig. 6 illustrates the use of the hose in order to determine the position of and measure the outbreak of vibrations in the soft palate (velum palatum).

[0040] Fig. 6 shows the situation illustrated in Fig. 5 as well as the situation where said soft parts of the palate compress the hose in the zone E.

[0041] The mode of operation of the device according to the invention will be explained below.

[0042] It should be recalled, as mentioned in the preamble of the specification, that it is possible with the measurement technique known from US-A-4.326.416 and from the Jackson article and the one used in the known measurement equipment of the applicant firm, to determine the cross-sectional area of a cavity as a function of the distance from the excitation signal giving transducer to the measurement spot.

[0043] While the known technique has the disadvantage that the measurements can be disturbed by cross modes (i.e. cross resonances) which e.g. is the case in examinations of the air passages and the lungs with a patient, the technique according to the invention has the essential advantage that it is the inner cavity of the hose which constitutes the measurement cavity proper, which on occasion will be modified by e.g. a constriction in the passage in which the hose has been introduced. The construction of the hose excludes the outbreak of cross resonances as in the known technique. If the hose, which as mentioned has thin, flexible walls, is affected locally by a constriction, one or more of the outer chambers 12, 13, 14 and/or the central canal (lumen 19, Fig. 2, or lumen 11, Fig. 3) is affected mechanically by this constriction, this situation being measured immediately by the measuring equipment.

[0044] Supposing that the hose has the form shown in Fig. 3 and 4 and that it has been introduced in the patient's air passage as shown in Fig. 5. The mechanical compression force from e.g. the rear end of the tongue on the hose can e.g. influence one of the outer chambers, e.g. the outer chamber 14, which can be ascertained electronically in the measurement equipment, or perhaps also the second and third outer chamber.

[0045] The invention therefore offers the possibility to get a "differentiated" determination of position, and measurement of the cross sectional area in the zone in question as a function of the distance from the excitation signal transmitting transducer in question to the zone in question.

[0046] If it is only the outer chamber 14, as mentioned in the previous paragraph, which in a patient's air passage is influenced by e.g. the rear end of the tongue, only the transducer(s) belonging to the chamber 14 will react.

[0047] Fig. 6 illustrates as already mentioned the situation where a patient is to be examined for vibrations in the soft parts of the palate, i.e. typically stertorous respiration. The vibrations in the zone E will influence at least one of the outer chambers of the hose and the measurement equipment can carry out the positioning and measurement.

[0048] Another field of particular medical and surgical interest for the invention is examinations of constrictions, i.e. calcification or other pathologic disorders in blood vessel, e.g. at the heart.

[0049] Fig. 7 shows another embodiment of the hose according to the invention, made for this kind of examination.

[0050] The distal end of the hose 31 is in a manner known *per se* (normal catheter technique for widening blood vessels) formed as an inflatable balloon 32. It can be inflated by pressure feed through longitudinal canals (not shown) in the outer wall of the hose. Between the balloon 32 and the distal end of the hose there is, in a manner known *per se*, a number of openings 33 which are to ensure blood passage and at some distance away from the balloon 32 in the direction towards the proximal end of the hose there are outlets (not shown) for the circulating blood.

[0051] In the case where it is medically or surgically advisable temporarily to disconnect the blood circulation through the hose in order to measure and/or widen, it is possible to use a hose which does not have a canal for circulating blood, i.e. having neither openings 33 nor matching outlets.

[0052] Upon introduction of the hose it is possible, in the above mentioned way, to position and measure the constriction or the calcification and the widening, if any.

[0053] Within the scope of the invention it is possible to make a hose without the above mentioned balloon and manufacture the hose so that it has, at its distal end, i.e. where the balloon otherwise would be placed, a con-

siderably thinner and/or considerably more flexible outer wall. Within the scope of the invention the hose can be formed near its proximal end with means (not shown) so as to establish a negative or positive pressure e.g. of fluid in the lumen and/or in each chamber. Such a positive pressure will bring about a dilation of said thinner and/or more flexible part of the hose at the distal end. Whether the hose has a balloon or not, whether it is inflated or not and whether one or more chambers are compressed by the constriction in the vein, the measurement equipment will give a picture of the situation in the area in question.

