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(54) **MEASUREMENT APPARATUS, MEASUREMENT METHOD, AND ULTRASONIC DIAGNOSIS APPARATUS**

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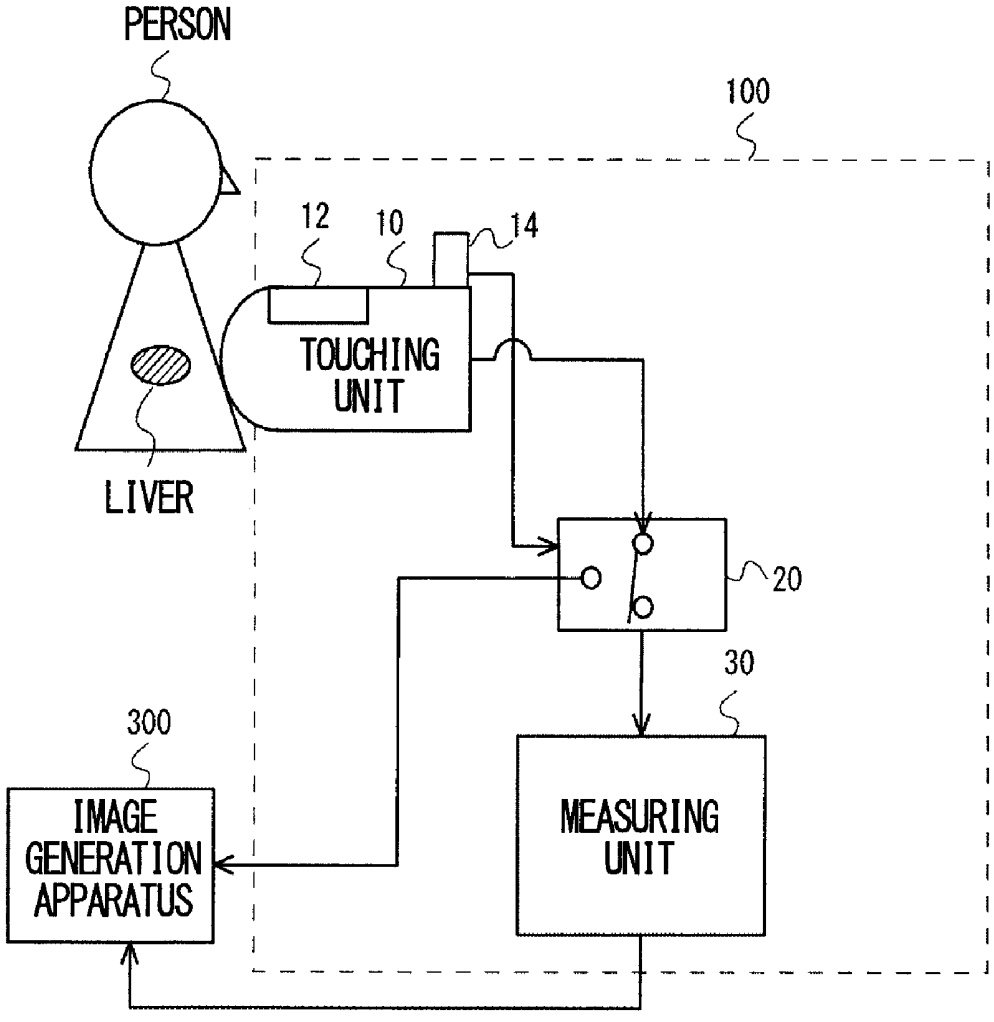
(57) **ABSTRACT**

To measure the content percentage of fat in a liver without increasing hardware size, provided is a measurement method and a measurement apparatus including a touching unit that supplies an ultrasonic signal to a body part and receives a response signal that has passed through an inner portion of the body part; a measuring unit that is connected to the touching unit and measures a characteristic of the body part based on the response signal received by the touching unit; and a switching section that switches between connecting the touching unit to the measuring unit and connecting the touching unit to an image generation apparatus that generates an image of a region including the body part in response to the touching unit scanning the region.



