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(54) **NON-INVASIVE ULTRASONIC BODY CONTOURING**

EINGRIFFSFREIE ULTRASCHALL KÖRPERKONTURIERUNG

SYSTEME NON INVASIF PAR ULTRASONS PERMETTANT DE DEFINIR LE CONTOUR D'UN CORPS HUMAIN

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to lipolysis generally and more particularly to ultrasonic lipolysis.

BACKGROUND OF THE INVENTION

[0002] The following US patents are believed to represent the current state of the art: 4,986,275, 5,143,063, 5,143,073, 5,209,221, 5,301,660, 5,431,621, 5,507,790, 5,526,815, 5,884,631, 6,039,048, 6,071,239, 6,113,558, 6,206,873.

[0003] US 5,507,790 describes accelerating lipolysis to reduce fat cell size without killing or eliminating the fat cells. In an embodiment of the invention, acceleration is provided by focusing radiant energy on the adipose cells to raise their temperature to between 40.0°C to 41.5°C. The radiant energy focused on the cells is maintained to increase cell lipolysis rate sufficiently to cause release of free fatty acids, thereby reducing the volume of the cells.

[0004] US Patent 6,071,239 to Cribbs et al describes non-invasively destroying fat cells in a living patient by applying to a fat layer of the patient high intensity focused ultrasound array. A novel phasing apparatus for producing a widely variable set of focal zone patterns for lipolytic therapy and other purposes is disclosed.

[0005] EP-A-1060728 describes equipment of lipolysis of fat of a living body by ultrasound sonification using low frequency ultrasound in a range from 15-140 kHz.

SUMMARY OF THE INVENTION

[0006] The present invention seeks to provide improved apparatus for ultrasonic lipolysis.

[0007] There is thus provided in accordance with a preferred embodiment of the present invention apparatus for lysing adipose tissue comprising:

> a source outside a body generating ultrasonic energy; and comprising
> a modulator that modulates the ultrasonic energy so that it has a duty cycle between 1:5 and 1:30; and
> an ultrasonic energy director, which directs said modulated ultrasonic energy to selectively lyse adipose tissue and not lyse non-adipose tissue in a target volume of the body containing the adipose tissue.

[0008] In accordance with a preferred embodiment of the present invention, the apparatus also includes an ultrasonic imager providing ultrasonic imaging of the region at least partially concurrently with directing the modulated ultrasonic energy at the target volume.

[0009] The directing may also include varying the focus of at least one ultrasonic transducer in order to direct the modulated ultrasonic energy at the target volume. Varying the focus may change the volume of the target volume, and/or the distance of the target volume from the at least one ultrasonic transducer,

[0010] The apparatus preferably also a includes a sensor sensing ultrasortic energy coupling to an external surface of the body adjacent the target volume.

[0011] The apparatus preferably additionally includes a sensor sensing of cavitation at the target volume.

[0012] In accordance with a preferred embodiment of the present invention, the ultrasonic energy has a frequency in a range of 100 KHz - 500 KHz, and most preferably in a range of 150 KHz - 300 KHz.

[0013] Preferably, the modulating may provide a duty cycle between 1:10 and 1:20.

[0014] In accordance with a preferred embodiment of the present invention, the modulating provides between 2 and 1000 sequential cycles at an amplitude above a cavitation threshold, more preferably between 25 and 500 sequential cycles at an amplitude above a cavitation threshold and most preferably between 100 and 300 sequential cycles at an amplitude above a cavitation threshold.

[0015] Preferably, the apparatus includes computerized tracking of the target volume notwithstanding movement of the body.

[0016] Preferably, the computerized tracking includes sensing changes in the position of markings on the body and employing sensed changes for tracking the position of the target volume in the body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings and ' appendix in which:

> Fig. 1 is a simplified pictorial illustration of the general structure and operation of ultrasonic lipolysis apparatus constructed and operative in accordance with a preferred embodiment of the present invention;
> Fig. 2 is a simplified block diagram illustration of a preferred power source and modulator showing a pattern of variation of ultrasonic pressure over time in accordance with a preferred embodiment of the present invention;
> Figs. 3A and 3B are simplified pictorial illustrations of the appearance of an operator interface display during normal operation and faulty operation respectively;
> Fig. 4 is a simplified block diagram illustration of an ultrasonic lipolysis system constructed and operative in accordance with a preferred embodiment of the present invention; and
> Figs. 5A, 5B and 5C are together, a simplified flowchart illustrating operator steps in carrying out lipolysis in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0018] Reference is now made to Fig. 1, which is a simplified pictorial illustration of the general structure and operation of ultrasonic lipolysis apparatus constructed and operative in accordance with a preferred embodiment of the present invention. As seen in Fig. 1, an ultrasonic energy generator and director, such as an ultrasonic transducer 10, disposed outside a body, generates ultrasonic energy which, by suitable placement of the transducer 10 relative to the body, is directed to a target volume 12 inside the body and is operative to selectively generally lyse adipose tissue and generally not lyse non-adipose tissue in the target volume.