[0054] A description of a hose has been given above with one single lumen or with one central lumen and peripheral chambers, but it is within the scope of the invention to allow for a hose with two axial canals or a central lumen and two, four or e.g. five peripheral chambers.

[0055] Obviously medical or surgical considerations decide the choice of the inner and outer dimensions of the hose which is the reason why the hose is manufactured in different sizes (and lengths too), while the measurement equipment decides the upper frequency limit, if a transient signal is used, as well as the other physical parameters.

[0056] If the hose according to the invention is to be used for examination of the breathing organs, the needed supply of air or gas to the patient can take place through the inlet of the hose (A in Fig. 1) and through a canal to the openings 33 (Fig. 7) at the distal end of the hose. In that case the response signal which comes from e.g. one or several of the peripheral chambers, can be separated electronically in the measuring equipment from the response signal coming from the lungs, due to the difference in the signal transit time.

[0057] A particular example of the use of the invention has already been mentioned.

[0058] Exact examinations of persons, whose air passages are blocked during their sleep and who can be described as having stertorous respiration, are naturally very difficult and through the ages many failed corrective operations have been made on these patients.

[0059] The invention is a very important contribution to determine the exact position of the blocking and to measure when and for how long the blocking will last. It will therefore be possible to connect an alarm system to the measuring equipment which gives an alarm when the probe has been compressed for a certain fixed period of time.

[0060] To-day a pulsoxymeter (instrument measuring the concentration of oxygen in blood) is connected during these examinations. An alarm is therefore activated when the concentration reaches certain predetermined limits.

[0061] It is not the stertorous respiration itself which is a risk, but the period during which the patient does not breathe because of a blocking.

[0062] This is the reason why equipment which acoustically registers the stertorous respiration does not activate an alarm with sufficient security, as the non-occurrence of a "snoring sound" is either due to a quiet, steady respiration with a low regular flow, which is all right, or the air passages being blocked for a long time. This is where the risk lies.

[0063] In order to stress the importance of the invention it should be mentioned that the under-supply of oxygen to the lungs for such a long time considerably increases the risk of brain damages and thrombosis, especially for older overweight persons.

[0064] An internal measurement has the advantage that the patient is not awakened by the excitation signal during the measuring and at the same time the measurements are not influenced to a large extent by the high tone sound spectrum of the snoring sounds.

[0065] The measurement probe itself is very easy to introduce ambulatory into the patient's nose before the night, in cooperation with a doctor or a nurse.

[0066] A correct "tightening" through the nose happens automatically due to the reflectory swallowing, and a connection (transducer/microphone part) at the end which projects out of the nose can be made without problems.

[0067] A synchronization of the area measurements with the snoring sound is easy to make either by means of an external microphone e.g. one of the transducers 22, 23, Fig. 4 or by using the low frequency signal received through the measurement microphone.

[0068] It should also be noted that the measurement equipment (hardware/software) which adequately makes the measurements in each chamber and during the measurements changes the static pressure in each chamber can also concurrently give information about the elasticity of the tissue giving counter-pressure to the surface of the chambers.

[0069] By establishing a pressure in the hose and a concurrent supply of acoustic energy in the infrasound band up to 200 Hz in the lumen and the chambers and a synchronization of this infrasound signal with the acoustic rhinometry (reflectometric) measurements, it is possible to obtain valuable information about the elasticity in the walls to which the hose wall establishes a contact during the various pressure conditions.

[0070] This kind of transducer, e.g. a piezoelectric transducer, functions in both directions, i.e. transmits a pressure signal when applied a voltage, or transmits an electric signal when applied a pressure. A random or a pseudo-random signal may be used as excitation signal, emitted continuously in the measurement period by the two separate transducers shown in Fig. 1.

[0071] It should also be added that the invention also offers the possibility of making prostate or uterus examinations, etc.

[0072] Finally, it should be mentioned that the invention also offers a possibility to make reflectometric examinations of other cavities, e.g. current control of the cavity in an item manufactured by extrusion, as the tech-

nique according to the invention makes it possible to closely monitor the extrusion parameters in order e.g. to obtain a constant thickness of walls in the item, which could e.g. be a hose.