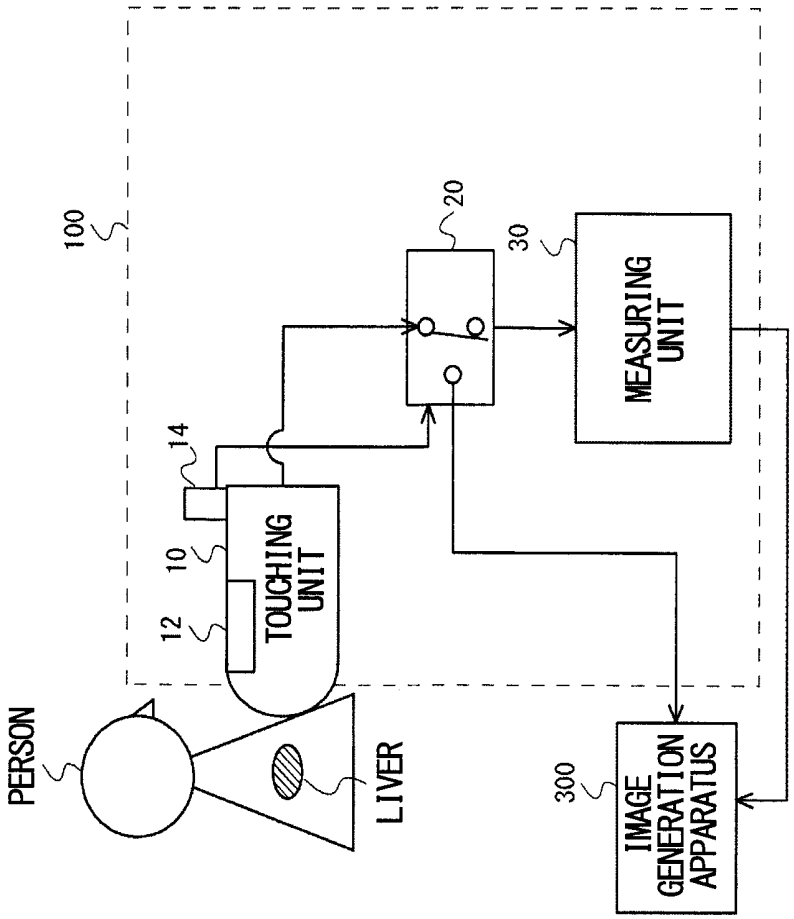

100
20
30
MEASURING UNIT
14
10
12
TOUCHING UNIT
PERSON
LIVER
300
IMAGE GENERATION APPARATUS

FIG. 1

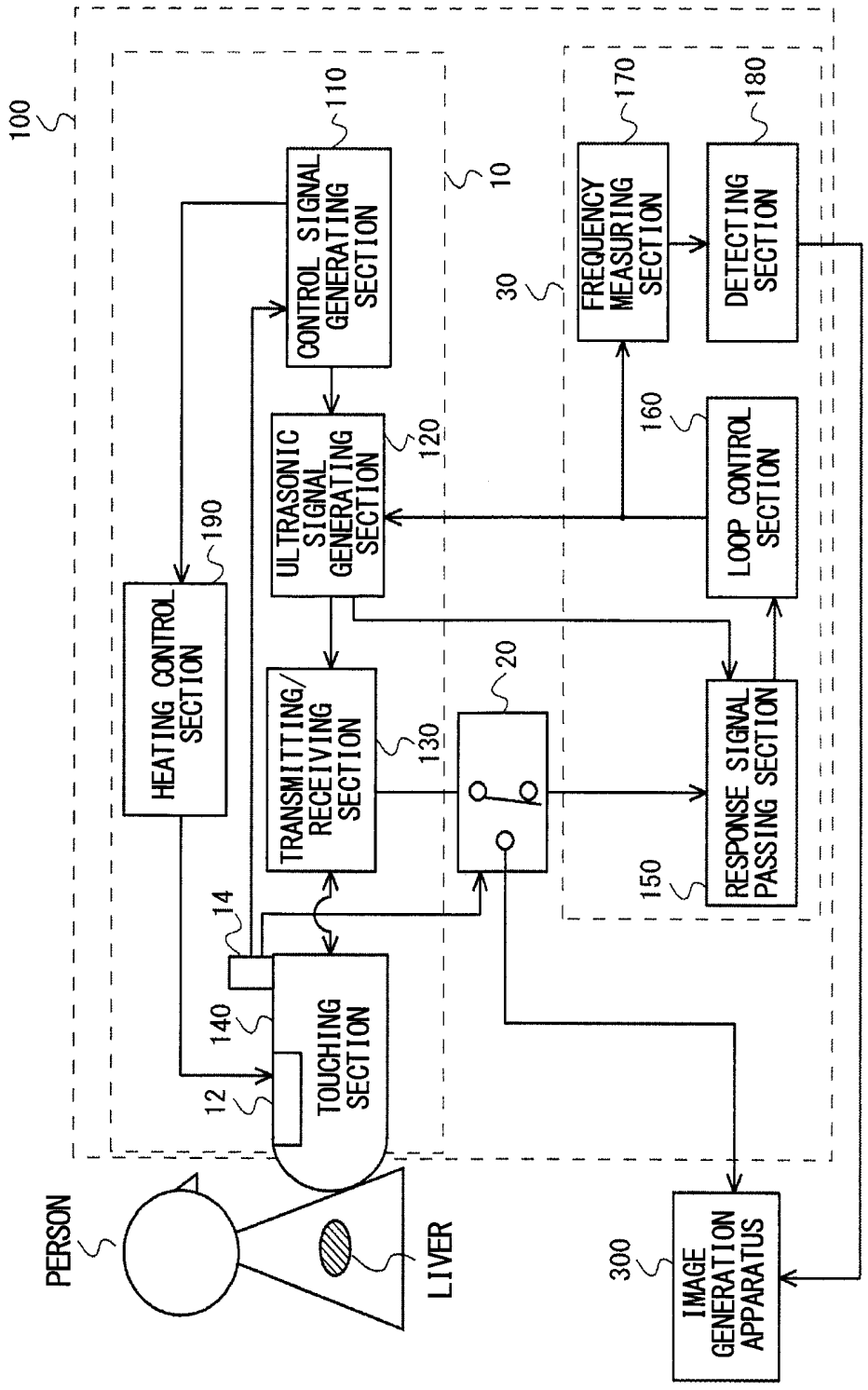

100
10
30
110
CONTROL SIGNAL GENERATING SECTION
120
ULTRASONIC SIGNAL GENERATING SECTION
130
TRANSMITTING/ RECEIVING SECTION
190
HEATING CONTROL SECTION
20
14
140
12
TOUCHING SECTION
150
RESPONSE SIGNAL PASSING SECTION
160
LOOP CONTROL SECTION
170
FREQUENCY MEASURING SECTION
180
DETECTING SECTION
PERSON
LIVER
300
IMAGE GENERATION APPARATUS

FIG. 2

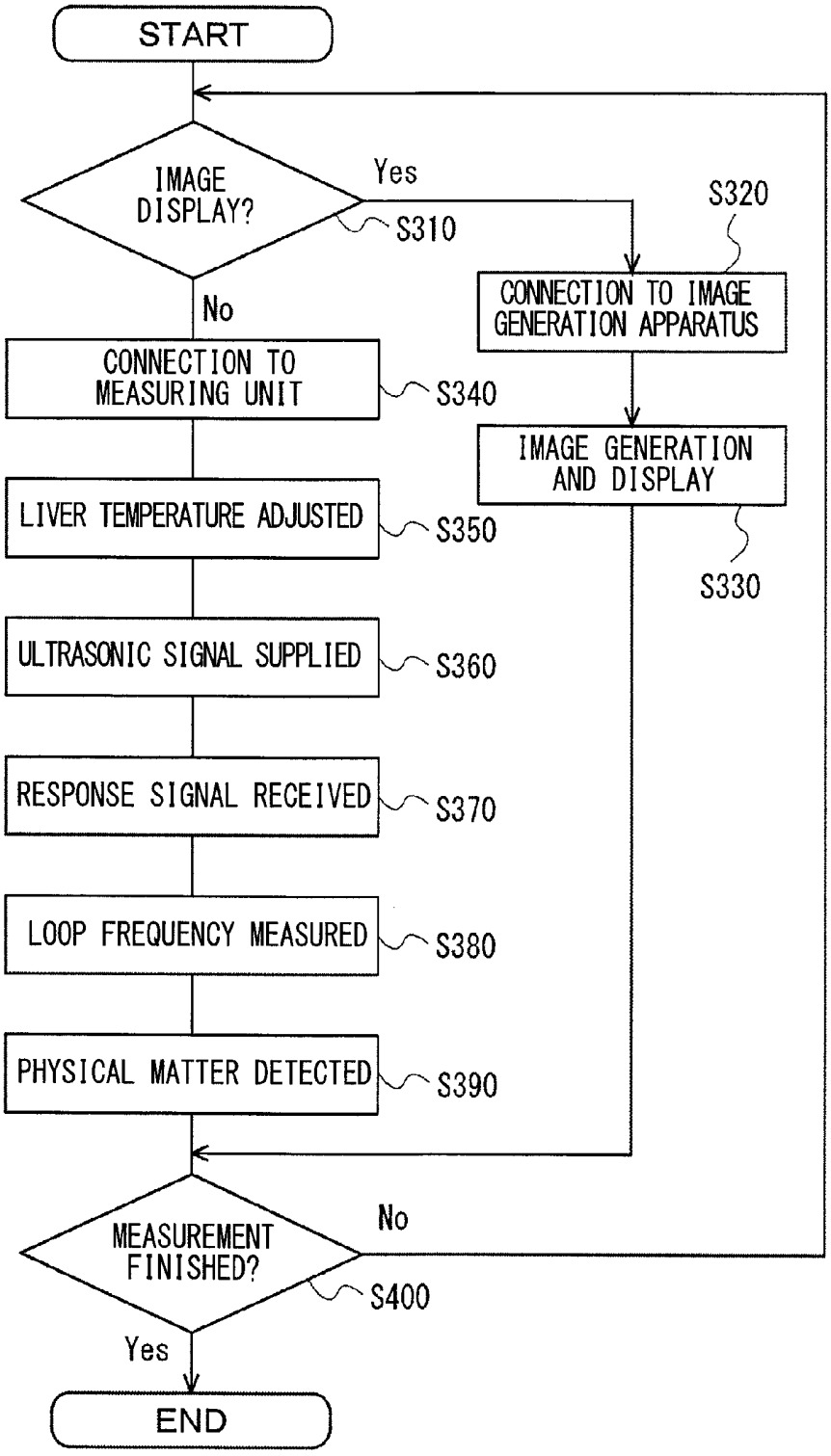

START
IMAGE DISPLAY?
Yes
S310
S320
CONNECTION TO IMAGE GENERATION APPARATUS
No
CONNECTION TO MEASURING UNIT
S340
IMAGE GENERATION AND DISPLAY
LIVER TEMPERATURE ADJUSTED
S350
S330
ULTRASONIC SIGNAL SUPPLIED
S360
RESPONSE SIGNAL RECEIVED
S370
LOOP FREQUENCY MEASURED
S380
PHYSICAL MATTER DETECTED
S390
MEASUREMENT FINISHED?
No
S400
Yes
END

