RAPIDLY QUANTIFYING THE RELATIVE DISTENTION OF A HUMAN BLADDER

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ABSTRACT

A device and method rapidly quantifying the relative distention of the bladder of a human subject are disclosed. Ultrasonic transducer 1, which is positioned on subject 2 in proximity to bladder 16, is excited by pulser 3A under command of microprocessor 4 to launch an acoustic wave into patient 2. This wave interacts with bladder walls 12,13 and is reflected back to ultrasonic transducer 1, whence it is received, amplified, and processed by receiver 3B. The resulting signal is digitized by analog-to-digital converter 5 under command of microprocessor 4, and is stored in data memory 6B. The software in microprocessor 4 determines the relative distention of bladder 16 as a function of the propagated ultrasonic energy; and based on programmed scientific measurements and past history with the specific subject as contained in program memory 6A, sends out a signal to turn on any or all of the audible alarm 7, the visible alarm 8, the tactile alarm 9, and the remote wireless alarm 10.

20 Claims, 6 Drawing Sheets
ULTRASONIC SIGNAL

ULTRASONIC ENERGY

FIGURE 2A

FIGURE 2B

FIGURE 2C
ULTRASONIC SIGNAL

FIGURE 5A

ULTRASONIC ENERGY

FIGURE 5B

TO THE MEMORY

FIGURE 5C

THE A/D CONVERTER

DIGITIZER BINS
FIGURE 6

F(J,E)  ALARM THRESHOLD  DESIRED DISTENTION

BLADDER FULLNESS
RAPIDLY QUANTIFYING THE RELATIVE DISTENTION OF A HUMAN BLADDER

ORIGIN OF THE INVENTION

The invention described herein was jointly made: in the performance of work under a U.S. Department of Education/National Institute for Handicapped Research grant to the Association for Retarded Citizens of the United States, and is subject to the provisions of the Education Department General Administrative Regulations, revised July 1, 1985; and in the performance of work under a NASA Contract, and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

This is a continuation of application Ser. No. 07/118,993, filed Nov. 10, 1987, and now U.S. Pat. No. 5,882,578, which application is a continuation-in-part of co-pending application Ser. No. 06/929,869, filed Nov. 13, 1986 and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to the rapid signature analysis characteristic of changes in an elastic membrane caused by stress, as a function of energy transmitted into the membrane and reflected therefrom. It relates particularly to a device for rapidly quantifying the relative distention of the bladder of a human subject as a function of ultrasonic energy transmitted into the subject and reflected therefrom.

There has been a long standing need for a device for rapidly quantifying the relative distention of bladders of human subjects, especially the mentally retarded, the infirm, and the elderly.

In attempts to normalize the lives of persons with mental retardation, much energy has been devoted to teaching these persons how to function independently in society. The problem of incontinence often thwarted the best of these efforts. While sophisticated toilet training programs are quite successful in teaching some persons what to do once the internal sensation of a full bladder is perceived, these programs typically presuppose that a person is capable of realizing when she/he has to void. The subset of the population of persons with mental retardation for whom continued incontinence is a more common problem are those persons with severe or profound mental retardation, i.e., those with IQs less than 35 and significant deficits in adaptive behavior, who have difficulty in recognizing the subtle and somewhat obscure signals of their bladders.

In addition, there is a substantial need to provide increased independence for persons who have permanently lost the ability to control their bladders for medical reasons such as diabetes, cerebral palsy, quadriplegia, spina bifida, and advanced age.

Incontinence typically results in a stigma for the person, reduced positive interaction with other people, unsanitary living conditions, excessive laundry expenses, and increased custodial attention by caregivers. Because of the failure to acquire fundamental toileting skills, such persons are often excluded from a wide variety of vocational, social, and recreational programs, in addition to many preschool programs—all of which are important components of overall experience necessary for their developmental growth and eventual integration into community life.

Previous attempts to employ technology in urinary toilet training fall into two classes. The first class is the wetness detector, which alerts the subject when urine is present on the person. A particular example of this is the employment of a moisture-sensitive apparatus in the clothing or in the bed, which device triggers an alarm when moisture is detected. The second class is the motion-sensitive device, which is located in the toilet. Once voiding has begun, the motion imparted to this device helps the user recognize that urination has been initiated. However, both classes of devices produce their effects after urination has taken place. That is to say, their users are helped to recognize when voiding has been initiated, but they are not helped to recognize the preliminary need to urinate, and thereby make the association between this need and socially-acceptable toileting behavior. In neither case is there a quantification of the relative distention of the bladder, which would be of significance in helping one to recognize the preliminary need to urinate.