Claims

1. A device for reflectometric examination and measurement of cavities, comprising:

   - an electronic signal generator (2),
   - a hose (1, 10) with a distal end (B) to be introduced via an entrance to the cavity to be examined,
   - a transmission transducer (3) at a proximal end (A) of the hose (1, 10) connected to the signal generator (2) for transmission of an excitation signal from the signal generator (2) to and through the hose (1, 10),
   - a reception transducer (3, 5) connected to the hose (1, 10) for reception of response signals from the hose, and
   - a computer (6) adapted for analysis of the response signal in relation to the excitation signal sent to and through the hose,

   characterised in:

   - **that** a distal zone (D, E, G) of the hose (1, 10) consists of a thin-walled, soft, flexible plastics or elastomeric material, whereby the hose is adapted to be introduced into the cavity in question with the distal end (B) placed past the zone to be examined and deformation of the hose wall causes said response signal to be reflected back to said reception transducer (3, 5).

2. A device according to claim 1, **characterised in that** the cavity is in the air passages, in the urinary system, or the arteries of a human being.

3. A device according to claim 1, **characterised in that** the hose (1) has one longitudinal, axially centered lumen (19).

4. A device according to claim 1, **characterised in that** the hose (1) has two longitudinal lumens separated from each other by a diametral partition.

5. A device according to claim 1, **characterised in that** the hose (10) has a longitudinal, axially centered lumen (11) surrounded by a ring-shaped wall (15) and around the ring-shaped wall (15) a number of spaced, longitudinal canals (12, 13, 14) separated from each other by means of essentially radial partitions (16, 17, 18) .

6. A device according to claim 5, **characterised in that** the number of longitudinal canals (12, 13, 14) is three, said canals (12, 13, 14) each having a cross section shaped as an angular section of an annular ring, and that there is essentially equal angular distance between the partitions (16, 17, 18).

7. A device according to any of the preceding claims, **characterised in that** the hose (1) over at least part of its length and preferably at its distal end has at least one zone (D, E, G) of increased outer wall flexibility.

8. A device according to claim 7, **characterised in that** said zone (D, E, G) of increased outer wall flexibility is created by the outer wall having a locally reduced wall thickness.

9. A device according to claim 7, **characterised in that** said zone (D, E, G) of increased outer wall flexibility is created by a local change in the nature of the outer wall material.

10. A device according to any of the preceding claims, **characterised in that** the proximal end (A) of the hose is adapted for connection of auxiliary equipment for introducing the hose (1) into the cavity in question.

11. A device according to any of the preceding claims, **characterised in that** the hose (1) at its proximal end has means so as to establish a negative or positive pressure, in relation to the environment, in the lumen or lumens and/or in each chamber.

12. A device according to any of the preceding claims, **characterised in that** the proximal end of the hose (1) is adapted for mounting said transducers.

13. A device according to any of the preceding claims, **characterised in that** the hose also has a longitudinal canal for blood circulation from blood inlet openings (33) at the distal end of the hose to a blood outlet at a certain distance from the distal end.

14. A device according to any of the claims 1-12 and for examination of the air passages, **characterised in that** the hose also has a longitudinal canal for venting the air passages during the examination performed.

Patentansprüche

1. Vorrichtung zur reflektometrischen Untersuchung und Messung von Körperhohlräumen umfassend:

   einen elektronischen Signalgeber (2),

einen Schlauch (1, 10) mit einem distalen Ende (B), das über einen Eingang zu dem zu untersuchenden Körperhohlraum eingeführt wird,
einen an einem proximalen Ende (A) des Schlauches (1, 10) vorgesehen Sendewandler (3), der an den Signalgeber (2) zur Absendung eines Erregungssignals vom Signalgeber (2) zum Schlauch und durch den Schlauch (1, 10) angeschlossen ist,
einen an den Schlauch (1, 10) angeschlossenen Empfangswandler (3, 5) zur Aufnahme von Responssignalen vom Schlauch, und
einen Computer (6), der zur Analyse des Responssignals eingerichtet ist, im Verhältnis zu dem zum Schlauch und durch den Schlauch gesendeten Aktivierungssignal,

dadurch gekennzeichnet, daß:

eine distale Zone (D, E, G) des Schlauchs (1, 10) aus einem dünnwandigen, weichen, flexiblen Kunststoff- oder elastomeren Material besteht, wobei der Schlauch zum Einführen in den betreffenden Körperhohlraum und mit dem distalen Ende (B) hinter der zu untersuchenden Zone plaziert, vorgesehen ist, und Deformation des Schlauches ein Reflektieren des erwähnten Responssignals zurück zum Empfangswandler (3, 5) mit sich führt.

2. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** sich der Hohlraum in den Luftpassagen, dem Harnsystem oder den Blutadern eines Menschen befindet.

3. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Schlauch (1) ein längsverlaufendes, axial zentriertes Lumen (19) aufweist.

4. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Schlauch (1) zwei längsverlaufende, durch eine diametrale Zwischenwand untereinander getrennte Lumen aufweist.

5. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Schlauch (10) ein längsverlaufendes, axial zentriertes, von einer ringförmigen Wand (15) umgebenes Lumen (11), und rund um die ringförmige Wand (15) eine Anzahl in Abstand angeordneter, längsverlaufender, über im wesentlichen radiale Zwischenwände (16, 17, 18) untereinander getrennte Kanäle (12, 13, 14) umfaßt.

6. Vorrichtung nach Anspruch 5, **dadurch gekennzeichnet, dass** die Anzahl längsverlaufender Kanäle (12, 13, 14) drei ist, welche Kanäle einen als Winkelabschnitt eines Kreisringes geformten Querschnitt aufweisen, und dass zwischen den Trennwänden (16, 17, 18) im wesentlicher ein gleicher Winkelabstand vorgesehen ist.

7. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Schlauch (1) zumindest über einen Teil seiner Länge und vorzugsweise an seinem distalen Ende mindestens eine Zone (D, E, G) mit erhöhter Außenwand-Flexibilität aufweist.

8. Vorrichtung nach Anspruch 7, **dadurch gekennzeichnet, dass** erwähnte Zone (D, E, G) mit erhöhter Außenwand-Flexibilität durch die Außenwand mit lokal reduzierter Wanddicke zustande kommt.

9. Vorrichtung nach Anspruch 7, **dadurch gekennzeichnet, dass** erwähnte Zone (D, E, G) mit erhöhter Außenwand-Flexibilität durch eine lokale Änderung der Beschaffenheit des Außenwandmaterials zustande kommt.

10. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das proximale Ende (A) des Schlauches zum Anschluss von Hilfsmitteln zum Einführen des Schlauches (1) in den betreffenden Körperhohlraum vorgesehen ist.

11. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Schlauch (1) an seinem proximalen Ende Mittel zum Erzeugen eines im Verhältnis zur Umgebung negativen oder positiven Druckes im Lumen oder in den Lumen und/oder in jeder Kammer umfaßt.

12. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das proximale Ende des Schlauches (1) zum Montieren erwähnter Wandler vorgesehen ist.

13. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Schlauch auch einen längsverlaufenden Kanal für Blutzirkulation von Bluteinlauföffnungen (33) am distalen Ende des Schlauches zu einem in einem gewissen Abstand vom distalen Ende befindlichen Blutauslauf aufweist.

14. Vorrichtung nach einem der Ansprüche 1-12 und zur Untersuchung der Luftpassagen, **dadurch gekennzeichnet, dass** der Schlauch auch einen Längsverlaufenden Kanal zum Belüften der Luftpassagen während der ausgeführten Untersuchung aufweist.

Revendications

1. Dispositif d'examen et de mesure réflectométriques de cavités, comprenant

   - une génératrice de signaux électronique (2)
   - un tuyau flexible (1, 10) avec un bout distant (B) à introduire via une entrée à la cavité à examiner,
   - un transducteur de transmission (3) à un bout proximal (A) du tuyau flexible (1, 10) relié à la génératrice de signaux (2) pour transmission d'un signal d'excitation depuis la génératrice de signaux (2) au tuyau flexible (1, 10) et suivant celui-ci,
   - un transducteur de réception (3, 5) relié au tuyau flexible (1, 10) pour recevoir des signaux de réponse depuis le tuyau flexible, et
   - un ordinateur (6) adapté à analyser le signal de réponse par rapport au signal d'excitation transmis au tuyau flexible et suivant celui-ci,

   caractérisé en ce que

   - une zone distante (D, E, G) du tuyau flexible (1, 10) est constituée d'une matière plastique ou d'élastomère flexible, molle et à parois minces, le tuyau flexible étant adapté à introduire dans la cavité en question avec le bout distant (B) placé derrière la zone à examiner, et une déformation de la paroi du tuyau flexible fait ledit signal de réponse retourner par réflexion audit transducteur de réception (3, 5).