[0019] A preferred embodiment of ultrasonic energy generator and director useful in the present invention comprises an ultrasonic therapeutic transducer 13 including a curved phased array 14 of piezoelectric elements 15, typically defining a portion of a sphere or of a cylinder, and having conductive coatings 16 on opposite surfaces thereof The piezoelectric elements 15 may be of any suitable configuration, shape and distribution. An intermediate element 18, formed of a material, such as polyurethane, which has acoustic impedance similar to that of soft mammalian tissue, generally fills the curvature defined by phased array 14 and defines a contact surface 20 for engagement with the body, typically via a suitable coupling gel (not shown), Contact surface 20 may be planar, but need not be.

[0020] Suitably modulated AC electrical power is supplied by conductors 22 to conductive coatings 16 to cause the piezoelectric elements 15 to provide a desired focused acoustic energy output.

[0021] In accordance with a preferred embodiment of the present invention an imaging ultrasonic transducer subassembly 23 is incorporated within transducer 10 and typically comprises a piezoelectric element 24 having conductive surfaces 26 associated with opposite surfaces thereof. Suitably modulated AC electrical power is supplied by conductors 32 to conductive surfaces 26 in order to cause the piezoelectric element 24 to provide an acoustic energy output. Conductors 32, coupled to surfaces 26, also provide an imaging output from imaging ultrasonic transducer subassembly 23.

[0022] It is appreciated that any suitable commercially available ultrasonic transducer may be employed or alternatively, imaging ultrasonic transducer subassembly 23 may be eliminated.

[0023] It is further appreciated that various types of ultrasonic transducers 10 may be employed. For example, such transducers may include multiple piezoelectric elements, multilayered piezoelectric elements and piezoelectric elements of various shapes and sizes arranged in a phase array.

[0024] In a preferred embodiment of the present invention shown in Fig. 1, the ultrasonic energy generator and director are combined in transducer 10. Alternatively, the functions of generating ultrasonic energy and focusing such energy may be provided by distinct devices.

[0025] In accordance with a preferred embodiment of the present invention, a skin temperature sensor 34, such as an infrared sensor, may be mounted alongside imaging ultrasonic transducer subassembly 23. Further in accordance with a preferred embodiment of the present invention a transducer temperature sensor 36, such as a thermocouple, may also be mounted alongside imaging ultrasonic transducer subassembly 23.

[0026] Ultrasonic transducer 10 preferably receives suitably modulated electrical power from a power source and modulator assembly 40, forming part of a control subsystem 42. Control subsystem 42 also typically includes a lipolysis control computer 44, having associated therewith a camera 46, such as a video camera, and a display 48. A preferred embodiment of power source and modulator assembly 40 is illustrated in Fig. 2 and described hereinbelow. Ultrasonic transducer 10 is preferably positioned automatically or semi-automatically as by an X-Y-Z positioning assembly 49. Alternatively, ultrasonic transducer 10 may be positioned at desired positions by an operator.

[0027] In accordance with a preferred embodiment of the present invention, camera 46 is operative for imaging a portion of the body on which lipolysis is to be performed. A picture of the portion of the patient's body viewed by the camera is preferably displayed in real time on display 48.

[0028] An operator may designate the outline of a region containing adipose tissue. In accordance with one embodiment of the present invention, designation of this region is effected by an operator marking the skin of a patient with an outline 50, which outline is imaged by camera 46 and displayed by display 48 and is also employed by the lipolysis control computer 44 for controlling the application of ultrasonic energy to locations within the region. A computer calculated representation of the outline may also be displayed on display 48, as designated by reference numeral 52. Alternatively, the operator may make a virtual marking on the skin, such as by using a digitizer (not shown), which also may provide computer calculated outline representation 52 on display 48.

[0029] In addition to the outline representation 52, the functionality of the system of the present invention preferably also employs a plurality of markers 54 which are typically located outside the region containing adipose tissue, but may be located inside the region designated by outline 50. Markers 54 are visually sensible markers, which are clearly seen by camera 46, captured by camera 46 and displayed on display 48. Markers 54 may be natural anatomic markers, such as distinct portions of the body or alternatively artificial markers such as colored stickers. These markers are preferably employed to assist the system in dealing with deformation of the region nominally defined by outline 50 due to movement and reorientation of the body. Preferably, the transducer 10 also bears a visible marker 56 which is also captured by camera 46 and displayed on display 48.

[0030] Markers 54 and 56 are typically processed by computer 44 and may be displayed on display 48 as respective computed marker representations 58 and 60 on display 48.

[0031] Fig. 1 illustrates the transducer 10 being positioned on the body over a location within the region containing adipose tissue. Blocks designated by reference numerals 62 and 64 show typical portions of a region containing adipose tissue, respectively before and after lipolysis in accordance with a preferred embodiment of the invention. It is seen from a comparison of blocks 62 and 64 that, in accordance with a preferred embodiment of the present invention, within the region containing adipose tissue, the adipose tissue, designated by reference numeral 66, is lysed, while non-adipose tissue, such as connective tissue, designated by reference numeral 68, is not lysed.

[0032] Reference is now Fig. 2, which is a simplified block diagram illustration of a preferred power source and modulator assembly 40 (Fig. 1), showing a pattern of variation of ultrasonic pressure over time in accordance with a preferred embodiment of the present invention. As seen in Fig. 2, the power source and modulator assembly 40 preferably comprises a signal generator 100 which provides a time varying signal which is modulated so as to have a series of relatively high amplitude portions 102 separated in time by a series of typically relatively low amplitude portions 104. Each relatively high amplitude portion 102 preferably corresponds to a cavitation period and preferably has a decreasing amplitude over time.