Urologists have recently employed an ultrasonic device which scans the entire bladder and images it with a sector scan to show the extent of the bladder wall over a sixty degree angle. Other recently-developed devices are based on an ultrasonic "A" scan technique, using the time of flight of the sound wave between the front and back walls. These devices are typically bulky and expensive. Moreover, even the most sophisticated of the current devices suffers from inaccuracies resulting from the assumption of a simple, usually spherical, shape for the bladder. In actuality, the bladder is not a sphere, rectangle, or other simple geometric shape. It varies in shape continuously as it fills, varies in shape as between individuals, varies in height relative to the pelvic girdle as between the sexes, and if it ever did approach the point of becoming a sphere, hyperdistention would be imminent.

While 50 cc of urine is considered to be a significant void volume, void volumes in test subjects varied from 30 cc up to over 600 cc. The test population to date has tended to void between 180 and 400 cc. The subject perception is of increasing discomfort above approximately 200 cc. In individuals with urinary dysfunction the bladder has been inflated through a catheter to upward of 600 cc with no real sensation being reported.

It is therefore a primary object of this invention to provide a device for the quantification of the relative distension of the urinary bladder of a human subject over a wide range of volumes, and with greater accuracy than any non-scanning ultrasound device available from the prior art.

A further object of this invention is to provide adaptability to the requirements of a human subject in a user selectable manner, thereby mimicking normal perception and affording help to the subject in recognizing the appropriate time to urinate. Since an intended application of the present invention is for individuals experiencing bladder dysfunction for varying reasons and at varying ages, an adaptable operating system is a must. A microprocessor based design, with as much as possible of the functionality of the device in software, is indicated.

A further object of this invention is to provide a device for rapidly quantifying the relative distension of the bladder of a human subject, thereby providing vital information needed by the subject during the critical time when the bladder is at or near its full extention, and
SUMMARY OF THE INVENTION

The present invention comprehends the provision of an ultrasonic transducer, which is positioned in proximity to the abdomen of the subject under test, for the purpose of transmitting energy in the form of acoustic waves into the bladder of the subject followed by receiving acoustic waves reflected from the bladder of the subject. A pulser/receiver communicates with a source of power and the transducer and excites the transducer to transmit energy in the form of acoustic waves. It also amplifies and processes the reflected acoustic waves received by the transducer and provides analog signals representative of at least one reflected ultrasonic waveform over a respective time interval. A converter communicates with the pulser/receiver to digitize the analog signal from the pulser/receiver to provide a corresponding digital signal representative of at least one waveform. A memory communicates with the converter for storage of the digital signal from the converter. An input means provides a digital input signal representative of a characteristic of the subject related to the amount of urine in the bladder. A logic system communicates with the pulser/receiver to command excitation of the ultrasonic transducer. The logic system communicates additionally with the converter to command digitization of the analog signals from the pulser/receiver. The logic system also communicates with the memory to receive the digital input and the stored signals for processing the stored signals to provide a function signal related to the value of the digitized signals and their time of occurrence within the respective time intervals, and for comparing the function signal with stored, preselected function levels to determine equivalency and to activate a preselected alarm upon the attainment of equivalency. The relative distention of the bladder of the human subject is thereby rapidly quantified.

According to the present invention, an ultrasonic transducer is placed in contact with the skin of the subject on the midline, just above the pubic symphisis. The transducer is coupled to the skin by means of a battery operated monitor that could be worn by an individual during the course of normal activity. The device should be adjustable by the individual in areas such as setting the appropriate volume level for the alarm to be given, and the type, intensity, and duration of the alarm. Further, variations of the programming should be selectable, including a setup mode to assist in proper positioning of the transducer, as well as slightly different versions of the program to optimize the signal processing for individuals of different body sizes and configurations.

In the interests of mechanical, electrical and fiscal simplicity, an "A" scan format was chosen. The signal processing differs from the prior art as used in other "A" scan based instruments, which, even were they to be reduced to a comparable size, would suffer from inaccuracies in the interpretation of the "A" line scan, related to the non-symmetric mode of expansion of a real bladder.