FIG. 3

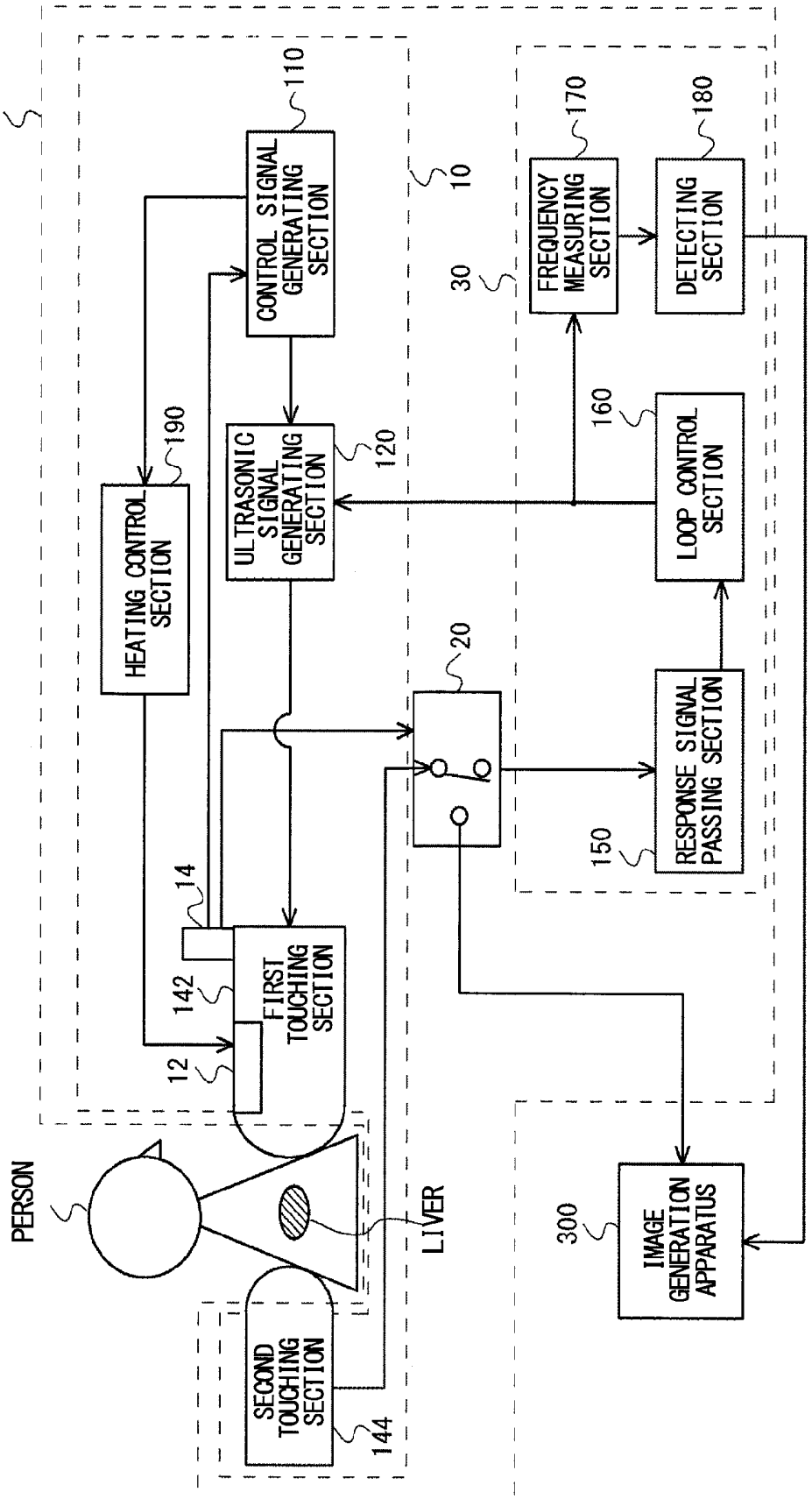

100
10
110
CONTROL SIGNAL GENERATING SECTION
190
HEATING CONTROL SECTION
120
ULTRASONIC SIGNAL GENERATING SECTION
30
170
FREQUENCY MEASURING SECTION
180
DETECTING SECTION
160
LOOP CONTROL SECTION
20
150
RESPONSE SIGNAL PASSING SECTION
14
142
FIRST TOUCHING SECTION
12
PERSON
LIVER
SECOND TOUCHING SECTION
144
300
IMAGE GENERATION APPARATUS

FIG. 4

MEASUREMENT APPARATUS, MEASUREMENT METHOD, AND ULTRASONIC DIAGNOSIS APPARATUS

[0001] The contents of the following Japanese patent application(s) are incorporated herein by reference: No. 2014-062182 filed in JP on Mar. 25, 2014.

BACKGROUND

[0002] 1. Technical Field

[0003] The present invention relates to a measurement apparatus, a measurement method, and an ultrasonic diagnosis apparatus.

[0004] 2. Related Art

[0005] It is known that the speed of sound passing through physical matter changes according to temperature and that the amount of this change differs according to the type of physical matter. For example, it is known that the speed of sound when propagating through muscle or internal organs, which contain a large amount of water, and the speed of sound propagating through fat cells experience different changes in speed in response to changes in temperature. Therefore, it is known that by applying ultrasonic waves to the liver or the like and measuring the change in speed of a reflected ultrasonic signal in response to a change in temperature of the liver, the liver can be diagnosed as being a fatty liver or not, as shown in International Publication WO 2011/125549, for example.

[0006] However, the change in speed of the ultrasonic wave that is dependent on the physical matter in this way is indicated by only a slight difference between approximately +2 m/s·° C. in water and approximately −4 m/s·° C. in fat cells, and therefore the received ultrasonic reflected signal must be processed through an A/D conversion with a high speed sampling rate of at least several hundred MHz. Furthermore, when the measurement point fluctuates due to breathing or the like during measurement, there is an error in the measurement results, and therefore signal processing such as calculating the correlation of a plurality of pieces of data is necessary, which increases the physical dimensions of the measurement apparatus.

SUMMARY

[0007] Therefore, it is an object of an aspect of the innovations herein to provide a measurement apparatus, a measurement method, and an ultrasonic diagnosis apparatus, which are capable of overcoming the above drawbacks accompanying the related art. The above and other objects can be achieved by combinations described in the claims. According to first aspect of the invention, provided is a measurement method and a measurement apparatus including a touching unit that supplies an ultrasonic signal to a body part and receives a response signal that has passed through an inner portion of the body part; a measuring unit that is connected to the touching unit and measures a characteristic of the body part based on the response signal received by the touching unit; and a switching section that switches between connecting the touching unit to the measuring unit and connecting the touching unit to an image generation apparatus that generates an image of a region including the body part in response to the touching unit scanning the region.