[0033] Preferably the relationship between the time durations of portions 102 and portions 104 is such as to provide a duty cycle between 1:5 and 1:30 and preferably between 1:10 and 1:20.

[0034] Preferably, the output of signal generator 100 has a frequency in a range of 100 KHz - 500 KHz and preferably in a range of 150 KHz - 300 KHz.

[0035] The output of signal generator 100 is preferably provided to a suitable power amplifier 106, which outputs via impedance matching circuitry 108 to an input of ultrasonic transducer 10 (Fig. 1), which converts the electrical signal received thereby to a corresponding ultrasonic energy output. As seen in Fig. 2, the ultrasonic energy output comprises a time varying signal which is modulated correspondingly to the output of signal generator 100 so as to having a series of relatively high amplitude portions 112, corresponding to portions 102, separated in time by a series of typically relatively low amplitude portions 114, corresponding to portions 104.

[0036] Each relatively high amplitude portion 102 preferably corresponds to a cavitation period and has an amplitude at a target volume 12 (Fig. 1) in the body which exceeds a cavitation maintaining threshold 120 and preferably has a decreasing amplitude over time. At least an initial pulse of each relatively high amplitude portion 112 has an amplitude at the target volume 12, which also exceeds a cavitation initiation threshold 122.

[0037] Relatively low amplitude portions 114 have an amplitude which lies below both thresholds 120 and 122.

[0038] Preferably the relationship between the time durations of portions 112 and portions 114 is such as to provide a duty cycle between 1:5 and 1:30 and preferably between 1:10 and 1:20.

[0039] Preferably, the ultrasonic energy output of ultrasonic transducer 10 has a frequency in a range of 100 KHz - 500 KHz and preferably in a range of 150 KHz - 300 KHz.

[0040] Preferably, each high amplitude portion 112 is comprised of between 2 and 1000 sequential cycles at an amplitude above the cavitation maintaining threshold 120, more preferably between 25 and 500 sequential cycles at an amplitude above the cavitation maintaining threshold 120 and most preferably between 100 and 300 sequential cycles at an amplitude above the cavitation maintaining threshold 120.

[0041] Reference is now made to Figs. 3A and 3B, which are simplified pictorial illustrations of the appearance of an operator interface display during normal operation and faulty operation respectively. As seen in Fig. 3A, during normal operation, display 48 typically shows a plurality of target volumes 12 (Fig. 1) within a calculated target region 200, typically delimited by outline representation 52 (Fig. 1). Additionally, display 48 preferably provides one or more pre-programmed performance messages 202 and status messages 203.

[0042] It is seen the various target volumes 12 are shown with different shading in order to indicate their treatment status. For example, unshaded target volumes, here designated by reference numerals 204 have already experienced lipolysis. A blackened target volume 12, designated by reference numeral 205 is the target volume next in line for lipolysis. A partially shaded target volume 206 typically represents a target volume which has been insufficiently treated to achieve complete lipolysis, typically due to an insufficient treatment duration.

[0043] Other types of target volumes, such as those not to be treated due to insufficient presence of adipose tissue therein or for other reasons, may be designated by suitable colors or other designations, and are here indicated by reference numerals 208 and 210.

[0044] Typical performance messages 202 may include "CAVITATION IN PROCESS" and "FAT LYSED IN THIS VOLUME". Typical status messages 203 may include an indication of the power level, the operating frequency, the number of target volumes 12 within the calculated target region 200 and the number of target volumes 12 which remain to undergo lipolysis.

[0045] Display 48 also preferably includes an graphical cross sectional indication 212 derived from an ultrasonic image preferably provided by imaging ultrasonic transducer subassembly 23 (Fig. 1). Indication 212 preferably indicates various tissues in the body in cross section and shows the target volumes 12 in relation thereto. In accordance with a preferred embodiment of the present invention, indication 212 may also provide a visually sensible indication of cavitation within the target volume 12.

[0046] Turning to Fig. 3B, it is seen that during abnormal operation, display 48 provides pre-programmed warning messages 214.

[0047] Typical warning messages may include "BAD ACOUSTIC CONTACT", "TEMPERATURE TOO HIGH". The "TEMPERATURE TOO HIGH" message typically relates to the skin tissue, although it may alternatively or additionally relate to other tissue inside or outside of the target volume or in transducer 10 (Fig. 1).

[0048] Reference is now made to Fig. 4, which illustrates an ultrasonic lipolysis system constructed and operative in accordance with a preferred embodiment of the present invention. As described hereinabove with reference to Fig. 1 and as seen in Fig. 4, the ultrasonic lipolysis system comprises a lipolysis control computer 44, which outputs to a display 48. Lipolysis control computer 44 preferably receives inputs from video camera 46 (Fig. 1) and from a temperature measurement unit 300, which receives temperature threshold settings as well as inputs from skin temperature sensor 34 (Fig. 1) and transducer temperature sensor 36 (Fig. 1). Temperature measurement unit 300 preferably compares the outputs of both sensors 34 and 36 with appropriate threshold settings and provides an indication to lipolysis control computer 44 of exceedance of either threshold.