From Grey's Anatomy the depiction of the bladder shows an organ that is well above the pelvic basin and with the major axis roughly parallel to the abdominal surface in infancy. As the individual ages, the bladder sinks toward the pelvis. In the female, probably beginning at puberty, the bladder is typically lower than in the male. As the bladder slides down and back over time into the pelvis, the major axis becomes more horizontal. In both the transverse and sagittal sections the bladder is roughly triangular, until some degree of distention is arrived at. The progress of fill of the bladder is as follows: the cavity of the empty bladder takes the shape of a flattened "Y", with the urethra at the bottom. This is true in both the fore-aft plane and the lateral plane. The "Y" gradually fills to the top and then the actual expansion begins. The bladder expands in the fore-aft plane, and in the vertical plane, giving rationale for the front-wall to back-wall time of flight measurements. However, as will be delineated hereinafter, the non-symmetric expansion of the bladder limits both the dynamic range and the overall accuracy of a strictly time-based system.

In the information content of any ultrasonic scan into the abdomen, there are a number of givens: the transmitted pulse and its associated decay will be present, the transducer-skin interface will produce an echo, the skin to underlying muscle will produce an echo, and the muscle to abdominal cavity interface will produce an echo. These echoes will always be present in the early portion of the return, on all subjects. At low levels of inflation, the front wall of the bladder is a poor target. It is rounded point in the transverse section and even more acute in the sagittal section. There is no single true diameter. To compound the problem, as the bladder expands, while it does become a better target, the front wall also moves toward and eventually merges with the ever present abdominal wall echoes at the front of the returning echo. All of this makes the front wall, for much of the range of bladder expansion, a poor marker. All of this does not negate the value of time of flight measurements, however, as the back wall will remain in view, and the transducer itself can serve as the first marker.

The time of flight measurement, however, has an additional deficiency—lack of dynamic range. If the bladder were expanding in a vacuum, this would not be the case. In the body, however, the bladder soon runs out of room to expand to the rear, the sides and the front. Taking the path of least resistance, the primary direction of expansion in the upper ranges of volume is vertical, lifting and displacing the intestines. Movement in individuals who have had major abdominal surgery can produce some interesting vectors. An additional factor that has a bearing on the analysis of data derived from an "A" line scan is that the movement of the back wall of the bladder, other than in very young children, is not a direct translation, but rather the elevation of the angle of a curved surface relative to the axis of the insonating beam. Further, as this surface
becomes more perpendicular to the axis, it is also effacing the rugose folds characteristic of the lining of the empty bladder. The net effect of these actions is to make the back wall a better reflector as the bladder distends.

There are two other mechanisms having an effect on the echo return at higher volume levels which have now come to light as a result of the present invention. At any acoustic interface, some portion of the incident wave will be reflected and some will pass through. This is true of the back wall of the bladder, particularly at the higher levels of distention. The insonating beam passes through a greater distance of the low attenuation urine than formerly, and the back wall has become a better target. Some portion of the energy will penetrate the back wall and produce reflections from the muscle layers surrounding the bladder. In addition, the distended bladder is now pressing against the organs and blood vessels that surround it.

Movements and pulsations in these organs are impressed on the wall of the bladder. The net effect of these two conditions is to cause an apparent increase in the duration of the back wall echo, which is related to increasing distention.

The difference between the present invention and previous "A" scan technology is that the resident software algorithm keeps track of all of the variables, assigns weighted values to them, depending on their relative information content, and then derives a discrete numerical value for the perceived volume in each scan. That value is put into memory and the trend of the value is periodically time averaged, with that resultant both saved and made available for display.

By fully exploiting not just the location of the bladder wall, but also the information extractable from the changing signature of the wall echoes, the range of volumes through which the relative bladder distention can be tracked is substantially enhanced.

As is understood by those of skill in the art from the foregoing, rapid quantification of the relative distention of the bladder of a human subject is achieved according to the present invention by transmitting an acoustic wave into the bladder of the human subject so as to create a reflected acoustic waveform; measuring a time range together with an energy level of the reflected acoustic waveform; applying a signal processing algorithm thereto; and comparing the resulting measurement against a selectable standard.