2. Dispositif selon la revendication 1, **caractérisé en ce que** la cavité est dans les voies respiratoires, dans le système urinaire ou dans les vaisseaux sanguins d'un être humain.

3. Dispositif selon la revendication 1, **caractérisé en ce que** le tuyau flexible (1) présente une lumière longitudinale et centré de manière axiale (19).

4. Dispositif selon la revendication 1, **caractérisé en ce que** le tuyau flexible (1) présente deux lumières longitudinaux, l'un séparé de l'autre par une cloison séparative diamétrale.

5. Dispositif selon la revendication 1, **caractérisé en ce que** le tuyau flexible (10) présente une lumière longitudinale, centré de manière axiale (11) et entouré d'une paroi annulaire (15) et, autour de la paroi annulaire (15), un nombre de canaux longitudinaux et espacés (12, 13, 14), l'un séparé de l'autre au moyen de cloisons séparatives et essentiellement radiales (16, 17, 18).

6. Dispositif selon la revendication 5, **caractérisé en ce que** le nombre de canaux longitudinaux (12, 13, 14) est de trois, lesdits canaux (12, 13, 14) chacun présentant une section formée comme une section angulaire d'un anneau annulaire, et **en ce que** la distance angulaire est essentiellement égale entre les cloisons séparatives (16, 17, 18).

7. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le tuyau flexible (1) sur au moins une portion de sa longueur et préférablement à son bout distant présente au moins une zone (D, E, G) d'une flexibilité augmentée de paroi extérieure.

8. Dispositif selon la revendication 7, **caractérisé en ce que** ladite zone (D, E, G) de flexibilité augmentée de paroi extérieure est créée par la paroi extérieure ayant une épaisseur de paroi localement réduite.

9. Dispositif selon la revendication 7, **caractérisé en ce que** ladite zone (D, E, G) de flexibilité augmentée de paroi extérieure est créée par une modification locale de la nature du matériau de paroi extérieure.

10. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le bout proximal (A) du tuyau flexible est adapté à relier de l'équipement auxiliaire pour introduire le tuyau flexible (1) dans la cavité en question.

11. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le tuyau flexible (1) à son bout proximal présente des moyens pour établir une pression négative ou positive, par rapport à l'environnement, dans le ou les lumière(s) et/ou dans chaque chambre.

12. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le bout proximal du tuyau flexible (1) est adapté à monter lesdits transducteurs.

13. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le tuyau flexible présente également un canal longitudinal pour la circulation du sang depuis des ouvertures d'entrée de sang (33) au bout distant du tuyau flexible à une sortie de sang arrangée à une certaine distance du bout distant.

14. Dispositif selon l'une quelconque des revendications 1-12 et pour l'examen des voies respiratoires, **caractérisé en ce que** le tuyau flexible présente également un canal longitudinal pour aérer les voies respiratoires lors de l'examen effectué.