[0049] Lipolysis control computer 44 also preferably receives an input from an acoustic contact monitoring unit 302, which in turn preferably receives an input from a transducer electrical properties measurement unit 304. Transducer electrical properties measurement unit 304 preferably monitors the output of power source and modulator assembly 40 (Fig. 1) to ultrasonic therapeutic transducer 13.

[0050] An output of transducer electrical properties measurement unit 304 is preferably also supplied to a power meter 306, which provides an output to the lipolysis control computer 44 and a feedback output to power source and modulator assembly 40.

[0051] Lipolysis control computer 44 also preferably receives inputs from cavitation detection functionality 308, tissue layer identification functionality 310 and lysed adipose tissue identification functionality 312, all of which receive inputs from ultrasonic reflection analysis functionality 314. Ultrasonic reflection analysis functionality 314 receives ultrasonic imaging inputs from an ultrasonic imaging subsystem 316, which operates ultrasonic imaging transducer 23 (Fig. 1).

[0052] Lipolysis control computer 44 provides outputs to power source and modulator assembly 40, for operating ultrasonic therapeutic transducer 13, and to ultrasonic imaging subsystem 316, for operating ultrasonic imaging transducer 23. A positioning control unit 318 also receives an output from lipolysis control computer 44 for driving X-Y-Z positioning assembly 49 (Fig. 1) in order to correctly position transducer 10, which includes ultrasonic therapeutic transducer 13 and ultrasonic imaging transducer 23.

[0053] Reference is now made to Figs. 5A, 5B and 5C, which are together a simplified flowchart illustrating operator steps in carrying out lipolysis in accordance with a preferred embodiment of the present invention. As seen in Fig. 4A, initially an operator preferably draws an outline 50 (Fig. 1) on a patient's body. Preferably, the operator also adheres stereotactic markers 54 (Fig. 1) to the patient's body and places transducer 10, bearing marker 56, at a desired location within outline 50.

[0054] Camera 46 (Fig. 1) captures outline 50 and markers 54 and 56. Preferably, outline 50 and markers 54 and 56 are displayed on display 48 in real time. The output of camera 46 is also preferably supplied to a memory associated with lipolysis control computer 44 (Fig. 1).

[0055] A computerized tracking functionality preferably embodied in lipolysis control computer 44 preferably employs the output of camera 46 for computing outline representation 52, which may be displayed for the operator on display 48. The computerized tracking functionality also preferably computes coordinates of target volumes for lipolysis treatment, as well as adding up the total volume of tissue sought to undergo lipolysis.

[0056] Preferably, the operator confirms the locations of markers 54 and 56 on display 48 and the computerized tracking functionality calculates corresponding marker representations 58 and 60.

[0057] In accordance with a preferred embodiment of the present invention the computerized tracking functionality employs markers 54 and marker representations 58 for continuously maintaining registration of outline 50 with respect to outline representation 52, and thus of target volumes 12 with respect to the patient's body, notwithstanding movements of the patients body during treatment, such as due to breathing or any other movements, such as the patient leaving and returning to the treatment location.

[0058] The computerized tracking functionality selects an initial target volume to be treated and positioning control unit 318 (Fig. 4), computes the required repositioning of transducer 10. X-Y-Z positioning assembly 49 repositions transducer 10 to overlie the selected target volume.

[0059] Referring additionally to Fig. 5B, it is seen that following repositioning of transducer 10, the lipolysis control computer 44 confirms accurate positioning of transducer 10 with respect to the selected target volume. The ultrasonic imaging subsystem 316 (Fig. 4) operates ultrasonic imaging transducer 23, causing it to provide an ultrasonic reflection analysis functionality 314 for analysis.

[0060] Based on an output from ultrasonic reflection analysis functionality 314, the thicknesses of the various tissue layers of the patient are determined. Upon receiving an indication of the tissue layer thicknesses, an operator may approve the selected target volume and activates the power source and modulator assembly 40 (Fig. 1).

[0061] Turning additionally to Fig. 5C, it is seen that the following functionalities take place:

[0062] Transducer electrical properties measurement unit 304 provides an output to acoustic contact monitoring unit 302, which determines whether sufficient acoustic contact with the patient is present, preferably by analyzing the current and voltage at therapeutic transducer 13.

[0063] Transducer electrical properties measurement unit 304 provides an output to power meter 306, which computes the average electrical power received by the therapeutic transducer 13. If the average electrical power received by the therapeutic transducer 13 exceeds a predetermined threshold, operation of the power source and modulator assembly 40 may be automatically terminated.

[0064] Skin temperature sensor 34 measures the current temperature of the skin at transducer 10 and supplies it to temperature measurement unit 300, which compares the skin temperature to the threshold temperature. Similarly, transducer temperature sensor 36 measures the current temperature at transducer 10 and supplies it to temperature measurement unit 300, which compares the transducer temperature to the threshold temperature. The outputs of temperature measurement unit 300 are supplied to lipolysis control computer 44.

[0065] The ultrasonic imaging subsystem 316 operates ultrasonic imaging transducer 23 and receives an imaging output, which is analyzed by ultrasonic reflection analysis functionality 314. The result of this analysis is employed for cavitation detection and a cavitation detection output is supplied to lipolysis control computer 44.