[0008] According to second aspect of the invention, provided is An ultrasonic diagnosis apparatus including the measurement apparatus according to the first aspect and an image generation apparatus that is connected to the touching unit and generates an image of a region including the body part, in response to the touching unit scanning the region. The ultrasonic diagnosis apparatus detects content percentage of fat at a designated measurement point in the image of the region, by having the switching section connect the touching unit to the measuring unit.

[0009] The summary clause does not necessarily describe all necessary features of the embodiments of the present invention. The present invention may also be a sub-combination of the features described above

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** shows an exemplary configuration of a measurement apparatus **100** according to an embodiment of the present invention, along with an image generation apparatus **300**.

[0011] FIG. **2** shows a configurational example of the measurement apparatus **100** with the touching unit **10** and the measuring unit **30** connected thereto, according to the present embodiment.

[0012] FIG. **3** shows an operational flow of the measurement apparatus **100** according to the present embodiment.

[0013] FIG. **4** shows a modification of the measurement apparatus **100** according to the present embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0014] Hereinafter, some embodiments of the present invention will be described. The embodiments do not limit the invention according to the claims, and all the combinations of the features described in the embodiments are not necessarily essential to means provided by aspects of the invention.

[0015] FIG. **1** shows an exemplary configuration of a measurement apparatus **100** according to an embodiment of the present invention, along with an image generation apparatus **300**. The measurement apparatus **100** supplies an ultrasonic signal to a body part and receives a response signal that has passed through an inner portion of this body part. The measurement apparatus **100** is connected to the image generation apparatus **300**, and switches between a function of supplying the response signal to the image generation apparatus **300** to generate an image of a region including the body part and a function of measuring characteristics or the like of the body part according to the response signal. The present embodiment describes an example in which the measurement apparatus **100** detects physical matter contained in the body part according to the response signal.

[0016] In a case where the measurement apparatus **100** supplies the response signal to the image generation apparatus **300**, the measurement apparatus **100** and the image generation apparatus **300** form an ultrasonic diagnosis apparatus or ultrasonic measurement apparatus that generates an image of a region containing a body part of an animal, particularly a human. In other words, the image generation apparatus **300** may be a portion of an ultrasonic measurement apparatus or an ultrasonic diagnosis apparatus, for example. In this case, the measurement apparatus **100** is connected to the image generation apparatus **300** instead of a probe that handles the ultrasonic signal of the image generation apparatus **300**. The measurement apparatus **100** includes a touching unit **10**, a switching section **20**, and a measuring unit **30**.

[0017] The touching unit **10** touches a body, supplies an ultrasonic signal to the body part, and receives a response signal that has passed through the inner portion of the body part. The touching unit **10** faces a measurement point or measurement region of the inner portion of the body, touches a location near this measurement point or the like, and supplies the ultrasonic signal, for example, in a manner to efficiently irradiate the measurement point or the like with the ultrasonic signal. Furthermore, the touching unit **10** receives, as a response signal, a reflected signal that has been reflected from the measurement point or measurement region. The touching unit **10** preferably has a size, shape, and weight that enable the touching unit **10** to be held in the hand of a user operating the measurement apparatus **100**, i.e. the person performing the measurement, and is used to touch the body of the person undergoing the measurement. The touching unit **10** includes a heating section **12** and a switching button **14**.

[0018] The heating section **12** heats the inner portion of the body part. The heating section **12** heats the inner portion of the body part to be a predetermined temperature. The heating section **12** is provided within the touching unit **10**, and is formed integrally with the touching unit **10**. Instead, the heating section **12** may be provided outside of the touching unit **10**.

[0019] The heating section **12** includes an irradiating section that radiates ultrasonic waves or electromagnetic waves, for example, and increases the temperature within the body. The heating section **12** may include a plurality of irradiating sections, and may perform irradiation by focusing ultrasonic waves or electromagnetic waves at a predetermined location within the body. Instead of or in addition to the heating section **12**, the touching unit **10** may include a cooling section that cools the inside of the body. The heating section **12** may touch the body to supply the ultrasonic waves or the like.

[0020] In a case where the measurement apparatus **100** measures characteristics or the like of the body part according to the response signal, the heating section **12** stops radiating the ultrasonic waves or electromagnetic waves after the temperature within the body has risen, for example. Then, the measurement apparatus **100** supplies the ultrasonic signal until the raised temperature within the body returns to the original temperature, and receives a response signal. The heating section **12** may stop operating when the measurement apparatus **100** supplies the response signal to the image generation apparatus **300**. Instead, the heating section **12** may maintain the temperature within the body at a predetermined temperature or designated temperature.

[0021] The switching button **14** supplies the switching section **20** with the control signal for controlling the switching section **20**, in response to input from the user, for example. The switching button **14** is provided in the touching unit **10** at a location enabling manipulation of the switching button **14** in a state where the user holds the touching unit **10** in a hand. In other words, the user manipulates the switching button **14** while touching the body with the touching unit **10**, and can control the switching between the measurement by the measurement apparatus **100** and the image generation by the image generation apparatus **300**. Furthermore, in addition to the switching button **14**, the touching unit **10** may further include ON and OFF buttons for the heating by the heating section and/or generation of the ultrasonic signal.

[0022] The switching section **20** switches between a state in which the touching unit **10** is connected to the measuring unit **30** and a state in which the touching unit **10** is connected to the image generation apparatus **300** that generates an image of a region including the body part in response to this region being scanned by the touching unit. The switching section **20** receives the control signal from the switching button **14** and, according to the input to the switching button **14**, switches whether the touching unit **10** is connected to the measuring unit **30** or to the image generation apparatus **300**.

[0023] In a case where the image generation apparatus **300** includes an input connector, for example, the switching section **20** includes a connector that engages with this input connector, and is connected to the image generation apparatus **300**. Furthermore, the switching section **20** may be connected to an internal wire of the image generation apparatus **300**. The switching section **20** may include one or more one-input/two-output switches, for example.

[0024] The switching section **20** may be formed integrally with the measuring unit **30**. As another example, the switching section **20** may be formed integrally with the touching unit **10**. In this case, the switching section **20** and the image generation apparatus **300** may be connected by a cable or the like. As yet another example, the touching unit **10**, the switching section **20**, and the measuring unit **30** may be formed integrally.

[0025] The measuring unit **30** is connected to the touching unit **10** and receives the response signal that is received in response to the ultrasonic signal supplied by the touching unit **10**. The measuring unit **30** measures the characteristics of the body part based on the response signal received by the touching unit **10**. For example, the measuring unit **30** detects the physical matter contained in the body part. The measuring unit **30** preferably has organs, internal organs, tissue, or the like that contain homogenous physical matter as the body part to be a measurement target. The present embodiment describes an example in which the measuring unit **30** uses a liver as the body part to be the measurement target.

[0026] The measuring unit **30** may transmit the measurement results to the image generation apparatus **300** and display the measurement results in a display section of the image generation apparatus. In this case, the measuring unit **30** is connected to the image generation apparatus **300** and supplies the image generation apparatus **300** with the measurement result data. Furthermore, the switching section **20** connects the touching unit **10** to the measuring unit **30**, and the measuring unit **30** transmits to the image generation apparatus **300** a timing signal for displaying the measurement results in the display section of the image generation apparatus **300**, in response to the measurement results being within a predetermined range of values. Instead of or in addition to this, the measuring unit **30** may include a display section that displays the measurement results.