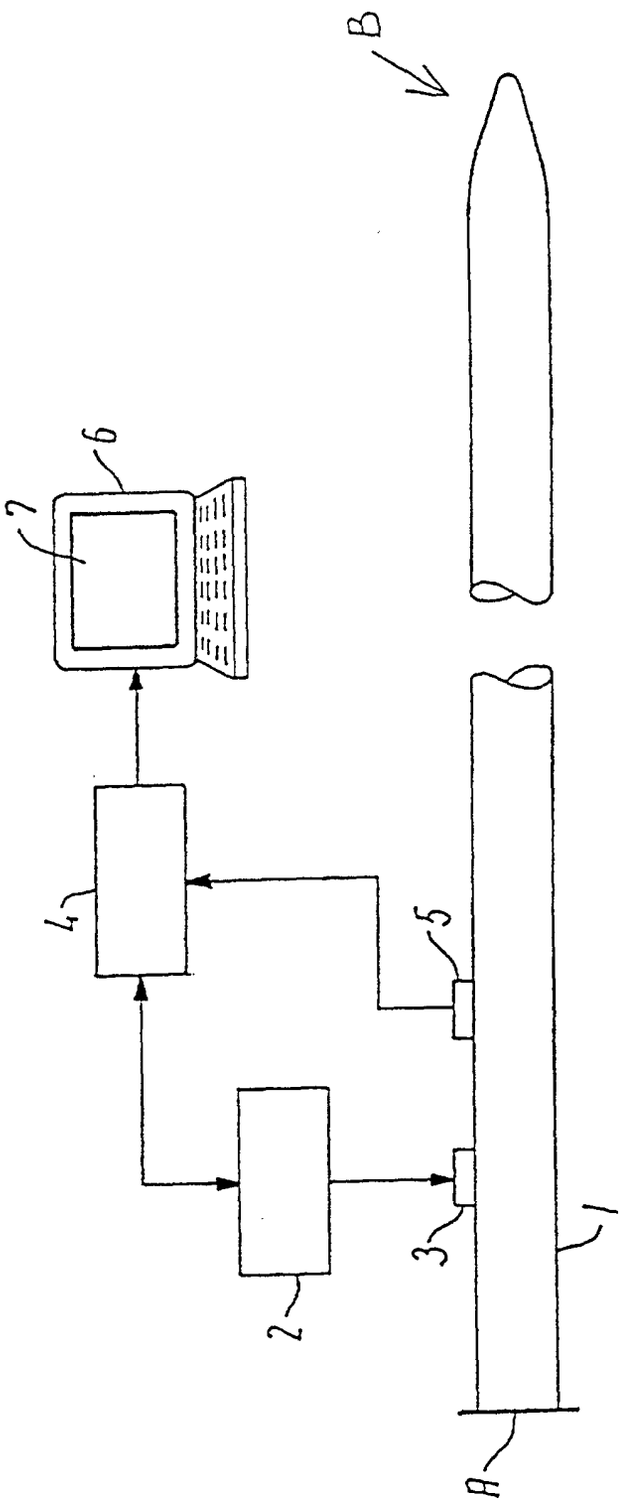

FIG. 1

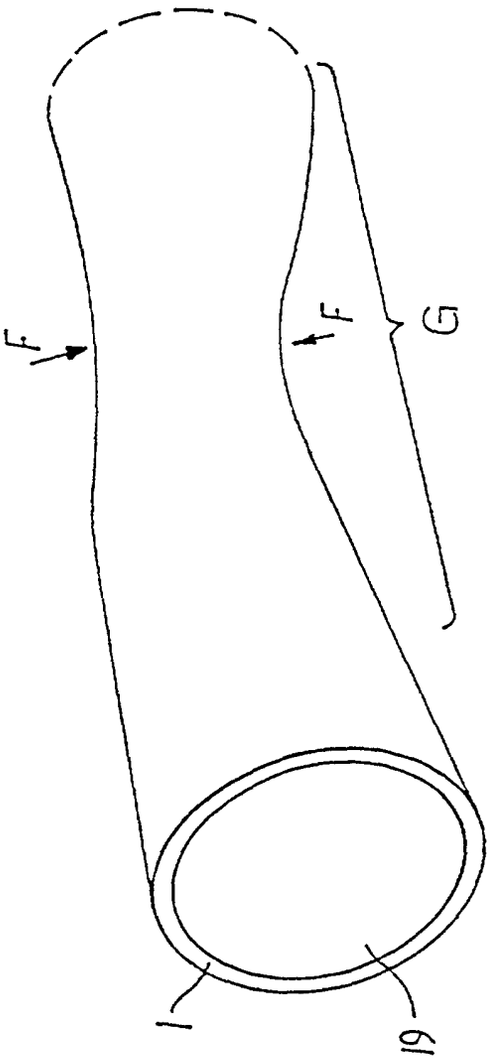

FIG. 2