[0066] Should any of the following four conditions occur, the power source and modulator assembly 40 automatically terminates operation of therapeutic transducer 13. Should none of the following conditions occur, the automatic operation of power source and modulator assembly 40 continues:

1. Acoustic contact is insufficient.
2. Skin temperature exceeds threshold temperature level.
3. Transducer 13 temperature exceeds threshold temperature level.
4. Cavitation is not detected.

[0067] Returning to Fig. 5B, it is noted that during automatic operation of power source and modulator assembly 40, video camera 46 preferably records the target region and notes whether the transducer 10 remained stationary during the entire treatment duration of the selected target volume 12. If so, and if none of the aforesaid four conditions took place, lipolysis control computer 44 confirms that the selected target volume was treated. The computerized tracking functionality of lipolysis control computer 44 then proposes a further target volume 12 to be treated.

[0068] If, however, the transducer 10 did not remain stationary for a sufficient duration, the selected target volume is designated by lipolysis control computer 44 as having been insufficiently treated.

[0069] It is appreciated that by using multiple transducers multiplicity of target volumes can be treated at various time patterns such as sequential time patterns or partially overlapping time patterns.

[0070] It is also appreciated that the multiplicity of target volumes may also overlap in space or partially overlap in space.

[0071] It is appreciated that the software components of the present invention may, if desired, be implemented in ROM (read-only memory) form. The software components may, generally, be implemented in hardware, if desired, using conventional techniques.

[0072] It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined by the claims.

Claims

1. Apparatus for lysing adipose tissue comprising:

> a source (10,13) outside a body generating ultrasonic energy;
> and comprising
> a modulator (40) that modulates the ultrasonic energy so that it has a duty cycle between 1:5 and 1:30.
> an ultrasonic energy director (14), which directs said modulated ultrasonic energy to selectively lyse adipose tissue and not lyse non-adipose tissue in a target volume (12) of the body containing the adipose tissue.

2. Apparatus for lysing .adipose tissue according to claim 1 and also comprising:

> an ultrasonic imager (23), providing ultrasonic imaging of said region at least partially concurrently with directing said modulated ultrasonic energy at said target volume (12).

3. Apparatus for lysing adipose tissue according to claim 1 or 2 and wherein said director varies the focus of at least one ultrasonic transducer in order to direct said modulated ultrasonic energy at said target volume.

4. Apparatus for lysing adipose tissue according to any of claims 1 to 3 and also comprising a sensor (302), sensing ultrasonic energy coupling to an external surface of said body adjacent said target volume.

5. Apparatus for lysing adipose tissue according to any of claims 1 to 3 and also comprising a sensor (308) sensing of cavitation at said target volume.

6. Apparatus according to any of claims 1 to 5 and wherein said ultrasonic energy has a frequency in a range of 100 KHz-500 KHz.

7. Apparatus according to any of claims 1-6 wherein said modulator provides between 2 and 1000 sequential cycles at an amplitude above a cavitation threshold.

8. Apparatus for lysing adipose tissue according to any preceding claim and also comprising computerized tracking functionality (44) providing computerized tracking of said target volume notwithstanding movement of said body.

9. Apparatus for lysing adipose tissue according to claim 8 and wherein said computerized tracking functionality is operative to sense changes in the position of markings (50) on said body and to employ sensed changes for tracking the position of said target volume in said body.

Patentansprüche

1. Vorrichtung zum Lysieren von Fettgewebe, die Folgendes umfasst:

eine Quelle (10, 13) außerhalb eines Körpers, die Ultraschallenergie erzeugt;
und Folgendes umfasst:

einen Modulator (40), der die Ultraschallenergie so moduliert, dass sich ein Arbeitszyklus zwischen 1:5 und 1:30 ergibt,
einen Ultraschallenergielenker (14), der die genannte modulierte Ultraschallenergie so lenkt, dass selektiv Fettgewebe lysiert und Nichtfettgewebe in einem Zielvolumen (12) des Körpers, der das Fettgewebe enthält, nicht lysiert wird.

2. Vorrichtung zum Lysieren von Fettgewebe nach Anspruch 1, die außerdem Folgendes umfasst: einen Ultraschallbilderzeuger (23) zum Erzeugen eines Ultraschallbildes der genannten Region wenigstens teilweise gleichzeitig mit der Lenkung der genannten modulierten Ultraschallenergie auf das genannte Zielvolumen (12).

3. Vorrichtung zum Lysieren von Fettgewebe nach Anspruch 1 oder 2, wobei der genannte Lenker den Fokus von wenigstens einem Ultraschallwandler variiert, um die genannte modulierte Ultraschallenergie auf das genannte Zielvolumen zu lenken.

4. Vorrichtung zum Lysieren von Fettgewebe nach einem der Ansprüche 1 bis 3, die außerdem einen Sensor (302) umfasst, der Ultraschallenergie erfasst, die an eine Außenfläche des genannten Körpers neben dem genannten Zielvolumen ankoppelt.

5. Vorrichtung zum Lysieren von Fettgewebe nach einem der Ansprüche 1 bis 3, die außerdem einen Sensor (308) umfasst, der Kavitation an dem genannten Zielvolumen erfasst.

6. Vorrichtung nach einem der Ansprüche 1 bis 5, wobei die genannte Ultraschallenergie eine Frequenz im Bereich von 100 KHz - 500 KHz hat.