**Detailed Description of the Drawings**

For a more complete understanding of the present invention, including its objects and benefits, reference should be made to the detailed description, which is set forth below. This detailed description should be read together with the accompanying drawings, wherein:

**FIG. 1** is a functional block diagram of a preferred embodiment of the present invention;

**FIGS. 2(a), (b), (c)** is a three-part diagram showing in simplified graphic form the acoustic beam path interaction with an empty bladder; a rendering of the oscilloscope presentation of the amplified and detected output resulting from that interaction; and the same waveform in digitized format, respectively;

**FIGS. 3(a), (b), (c)** is a three-part diagram in the same format as FIG. 2, but with the bladder in a partially distended state;

**FIGS. 4(a), (b), (c)** is a three-part diagram in the same format as FIGS. 2 and 3, but with the bladder in a well-distended state;
are averaged, the output of display 17 is updated, and
the numerical value is compared to the value of the
desired alarm volume level. If the currently perceived
volume value meets or exceeds the desired level, then
the selected alarm is activated. In order to accommo-
date the varying needs of the individual users, both the
type and the duration of the alarm are switch selectable.
The alarm suite is comprised of visual 8, tactile 9, and
audio 7 (volume is also adjustable), and remotes 10.
Alarm duration is adjustable from one second to eight
seconds in one second increments.

In actual practice, the setup and utilization of the
device of the present invention is straightforward. The
individual under test is allowed to accumulate some
quantity of urine in the bladder by simply drinking a
fluid and waiting approximately thirty minutes. The
transducer 1 with a suitable couplant is applied to the
abdomen of subject 2 in the area just above the pubic
hair. The transducer 1 is then moved around to obtain a
maximum reading on display 17 with the device set to
pulse continuously. This is taken to be an indication that
bladder 16 is in the view of the insonating beam, as an
empty bladder or a misaligned beam will afford very
low numerical values. The (arbitrary) numerical range
shown on display 17 has typically varied in the test
population from a value of 8-10 representing an essen-
tially empty bladder—up to a reading of 55-65—repre-
senting volumes in excess of 500 cc. Alarm level switch
15A permits the selection of sixteen levels ranging from
9-57. This is an arbitrary range based on the statistics of
the test population who tended to void between values
of twenty-four, which typically gave volumes of
240-260 cc, and forty-two, which gave volumes of
approximately 400 cc. The transducer 1 is secured to
patient 2 by an elastic belt, similar in construction to a
hernia truss belt. The electronics package, including
power control 18A and battery 18B, is carried in a case
on a shoulder strap.

In practice, with the device being worn by an individ-
ual for an extended period of time who is going through
the normal daily routines, some operational characteris-
tics were noted. When a normal, functioning individual
accumulates some volume in his/her bladder, the physi-
ological sensation is not constant. When the feeling of
need to urinate is first apparent, it comes and goes, and
the individual can be distracted. As the volume of urine
increases, however, so does the frequency and urgency
of the sensations, until such point as the individual feels
substantial discomfort, which may be distracting from
the task at hand, and he/she decides to void. Through-
out, there are strains and postures that increase the
physiological sensations. These are, however, transitory
until the volume of urine becomes excessive.

The present invention mimics the type of progression
set forth above. Since it is reasonable to assume that the
individual will want to accumulate an appreciable vol-
ume of urine in the bladder before taking the time to
void, an intermediate alarm level was selected for the
test program. It was noted that when the bladder is
empty, or when it has a very small amount of urine
therein, body movement did not produce any false
alarms. When some amount of urine is present in the
bladder, however, (80-100 cc) then body movement
can produce an occasional, transitory alarm. When such
movement ceases, the alarm stops. Of course, the in-
dividual does not choose to void at this time, but, as is usu-
ally the case with normal perceptions, the individual
does not choose to void at the first sensation. Rather, as
time goes on and the alarm set level is approached, the
alarm (again as with the natural sensation) becomes
more and more frequent, until they are annoying. The
individual, or the individual’s caretaker can over a per-
iod of time adjust the alarm level to that point which
works best for the individual involved.

To better understand the function and operation of
the invention, it is necessary to examine the acoustic
wave interaction and the bladder shape as shown in FIGS.
2-4. In FIGS. 2(a-c), the bladder is essentially empty. In
FIGS. 3(a-c), the bladder is being filled, and in FIGS.
4(a-c), the bladder is at maximum fullness. In each of
FIGS. 2-4 are simplified, illustrative diagrams of the
physical bladder and the ultrasonic transducer (A), a
conventional ultrasonic signal S showing the electrical
radio frequency (RF) wave forms obtained from the
transducer after conversion in the receiver(B), and the
energy wave forms E(C). Each of FIGS. 2-4 shows the
tissue/transducer interface 11, the bladder front wall 12,
and the bladder rear wall 13.