[0027] The measuring unit **30** measures the characteristics of the liver according to phase change of the response signal caused by temperature change in an inner portion of the liver. FIG. **2** is used to describe an example in which the measurement apparatus **100** measures the characteristics of the liver of a person using the measuring unit **30**.

[0028] FIG. **2** shows a configurational example of the measurement apparatus **100** with the touching unit **10** and the measuring unit **30** connected thereto, according to the present embodiment. The measurement apparatus **100** irradiates the liver of the person with an ultrasonic signal, and receives the ultrasonic signal that has passed through the liver as a response signal. The measurement apparatus **100** receives a response signal that is a reflected signal that has been reflected

from the inner portion of the liver, for example. FIG. **2** shows an example in which the touching unit **10** supplies the liver with an ultrasonic signal and receives a reflected signal generated at a border between lobes of the liver, e.g. the right lobe, the left lobe, the caudate lobe, and the quadrate lobe, as the response signal, and the measuring unit **30** measures the content percentage of fat in the liver.

[0029] The measurement apparatus **100** includes a control signal generating section **110**, an ultrasonic signal generating section **120**, a transmitting/receiving section **130**, a touching section **140**, a response signal passing section **150**, a loop control section **160**, a frequency measuring section **170**, a detecting section **180**, and a heating control section **190**. Specifically, the touching unit **10** includes the control signal generating section **110**, the ultrasonic signal generating section **120**, the transmitting/receiving section **130**, the touching section **140**, and the heating control section **190**, while the measuring unit **30** includes the response signal passing section **150**, the loop control section **160**, the frequency measuring section **170**, and the detecting section **180**.

[0030] The control signal generating section **110** generates a control signal for generating the ultrasonic signal, and supplies this control signal to the ultrasonic signal generating section **120**. The control signal generating section **110** may generate the control signal for generating the ultrasonic signal, in response to the switching button **14** being turned ON. Furthermore, in a case where the touching unit **10** includes an ON and OFF button for generating the ultrasonic signal, the control signal generating section **110** may generate the control signal for generating the ultrasonic signal in response to this button being turned ON. Instead, the control signal generating section **110** may constantly output the ultrasonic signal when the power source of the measurement apparatus **100** is ON.

[0031] The control signal generating section **110** is connected to the heating control section **190**, and may supply a control signal for changing the temperature of the inner portion of the liver to the heating control section **190**. In this case, for example, the control signal generating section **110** supplies the heating control section **190** with the control signal for changing the temperature of the inner portion of the liver and then, after a predetermined time has passed, supplies the ultrasonic signal generating section **120** with the control signal for generating the ultrasonic signal.

[0032] The ultrasonic signal generating section **120** is connected to the control signal generating section **110**, and generates the ultrasonic signal according to the control signal received from the control signal generating section **110**. The ultrasonic signal generating section **120** supplies the ultrasonic signal to the portion including the liver, through the transmitting/receiving section **130** and the touching section **140**. The ultrasonic signal generating section **120** includes a puller for generating ultrasonic waves and outputs a high-voltage pulse in which the wave peak reaches from tens to a hundred and tens of volts, for example.

[0033] The transmitting/receiving section **130** is connected to the ultrasonic signal generating section **120** and the touching section **140**, and supplies the touching section **140** with the ultrasonic signal received from the ultrasonic signal generating section **120**. When the connection of the switching section **20** is set to the measuring unit **30**, the transmitting/receiving section **130** is connected to the signal passing section **150** via the switching section **20**, and supplies the signal passing section **150** with the response signal received form the touching section **140**. When the connection of the switching section **20** is set to the image generation apparatus **300**, the transmitting/receiving section **130** supplies the image generation apparatus **300** with the response signal via the switching section **20**. The transmitting/receiving section **130** includes a transmission/reception switch for the ultrasonic signal, for example.

[0034] The touching section **140** touches the body and receives the ultrasonic signal. The touching section **140** may include the heating section **12**. In this case, the heating section **12** may touch the body in the same manner as the touching section **140**, and may supply the ultrasonic signal to the measurement point or the like.

[0035] The response signal passing section **150** is provided between the ultrasonic signal generating section **120** and the loop control section **160**, passes the response signal supplied from the touching section **140** to the loop control section **160**, and attenuates the ultrasonic signal that leaks from the transmitting/receiving section **130**. The response signal passing section **150** includes an amplification circuit with variable amplification and/or a switch circuit that amplify or attenuate a signal input thereto, according to a timing signal input thereto.

[0036] The response signal passing section **150** is connected to the ultrasonic signal generating section **120** and acquires the timing at which the ultrasonic signal is attenuated from the ultrasonic signal generating section **120**, for example. Instead, the response signal passing section **150** may be connected to the control signal generating section **110** and may acquire the timing at which the ultrasonic signal is attenuated from the control signal generating section **110**.

[0037] The loop control section **160** is connected to the ultrasonic signal generating section **120** and the response signal passing section **150**, and supplies the ultrasonic signal generating section **120** with the control signal for generating the ultrasonic signal, in response to receiving the response signal from the liver from the response signal passing section **150**. Specifically, the ultrasonic signal generating section **120**, the transmitting/receiving section **130**, the touching section **140**, the liver, the response signal passing section **150**, and the loop control section **160** form a loop path through which a signal based on the ultrasonic signal is sequentially transmitted.

[0038] The frequency measuring section **170** is connected to the loop control section **160** and measures the repeating frequency of the control signal that is repeatedly supplied to the ultrasonic signal generating section **120** by the loop control section **160** according to the response signal. The frequency measuring section **170** may be a frequency counter that counts how many times the electrical signal is input per unit time, to measure the frequency of this electrical signal. The frequency measuring section **170** supplies the detecting section **180** with the measured frequency.

[0039] The detecting section **180** is connected to the frequency measuring section **170** and detects the physical material contained in the liver through which the ultrasonic signal has passed, based on the frequency measured by the frequency measuring section **170**. For example, the detecting section **180** detects a change in the frequency measured by the frequency measuring section **170**, and detects the content percentage of fat in the liver.

[0040] The heating control section **190** controls the heating of the heating section **12**. The heating control section **190** controls the heating of the heating section **12** in response to

receiving the control signal from the control signal generating section **110**. As another example, the heating control section **190** may control the heating of the heating section **12** in response to the switching section **20** connecting the touching unit **10** to the measuring unit **30**. In this case, the control signal generating section **110** may supply the heating control section **190** with the control signal for changing temperature in response to receiving the control signal from the switching button **14**.

[0041] The above describes an example in which, in the measurement apparatus **100** of the present embodiment, the switching section **20** is connected between the transmitting/receiving section **130** and the response signal passing section **150**. Instead, the switching section **20** may be connected between the response signal passing section **150** and the loop control section **160**.

[0042] The measurement apparatus **100** of the present embodiment described above forms a loop path through which the ultrasonic signal is supplied to the liver according to the received response signal, acquires speed information for the response signal by measuring the signal frequency at which the signal travels around the loop path, and detects the physical matter contained in the liver based on the speed change of the response signal. The operation of the measurement apparatus **100** is described below using an operational flow.

[0043] FIG. **3** shows an operational flow of the measurement apparatus **100** according to the present embodiment. The following describes an example in which the measurement apparatus **100** of the present embodiment displays an image of the liver and detects the content percentage of fat by performing steps S**310** to S**400** shown in FIG. **3**.