7. Vorrichtung nach einem der Ansprüche 1 bis 6, wobei der genannte Modulator zwischen 2 und 1000 sequentielle Zyklen in einer Amplitude über einer Kavitationsschwelle bereitstellt.

8. Vorrichtung zum Lysieren von Fettgewebe nach einem der vorherigen Ansprüche, die außerdem computerisierte Verfolgungsfunktionalität (44) umfasst, die eine computerisierte Verfolgung des genannten Zielvolumens ungeachtet einer Bewegung des genannten Körpers erbringt.

9. Vorrichtung zum Lysieren von Fettgewebe nach Anspruch 8, wobei die genannte computerisierte Verfolgungsfunktionalität Veränderungen der Position von Markierungen (50) auf dem genannten Körper erfasst und erfasste Veränderungen zum Verfolgen der Position des genannten Zielvolumens in dem genannten Körper verwendet.

Revendications

1. Appareil pour lyser du tissu adipeux comprenant :

une source (10, 13) en dehors d'un corps générant de l'énergie ultrasonique ;
et comprenant
un modulateur (40) qui module l'énergie ultrasonique de sorte qu'elle possède un facteur d'utilisation compris entre 1/5 et 1/30,
une sonde cannelée d'énergie ultrasonique (14) qui dirige ladite énergie ultrasonique modulée pour lyser sélectivement du tissu adipeux et ne pas lyser du tissu non adipeux dans un volume cible (12) du corps contenant le tissu adipeux.

2. Appareil pour lyser du tissu adipeux selon la revendication 1 et comprenant également :

un système imageur ultrasonique (23) fournissant l'imagerie ultrasonique de ladite région au moins partiellement en même temps que la direction de ladite énergie ultrasonique modulée au niveau dudit volume cible (12).

3. Appareil pour lyser du tissu adipeux selon la revendication 1 ou 2 et dans lequel ladite sonde cannelée fait varier le foyer d'au moins un transducteur ultrasonique afin de diriger ladite énergie ultrasonique modulée au niveau dudit volume cible.

4. Appareil pour lyser du tissu adipeux selon l'une quelconque des revendications 1 à 3 et comprenant également un capteur (302) détectant de l'énergie ultrasonique s'accouplant à une surface externe dudit corps adjacent audit volume cible.

5. Appareil pour lyser du tissu adipeux selon l'une quelconque des revendications 1 à 3 et comprenant également un capteur (308) détectant la cavitation acoustique au niveau dudit volume cible.

6. Appareil selon l'une quelconque des revendications 1 à 5 et dans lequel ladite énergie ultrasonique possède une fréquence dans la plage de 100 KHz à 500 KHz.

7. Appareil selon l'une quelconque des revendications 1 à 6, dans lequel ledit modulateur fournit entre 2 et 1000 cycles séquentiels à une amplitude au-dessus d'un seuil de cavitation acoustique.

8. Appareil pour lyser du tissu adipeux selon l'une quelconque des revendications précédentes et comprenant également une fonctionnalité de traçage informatisé (44) fournissant le traçage informatisé dudit volume cible nonobstant le mouvement dudit corps.

9. Appareil pour lyser du tissu adipeux selon la revendication 8 et dans lequel ladite fonctionnalité de traçage informatisé est opérationnelle pour détecter des changements de la position de marques (50) sur ledit corps et pour employer les changements détectés pour tracer la position dudit volume cible dans ledit corps.