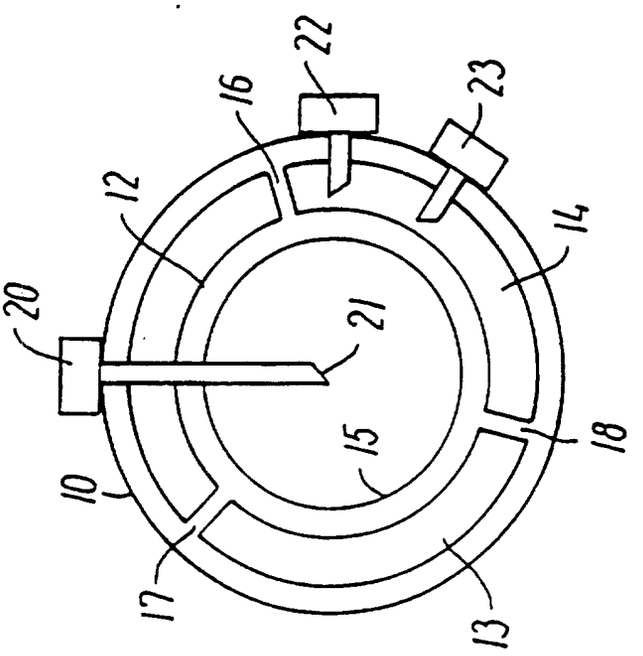

FIG.4

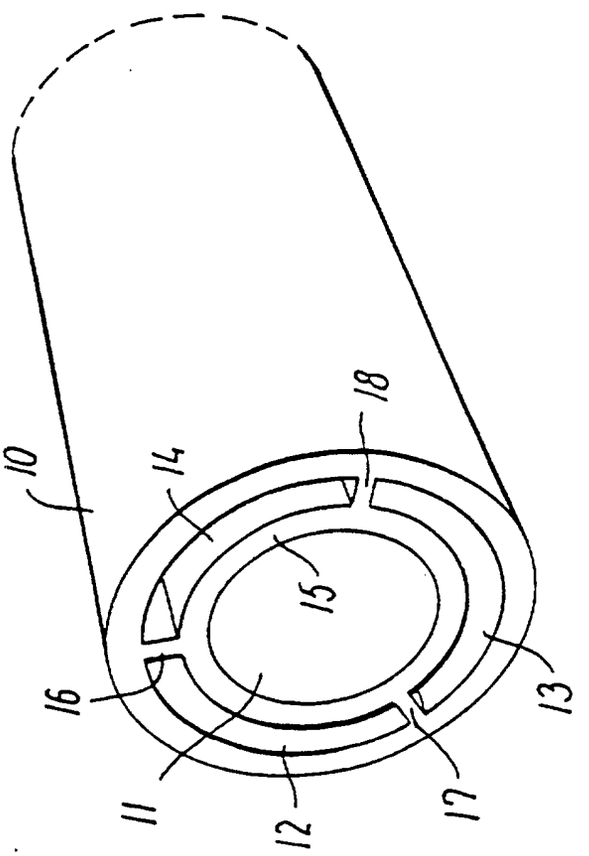

FIG.3

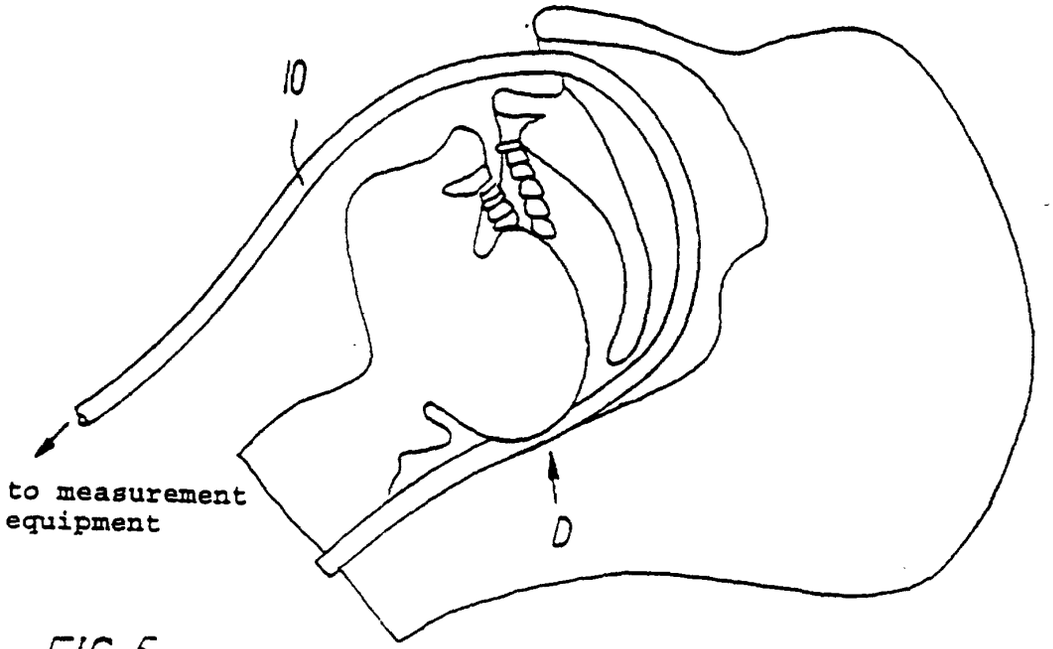