[0044] First, the measurement apparatus **100** switches whether the touching unit **10** is connected to the measuring unit **30** or to the image generation apparatus **300**, according to the state of the switching button **14**. In a case were the initial setting or input from the user indicates that the state of the switching button **14** is to be image display (S**310**: Yes), the switching section **20** connects the touching unit **10** to the image generation apparatus **300** (S**320**).

[0045] The ultrasonic signal generating section **120** supplies the ultrasonic signal to the liver of the person. For example, the control signal generating section **110** supplies the ultrasonic signal generating section **120** with the control signal for generating the ultrasonic signal, in response to the user manipulating the button for turning ON or OFF the generation of the ultrasonic signal to be ON.

[0046] The ultrasonic signal is supplied into the body from the touching section **140** and the image generation apparatus **300** receives, via the switching section **20**, the response signal output in response to this ultrasonic signal. The image generation apparatus **300** generates an image of the inside of the person to which the ultrasonic signal was supplied, according to the response signal, and outputs this image to the display section (S**330**). Here, in order to generate the image of the inside of the body of the person, the touching unit **10** may scan a region that is to be observed while touching the body.

[0047] In other words, when the touching unit **10** is connected to the image generation apparatus **300**, the image generation apparatus **300** generates an image of a region including the liver in response to the touching unit **10** scanning this region. In a case where the ultrasonic signal supplied by the touching unit **10** is to generate an image of a region including the liver, the radiation direction of the ultrasonic signal may be adjusted or scanned toward this region, and in this case the touching unit **10** may be fixed while touching the body.

[0048] When the measurement is not yet finished (S**400**: No) and there has been no change in the input of the switching button **14** (S**310**: Yes), the measurement apparatus **100** keeps the connection of the switching section **20** set to the image generation apparatus **300** (S**320**) and continues the image generation (S**330**). When the input of the user or the initial settings indicate that the state of the switching button **14** is to detect physical matter (S**310**: No), the measurement apparatus **100** connects the touching unit **10** to the measuring unit **30** (S**340**).

[0049] The control signal generating section **110** supplies the heating control section **190** with the control signal for changing the temperature of the inner portion of the liver, to adjust the temperature of the inner portion of the liver before the liver is supplied with the ultrasonic signal from the ultrasonic signal generating section **120** (S**350**). For example, the control signal generating section **110** transmits the control signal for changing the temperature to the heating control section **190** in response to receiving a control signal from the switching button **14**. In this way, prior to supplying the ultrasonic signal, the control signal generating section **110** supplies a control signal for increasing the temperature of the inner portion of the liver to a predetermined temperature. The heating control section **190** controls the heating section **12** to adjust the temperature of the inner portion of the liver to be the predetermined temperature, according to this control signal.

[0050] Next, the control signal generating section **110** supplies the ultrasonic signal generating section **120** with the control signal for generating the ultrasonic signal, and the ultrasonic signal is supplied to the inner portion of the liver (S**360**). The control signal generating section **110** raises the temperature of the inner portion of the liver to the predetermined temperature, and then supplies the ultrasonic signal generating section **120** with the control signal for generating the ultrasonic signal.

[0051] For example, the control signal generating section **110** supplies the control signal to the heating control section **190** and then, after a predetermined time has passed, supplies the ultrasonic signal generating section **120** with the control signal for generating the ultrasonic signal. In this case, the actual transition time needed for the temperature of the inner portion of the liver to change from when the heating control section **190** begins adjusting the temperature within the liver is measured in advance, and the time at which the ultrasonic signal generating section **120** supplies the control signal may be determined in advance according to the transition time measurement result. In this way, the measurement apparatus **100** can measure the temperature conditions from when the temperature of the liver is raised to the predetermined temperature to when the temperature of the liver has dropped back down to normal body temperature.

[0052] The ultrasonic signal generating section **120** supplies the ultrasonic signal to the inner portion of the liver through the transmitting/receiving section **130** and the touching section **140**, according to the received control signal. Here, the ultrasonic signal generating section **120** may notify the response signal passing section **150** concerning the timing at which the ultrasonic signal is generated. The response signal passing section **150** acquires the timing at which the ultrasonic signal received from the ultrasonic signal generating section **120** is generated, as the timing at which the input

signal is attenuated, and may attenuate the input signal from when this timing is acquired until a predetermined time has passed.

[0053] If there is an amplification circuit included, for example, the response signal passing section **150** decreases the amplification amount of the amplification circuit to attenuate the signal strength of the signal component supplied to the loop control section **160**. Furthermore, if there is a switch circuit included, the response signal passing section **150** switches this switch circuit to cut off the electrical connection between the transmitting/receiving section **130** and the loop control section **160**. In this way, the response signal passing section **150** attenuates the input signal in synchronization with the generation timing of the ultrasonic signal, even when a portion of the ultrasonic signal generated by the ultrasonic signal generating section **120** is leaked from the transmitting/receiving section **130** and input, and therefore the response signal passing section **150** can reduce the noise component and prevent incorrect operation of the loop control section **160**.

[0054] Here, the response signal passing section **150** may determine in advance the time during which the input signal continues to be attenuated, according to the time during which the pulse is continuously generated as the ultrasonic signal by the ultrasonic signal generating section **120**, and the attenuation of the input signal may be stopped after this predetermined time has passed. In this way, every time the ultrasonic signal generating section **120** generates the ultrasonic signal, the response signal passing section **150** can repeatedly switch whether the input signal is being attenuated, thereby reducing or blocking out the signal components other than the response signal.

[0055] Next, the touching section **140** receives the response signal, which is the reflected signal of the ultrasonic signal reflected from the inner portion of the liver (S**370**). The touching section **140** supplies the response signal passing section **150** with the received response signal through the transmitting/receiving section **130** and the switching section **20**. The response signal passing section **150** passes the received response signal to the loop control section **160**. Specifically, the response signal passing section **150** sets the amplification amount of the amplification circuit and/or the switches the switch circuit such that the response signal is passed to the loop control section **160**.

[0056] For example, during periods other than the period in which a portion of the ultrasonic signal generated by the ultrasonic signal generating section **120** is leaked from the transmitting/receiving section **130** and input, the response signal passing section **150** passes the signal input thereto to the loop control section **160**. Furthermore, the response signal passing section **150** may determine the timing at which the response signal is passed to the loop control section **160** according to the distance between the inner portion of the liver and the touching section **140**.

[0057] The response signal to be passed to the loop control section **160** is the reflected signal that has been reflected from the inner portion of the liver, and therefore the timing at which the response signal is input to the response signal passing section **150** is determined according to the distance between the touching section **140** and the border between lobes in the inner portion of the liver, for example. Accordingly, the passage time corresponding to the distance that can be obtained between the touching section **140** and the inner portion of the liver is preferably obtained in advance based on information such as the position of the liver of the person and the position where the touching section **140** touches the person. The response signal passing section **150** may perform the setting of the amplification amount of the amplification circuit and/or the switching of the switch such that the response signal is passed during the passage time.

[0058] Instead of or in addition to the above, the response signal passing section **150** may pass a signal that exceeds a predetermined amplitude value and may attenuate a signal that is below this amplitude value. In this way, the loop control section **160** can reduce or cut off signals that have an amplitude value below the amplitude value that can be predicted for the response signal. Furthermore, when the amplitude value of a signal leaked from the transmitting/receiving section **130** and input, for example, is less than the predetermined amplitude value, the response signal passing section **150** need not perform the process to attenuate the input signal. If the response signal passing section **150** includes an amplification circuit, the response signal passing section **150** may amplify the signal to be passed, and then pass the resulting signal.