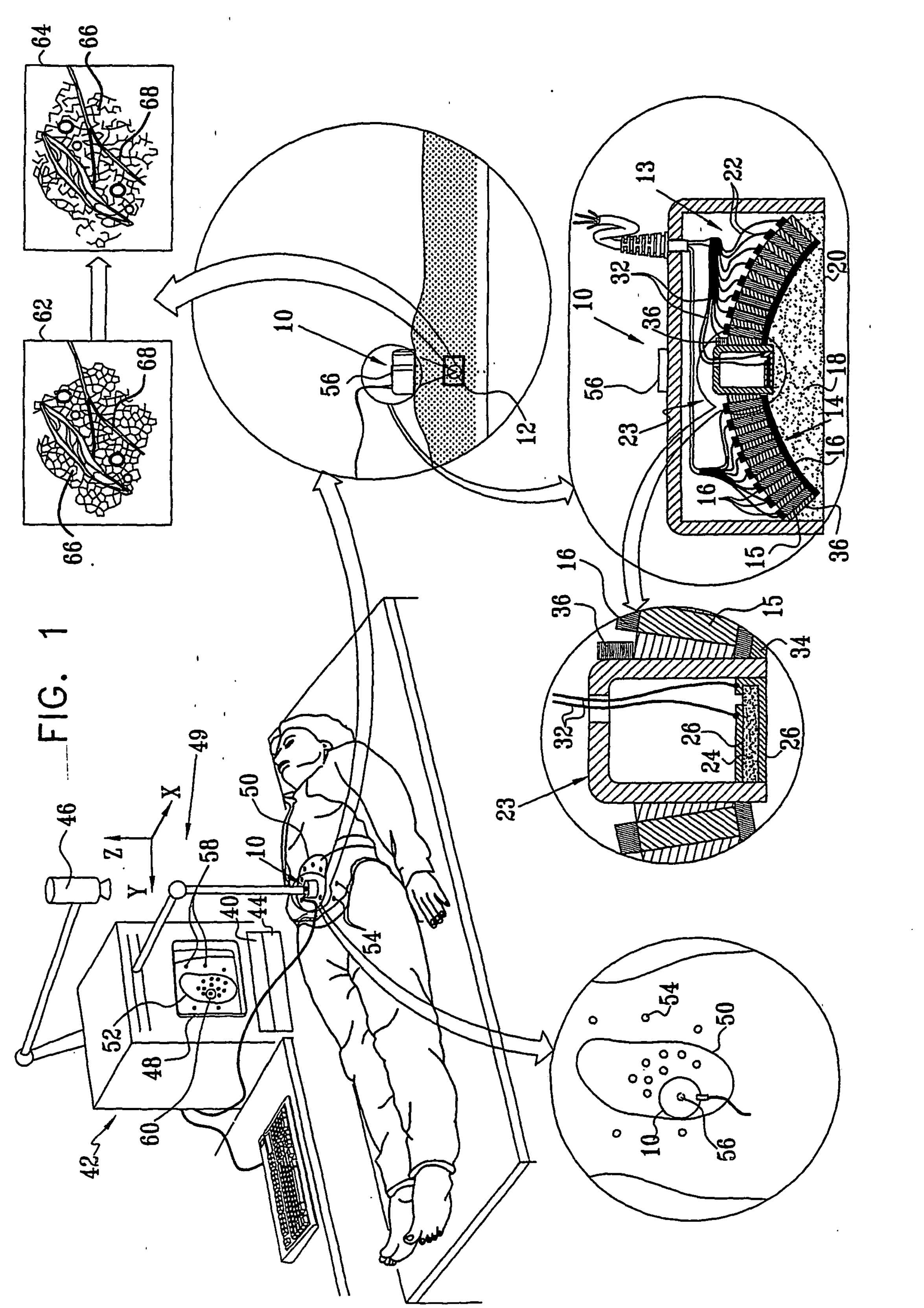

64
66
68
62
10
56
12
13
22
32
36
20
18
14
16
23
15
34
26
24
46
Z
Y
X
49
50
58
40
44
54
52
48
60
42

FIG. 1

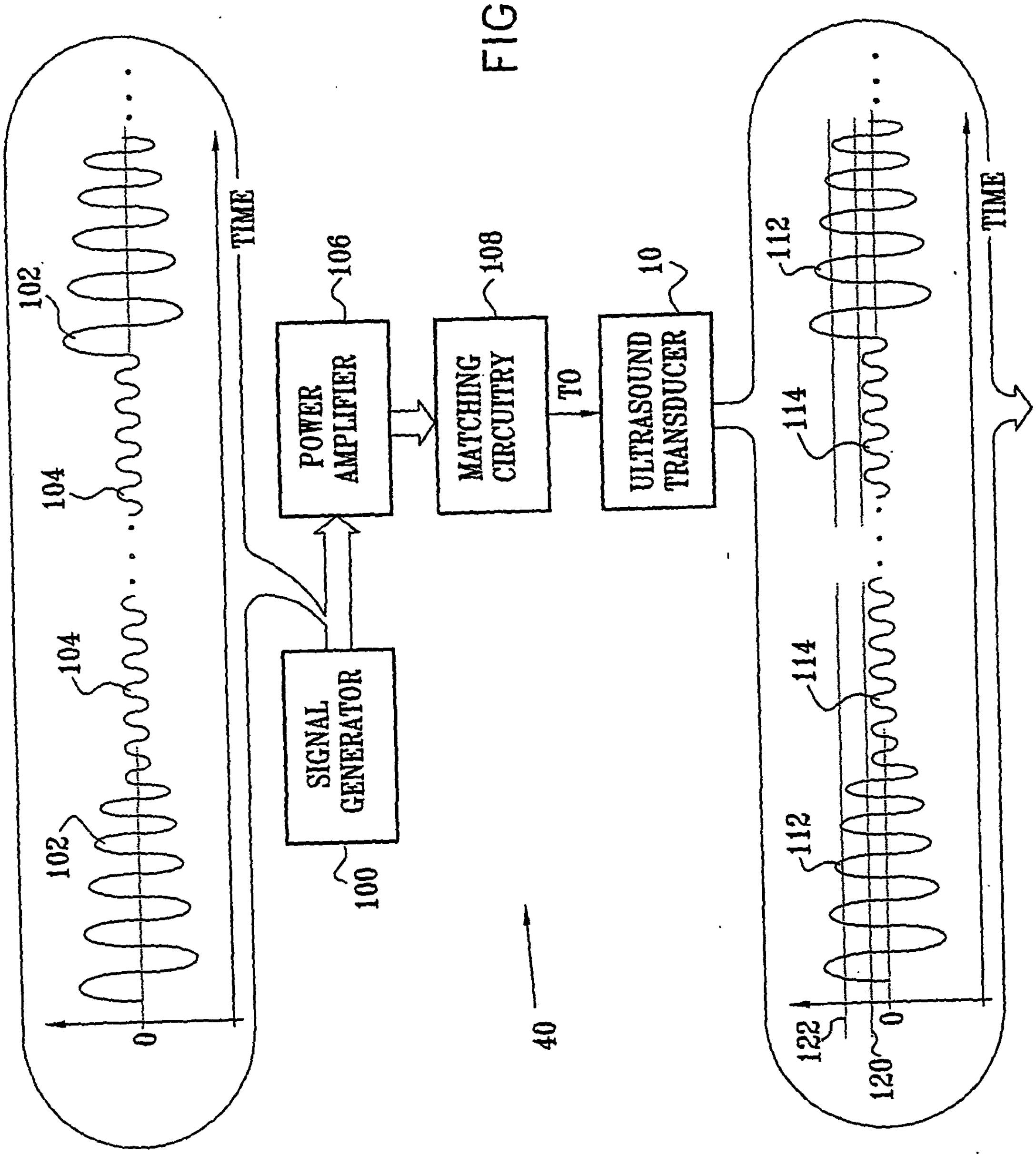

SIGNAL GENERATOR
POWER AMPLIFIER
MATCHING CIRCUITRY
TO
ULTRASOUND TRANSDUCER
TIME
TIME
0
0
100
102
104