In FIG. 2, with the bladder essentially empty, trans-
ducer 1 is placed on the patient with a conventional
couplant for ultrasound. The sound wave excited by the
pulsers/receiver 3 of FIG. 1 causes the ultrasonic signal
shown in FIG. 2, diagram 2B, time position 11. The
wave also reflects off the bladder front wall 12 and the
bladder rear wall 13, with the resulting ultrasonic sig-
als 12 and 13, respectively, in diagram 2B. The bottom
diagram 2C in FIG. 2 is the ultrasonic energy with its
corresponding signals 11, 12, and 13. These signals are
obtained by adding the absolute amplitude of the RF
wave forms for each pulse and averaging the resulting
summation over N cycles of the measurement, in accord
with the value weighting function by the programmed
algorithm.

In FIG. 3, with the bladder partially full, the bladder
has inflated as shown in diagram 3A of the figure, and
the RF waveforms have changed as the bladder shape
has changed. In particular, the rear wall reflection has
moved back in time, and additional reverberation has
built up in the rear wall signal as shown in 3B, wave 3
as well as in 3C, wave 3.

In FIG. 4, with the bladder substantially full, the
change in shape has continued, although the rear wall
13 has not moved in a simple fashion during filling. The
energy seen in the rear wall reflection, however, contin-
ued to increase as the bladder was being filled. In fact,
for a bladder filling past about 60% fullness, the rear
wall hardly moves at all, while the energy reverberation
at the rear wall continues to increase. Thus, it can be
seen that a monitor of the rear wall position only would
not be accurate during critical near-full periods. In
sharp contrast thereto, this invention, which measures
the energy in the rear wall reflection as well as the rear
wall position, is accurate as a monitor for the entire
range of bladder fullness.

FIGS. 5 and 6 relate to the internal components of
this invention and their function in more detail. The
converter 5 and the memory 6 actually act as a signal
averager, raking the digitizer output and multiplying it
by some weighting function related to bin number,
while checking that the signal falls in the correct time
range or bin number (J). The entire operation is con-
trolled by the software to configure the function and
the mathematical operations for the specific subject.

As the simplest case, the function used is the sum of
energy amplitudes in bins (J-K+W) that correspond to
the rear wall and beyond of the bladder, where W is the
width of the reverberation signal at the rear wall. A check on the data quality is that bins less than (J-K) show no significant amplitude. Such a lack of signal corresponds to the fact that when the bladder contains water, the path length between the front and rear walls should show no scattering, i.e., a simple water path exists.

The internal logic calculation of FIG. 6 shows the result of a typical bladder during filling. The function has been adapted to the specific subject so that the P(J,E) and the alarm threshold correspond to the best time for that subject to be notified to urinate.

A complete electronics package is worn by the subject with the transducer positioned by means of a flexible mounting belt. The electronics package advantageously contains means to alert the subject with any of a variety of stimuli including a tactile alarm (e.g., a vibrator), a visual alarm (e.g., an LED mounted on eyeglasses), an audible alarm (e.g., a buzzer), and a remote alarm (an RF link to a receiver monitor). In addition, the electronics package advantageously contains a working mode which lets the package work in a “sleep” configuration when the bladder should be empty (after successful elimination). In that mode, the frequency of pulses and measurements is reduced to lengthen the life of the power supply (which is advantageously a battery) in the package. Moreover, parameters governing the user’s interaction with the device, are entered by the user or his/her caregiver into the logic system externally by adjusting controls on the face of the microprocessor. This affords a customization for each individual and a quick and simple modification of existing parameters at any time. The user or his/her caretaker is accordingly allowed to select the level of bladder fullness at which he/she would like the alarm to sound.

As is understood by those of skill in the art, the ultrasonic transducer, pulser/receiver, analog-to-digital converter, program and data memory, audible alarm, visual alarm, tactile alarm, and remote alarm employed herein are per se well-known, and therefore are not disclosed in detail herein.

The preferred embodiment of the invention disclosed hereinabove relates to the propagation of ultrasonic energy and averaging the energy signals over a number of measurement cycles to rapidly quantify the relative distention of the bladder of a human subject. Moreover, the programming of specific functions of the particular subject into the logic system permits a fine tuning which affords accurate operation with a wide variety of subjects and conditions.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A process for measuring the fullness of a bladder in an animal body, comprising transmitting a pulse of energy to and through the bladder, receiving reflections of said pulse of energy over a selected period of time, identifying a set of segments of time over said period of time, measuring the levels of the reflected energy received in each of said segments of time, and computing a measure of bladder fullness from both the respective levels of energy in said segments of time and the location of said respective levels of energy in said period of time.