[0059] Next, upon receiving the response signal passed by the response signal passing section **150**, the loop control section **160** supplies the control signal for generating the ultrasonic signal to the ultrasonic signal generating section **120**. The ultrasonic signal generating section **120** generates the ultrasonic signal according to this control signal, and supplies the ultrasonic signal to the inner portion of the liver.

[0060] In the manner described above, the measurement apparatus **100** of the present embodiment supplies the ultrasonic signal to the liver in response to receiving the response signal that has passed through the liver, and therefore the supply of this ultrasonic signal and the reception of this response signal are repeated. Specifically, a signal based on the ultrasonic signal travels around the loop path formed by the ultrasonic signal generating section **120**, the transmitting/receiving section **130**, the touching section **140**, the liver, the touching section **140**, the switching section **20**, the response signal passing section **150**, and the loop control section **160**.

[0061] The frequency measuring section **170** measures the loop frequency at which the signal based on the ultrasonic signal travels around the loop path (S**380**). Specifically, the frequency measuring section **170** measures the speed of the signal passing through the loop path and the loop frequency determined according to the loop length, and therefore detects the frequency corresponding to the response speed. In other words, the speed information of the signal passing through the loop path can be acquired according to the frequency measured by the frequency measuring section **170**. For example, when there is a difference in the speed at which the ultrasonic signal passes through different physical matter, the frequency measuring section **170** can detect the difference between these types of physical matter as the difference in the loop frequency.

[0062] As an example, the water, fat, and the like contained in the liver has an almost uniform distribution in the inner portion of the liver, and therefore the speed of the ultrasonic wave passing through the liver depends on the amount of water, fat, and the like contained in the liver. Accordingly, a liver in which the content percentage of water is low enough and the content percentage of fat is high enough to create a difference in speed when compared to a normal liver can be detected due to the difference in the loop frequency.

[0063] Furthermore, even when the content percentage of the physical material or between physical materials is such that it is difficult to detect this difference as the difference in the loop frequency, there are cases where this difference can still be detected by utilizing the temperature dependent nature of the loop frequency. For example, the temperature dependency of the speed of an ultrasonic wave is approximately +2 m/s·° C. in water and approximately −4 m/s·° C. in fat cells, thereby exhibiting different directions of change in the speed relative to temperature. Accordingly, in the case of a liver containing a greater amount of water, the loop frequency decreases when the temperature decreases, while in the case of a liver containing a greater amount of fat, the loop frequency increases when the temperature decreases, and therefore the frequency measuring section **170** outputs the increase or decrease in the frequency corresponding to the content percentage of such physical matter.

[0064] The detecting section **180** detects the physical matter contained in the liver based on the change in frequency corresponding to the change in temperature of the inner portion of the liver (S**390**). Furthermore, the detecting section **180** may detect the content percentage of fat in the liver based on the slope of the change in frequency corresponding to the temperature change. For example, when the temperature dependency has a positive sign when the ultrasonic wave speed decreases, in response to there being a decrease in the loop frequency when the temperature decreases, the detecting section **180** detects that the content percentage of water in the liver is high. Here, by measuring in advance the speed change corresponding to the content percentage of fat in the liver and comparing this to the measurement results, the detecting section **180** may identify the content percentage of fat in the liver of the measurement target.

[0065] In the manner described above, the measurement apparatus **100** of the present embodiment acquires speed information for the ultrasonic signal passing through the inner portion of the liver by measuring the frequency of the signal travelling around the loop path. Accordingly, the measurement apparatus **100** can detect the speed of the response signal and changes in the speed without performing an A/D conversion with a high-speed sampling rate.

[0066] Furthermore, the frequency measuring section **170** can measure the loop frequency using a frequency counter. The frequency counter can improve the accuracy of the measured frequency by using a liquid crystal oscillator or the like to improve the time accuracy, and therefore the accuracy of the detected speed can be increased regardless of the sampling rate.

[0067] The frequency counter can easily perform measurement for a high frequency that exceeds 100 MHz, for example, by using a prescaler (frequency divider) to divide the input frequency and then measuring the frequency. Accordingly, the measurement apparatus **100** can improve the design freedom of the loop length. In this way, the measurement apparatus **100** can accurately measure the change in speed of the response signal, and can more accurately detect the content percentage of water or fat contained in the liver of the measurement target.

[0068] Furthermore, the frequency counter counts the pulses input per unit time, and can therefore finish the frequency measurement within this unit of time. Accordingly, even when a person is breathing, the frequency measuring section **170** can perform the frequency measurement faster than the person breaths, and can therefore reduce the effect of breathing on the measurement results. Furthermore, the frequency measuring section **170** can perform more frequency measurements during a period when the temperature of the liver drops back to normal body temperature after being increased to a predetermined temperature, and can therefore measure the change in frequency relative to change in temperature with a higher (temperature) resolution.

[0069] Yet further, by periodically measuring the liver of the person being targeted, the measurement apparatus **100** can detect the fat content percentage of the liver increasing or decreasing in response to the lifestyle of the person being measured, for example. The detecting section **180** may also have a simple diagnosis function to identify a liver as a fatty liver when the fat content of the liver is greater than or equal to a predetermined value. In the manner described above, the measurement apparatus **100** of the present embodiment can easily detect the physical matter contained in a liver without increasing the size of the apparatus by using high-speed digital signal processing.

[0070] The detecting section **180** may supply the image generation apparatus **300** with the detection results, and in this case, the image generation apparatus **300** outputs the detection results to the display section. The image generation apparatus **300** may display the detection results along with the image generated before the connection to the measuring unit **30** is made. Instead of or in addition to this, the measuring unit **30** may include a display section to display the measurement results and the detecting section **180** may display the detection results in the display section of the measuring unit **30**.

[0071] The detecting section **180** supplies the detection results to the image generation apparatus **300**, in response to the detection results being within a predetermined range, for example. In this way, when a measurement error occurs, e.g. when the touching section **140** does not achieve sufficient contact with the body, an abnormal value can be prevented from being displayed as the measurement value in the display section. Furthermore, in this way, a warning lamp or the like may be provided in the touching unit **10** to provide notification through light to the user manipulating the touching unit **10** when it is determined that a measurement error has occurred.

[0072] When input indicating the end of measurement is made, e.g. when the power supply of the apparatus is turned OFF, the measurement apparatus **100** ends the measurement (S**400**: Yes). Furthermore, when measurement continues (S**400**: No), the measurement apparatus **100** returns to step S**310** and switches the switching section **20** according to the state of the switching button **14**.

[0073] In this way, the measurement apparatus **100** can switch between image generation by the image generation apparatus **300** and physical matter detection by the measurement apparatus **100**. Therefore, the user can confirm the image with the image generation apparatus **300** and then begin detection of the physical matter at the measurement point or the like. In this case, the image generation apparatus **300** may generate an image of the region including the liver and then, by having the switching section **20** connect the touching unit **10** to the measuring unit **30**, the measuring unit **30** may detect the content percentage of fat at the designated measurement point in the image of this region.