FIG. 5

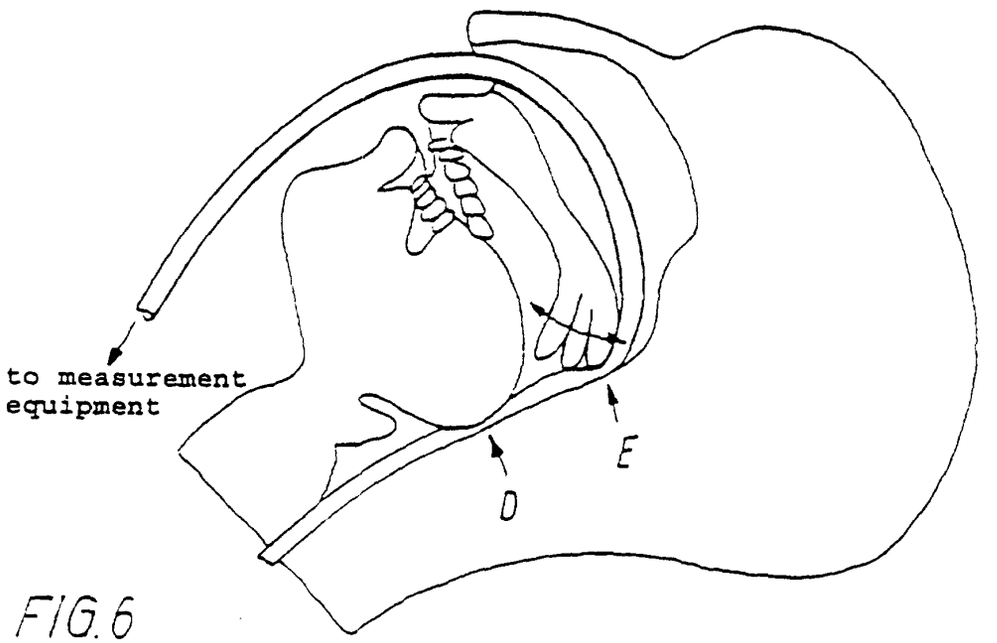

FIG. 6

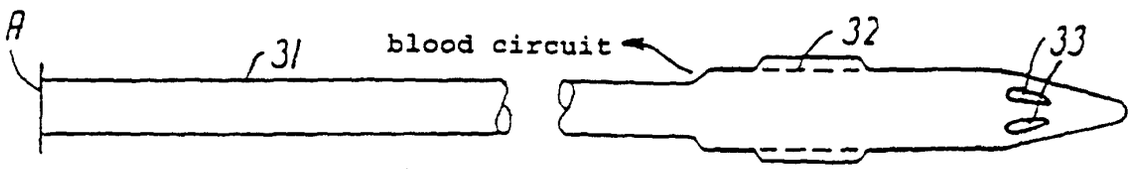

FIG. 7