2. A process for measuring the fullness of a bladder as set forth in claim 1, wherein the computing is done from said respective levels of energy primarily as reflected from a distal wall of the bladder and body tissue adjacent said distal wall.

3. A process for measuring the fullness of a bladder as set forth in claim 2, wherein the results of said computing are compared with a preestablished reference.

4. A process for measuring the fullness of a bladder as set forth in claim 1, wherein a first of said reflections is from the proximate wall of said bladder, a second of said reflections is from the distal wall of said bladder and adjacent body tissue, said second of said reflections extending over a plurality of said segments of time, and said computing of bladder fullness utilizes both the time between said first and second of said reflections and the levels of energy in said segments of time of said second of said reflections.

5. A process for measuring the fullness of a bladder as set forth in claim 1, wherein said pulse of energy is a pulse of acoustic energy.

6. A process for measuring the degree of distention of a distendable organ within an animal body, comprising transmitting a pulse of energy to and through the organ, receiving reflections of said pulse of energy over a selected period of time, identifying a set of segments of time over said period of time, measuring the levels of the reflected energy received in each of said segments of time, and computing a measure of the distention from both the respective levels of energy in said segments of time and the location of said respective levels of energy in said period of time.

7. A process as set forth in claim 6, wherein the computing is done from said respective levels of energy primarily as reflected from a distal wall of the organ body tissue adjacent said distal wall.

8. A process as set forth in claim 6, wherein the results of said computing are compared with a preestablished reference.

9. A process as set forth in claim 6, wherein a first of said reflections is from the proximate wall of said organ, a second of said reflections is from the distal wall of said organ and adjacent body tissue, said second of said reflections extending over a plurality of said segments of time, and said computing of organ distention utilizes both the time between said first and second of said reflections and the levels of energy in said segments of time of said second of said reflections.

10. A process as set forth in claim 6, wherein said pulse of energy is a pulse of acoustic energy.

11. Apparatus for measuring the fullness of a bladder in an animal body, comprising means for transmitting a pulse of energy to and through the bladder, means for receiving reflections of said pulse of energy over a selected period of time, means for identifying a set of segments of time over said period of time, means for computing a measure of bladder fullness from both the respective levels of energy in said segments of time and the location of said respective levels of energy in said period of time.

12. Apparatus for measuring the fullness of a bladder as set forth in claim 11, wherein the computing is done from said respective levels of energy primarily as reflected from a distal wall of the bladder and body tissue adjacent said distal wall.

13. Apparatus for measuring the fullness of a bladder as set forth in claim 12, and means for comparing the results of said computing with a preestablished reference.
14. Apparatus for measuring the fullness of a bladder as set forth in claim 11, wherein a first of said reflections is from the proximate wall of said bladder, a second of said reflections is from the distal wall of said bladder and adjacent body tissue, said second of said reflections extending over a plurality of said segments of time, and the computing of bladder fullness utilizes both the time between said first and second of said reflections and the levels of energy in said segments of time of said second of said reflections.

15. Apparatus for measuring the fullness of a bladder as set forth in claim 11, wherein said pulse of energy is a pulse of acoustic energy.

16. Apparatus for measuring the degree of distention of a distendable organ within an animal body, comprising means for transmitting a pulse of energy to and through the organ, means for receiving reflections of said pulse of energy over a selected period of time, means for identifying a set of segments of time over said period of time, means for measuring the levels of the reflected energy received in each of said segments of time, and means for computing a measure of the distention from both the respective levels of energy in said segment of time and the location of said respective levels of energy in said period of time.

17. Apparatus as set forth in claim 16, wherein the computing is done from said respective levels of energy primarily as reflected from a distal wall of the organ and body tissue adjacent said distal wall.

18. Apparatus as set forth in claim 16, and means for comparing the results of said computing with a preestablished reference.

19. Apparatus as set forth in claim 16, wherein a first of said reflections is for the proximate wall of said organ, a second of said reflections is from the distal wall of said organ and adjacent body tissue, said second of said reflections extending over a plurality of said segments of time, and the computing of organ distention utilizes both the time between said first and second of said reflections and the levels of energy in said segments of time of said second of said reflections.

20. Apparatus as set forth in claim 16, wherein said pulse of energy is a pulse of acoustic energy.

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