[0074] Furthermore, the measurement apparatus **100** checks the image from the image generation apparatus **300** and then changes the temperature of the measurement region

or the like, and therefore heating can be started after confirming that the measurement region does not include locations where heating should be prevented such as arteries, for example, thereby enabling safe measurement. Yet further, the measurement apparatus **100** is connected to an existing ultrasonic measurement apparatus or ultrasonic diagnosis apparatus that generates an image, and has functions other than image detection, and therefore these functions can be added to existing apparatuses with reduced cost.

[0075] FIG. **4** shows a modification of the measurement apparatus **100** according to the present embodiment. In the measurement apparatus **100** of the present modification, components having substantially the same operation as components in the measurement apparatus **100** according to the embodiment shown in FIG. **2** are given the same reference numerals, and redundant descriptions are omitted. The measurement apparatus **100** of the present modification includes a first touching section **142** and a second touching section **144**.

[0076] The first touching section **142** touches a human body and supplies the liver of the inner portion of the person with an ultrasonic signal generated by the ultrasonic signal generating section **120**. In other words, the first touching section **142** includes at least the function of supplying the liver of the inner portion of the person with an ultrasonic signal, which is a function of the touching section **140** according to the embodiment shown in FIG. **2**. Furthermore, the first touching section **142** includes a heating section **12**, in the same manner as the touching section **140**.

[0077] The second touching section **144** touches the human body and receives the ultrasonic signal that has passed through the inner portion of the liver as a response signal. In other words, the second touching section **144** includes at least the function of receiving the response signal, which is a function of the touching section **140** according to the embodiment shown in FIG. **2**.

[0078] When the switching section **20** connects the second touching section **144** to the measuring unit **30**, the second touching section **144** supplies the loop control section **160** with the response signal, through the response signal passing section **150** and the switching section **20**. When the switching section **20** connects the second touching section **144** to the image generation apparatus **300**, the second touching section **144** supplies the image generation apparatus **300** with the response signal through the switching section **20**.

[0079] The loop control section **160** causes the ultrasonic signal to be generated from the ultrasonic signal generating section **120** according to the response signal, and supplies the generated ultrasonic signal to the first touching section **142**. In this way, the measurement apparatus **100** of the present modification creates a loop path formed by the ultrasonic signal generating section **120**, the transmitting/receiving section **130**, the first touching section **142**, the liver, the second touching section **144**, the switching section **20**, the response signal passing section **150**, and the loop control section **160**.

[0080] As a result, the second touching section **144** can receive the response signal based on the ultrasonic signal supplied from the first touching section **142** to the liver, from a location differing from the location where the first touching section **142** touches the human body. Therefore, the touching sections can be designed as separate and independent components on the transmission side and the reception side, thereby increasing the design freedom. Furthermore, a portion of the ultrasonic signal supplied from the first touching section **142** on the transmission side is prevented from leaking to the second touching section **144** on the reception side. Yet further, by optimizing the location at which each touching section touches the body, an ultrasonic signal that has passed through organs and tissue from the first touching section **142** can be received by the second touching section **144**.

[0081] In the manner described above, the measurement apparatus **100** of the present modification divides the touching section **140** that touches the body into the first touching section **142** on the transmission side and the second touching section **144** on the reception side, to transmit and receive the ultrasonic signal. In this case as well, the measurement apparatus **100** can cause the signal based on the ultrasonic signal to travel around the loop path, acquire the speed information indicating the speed at which the ultrasonic signal travels through the liver or the like, and detect the physical matter included in the liver.

[0082] While the embodiments of the present invention have been described, the technical scope of the invention is not limited to the above described embodiments. It is apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiments. It is also apparent from the scope of the claims that the embodiments added with such alterations or improvements can be included in the technical scope of the invention.

[0083] The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessarily mean that the process must be performed in this order.

What is claimed is:

1. A measurement apparatus comprising:

a touching unit that supplies an ultrasonic signal to a body part and receives a response signal that has passed through an inner portion of the body part;

a measuring unit that is connected to the touching unit and measures a characteristic of the body part based on the response signal received by the touching unit; and

a switching section that switches between connecting the touching unit to the measuring unit and connecting the touching unit to an image generation apparatus that generates an image of a region including the body part in response to the touching unit scanning the region.

2. The measurement apparatus according to claim **1**, wherein

the touching unit includes a switching button, and

the switching section switches between connecting the touching unit to the measuring unit and connecting the touching unit to the image generation apparatus in response to input to the switching button.

3. The measurement apparatus according to claim **1**, wherein

the touching unit includes a heating section that heats the inner portion of the body part.

4. The measurement apparatus according to claim **3**, wherein

the heating section heats the inner portion of the body part to a predetermined temperature.

5. The measurement apparatus according to claim 3, wherein

the touching unit includes a heating control section that controls the heating of the heating section.

6. The measurement apparatus according to claim 5, wherein

the heating control section controls the heating of the heating section in response to the switching section connecting the touching unit to the measuring unit.

7. The measurement apparatus according to claim 4, wherein

the measuring unit measures the characteristic of the body part according to a phase change of the response signal that accompanies a temperature change of the inner portion of the body part.

8. The measurement apparatus according to claim 1, wherein

the switching section is provided integrally with the measuring unit.

9. The measurement apparatus according to claim 1, wherein

the switching section is provided integrally with the touching unit.

10. The measurement apparatus according to claim 1, wherein

the measuring unit transmits a measurement result to the image generation apparatus and causes the measurement result to be displayed in a display section of the image generation apparatus.

11. The measurement apparatus according to claim 10, wherein

in response to the switching section connecting the touching unit to the measuring unit and the measurement result being within a predetermined range of values, the measuring unit transmits to the image generation apparatus a timing signal for displaying the measurement result in the display section of the image generation apparatus.

12. The measurement apparatus according to claim 1, wherein

the measuring unit further includes a display section for displaying a measurement result.

13. The measurement apparatus according to claim 1, wherein

the touching unit supplies the ultrasonic signal to a liver, and

the measuring unit measures a content percentage of fat in the liver.

14. The measurement apparatus according to claim 1, wherein the response signal is a reflected signal that has been reflected from the inner portion of the body part.

15. A measurement method comprising:

switching between connecting a touching unit to a measuring unit and connecting the touching unit to an image generation apparatus;

supplying an ultrasonic signal to a body part;

receiving, with the touching unit, a response signal that has passed through an inner portion of the body part;

when the touching unit is connected to the measuring unit, measuring, with the measuring unit, a characteristic of the body part based on the received response signal; and

when the touching unit is connected to the image generation apparatus, generating, with the image generation apparatus, an image of a region including the body part in response to the touching unit scanning the region.

16. An ultrasonic diagnosis apparatus comprising:

the measurement apparatus according to claim 1; and

an image generation apparatus that is connected to the touching unit and generates an image of a region including the body part, in response to the touching unit scanning the region, wherein

the measuring unit detects content percentage of fat at a designated measurement point in the image of the region, by having the switching section connect the touching unit to the measuring unit.

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摘要(译)

为了在不增加硬件尺寸的情况下测量肝脏中脂肪的含量百分比，提供了一种测量方法和测量装置，其包括触摸单元，其向身体部分提供超声信号并接收已经通过内部的响应信号。身体部位;测量单元，连接到触摸单元，并基于触摸单元接收的响应信号测量身体部位的特征;切换部分在将触摸单元连接到测量单元和将触摸单元连接到图像生成设备之间切换，该图像生成设备响应于扫描该区域的触摸单元生成包括身体部分的区域的图像。