106
108
10
112
114
120
122
40

FIG. 2

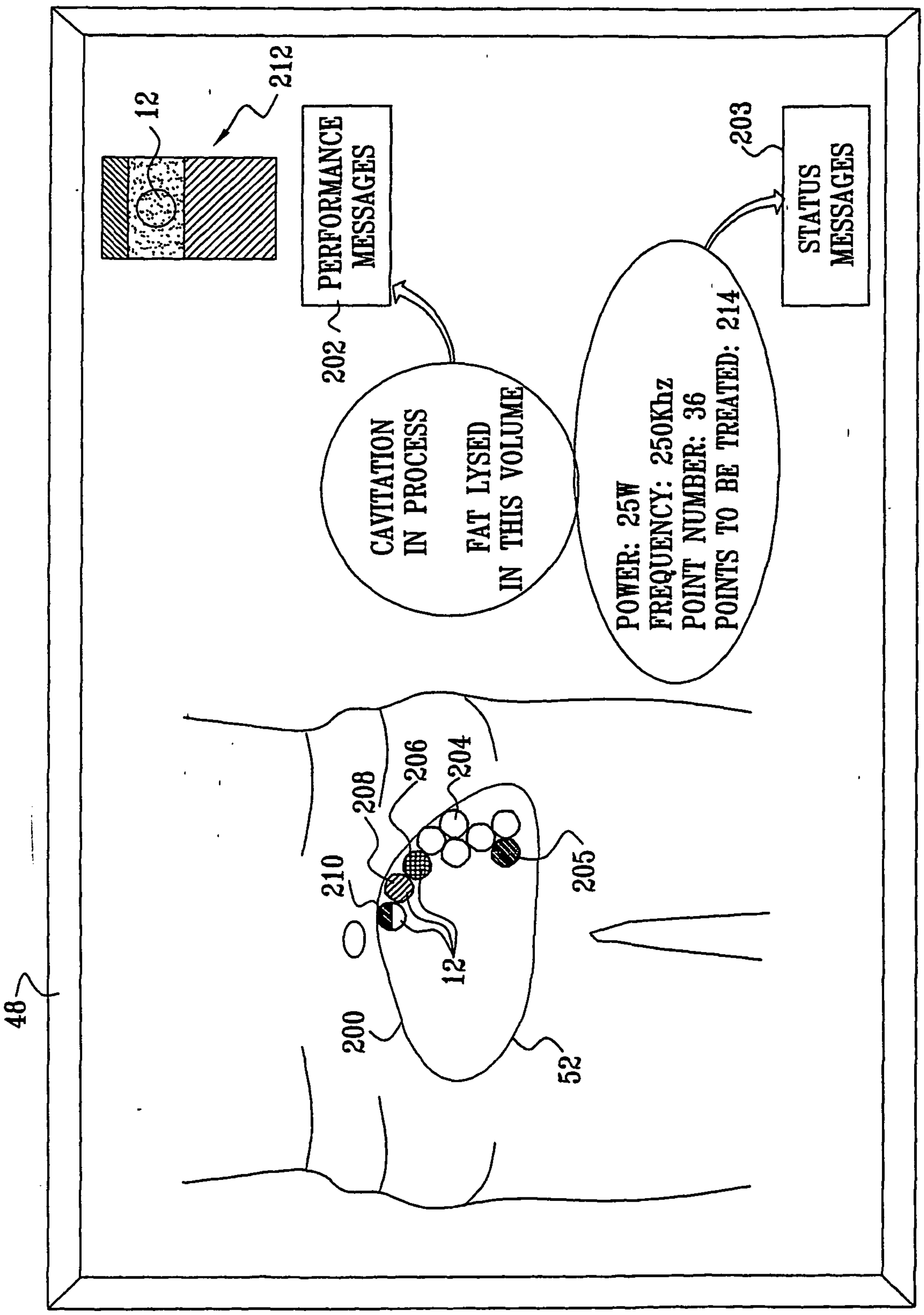

48
12
212
PERFORMANCE MESSAGES
202
CAVITATION IN PROCESS
FAT LYSED IN THIS VOLUME
203
STATUS MESSAGES
POWER: 25W
FREQUENCY: 250Khz
POINT NUMBER: 36
POINTS TO BE TREATED: 214
210
208
206
204
205
12
200
52

FIG. 3A

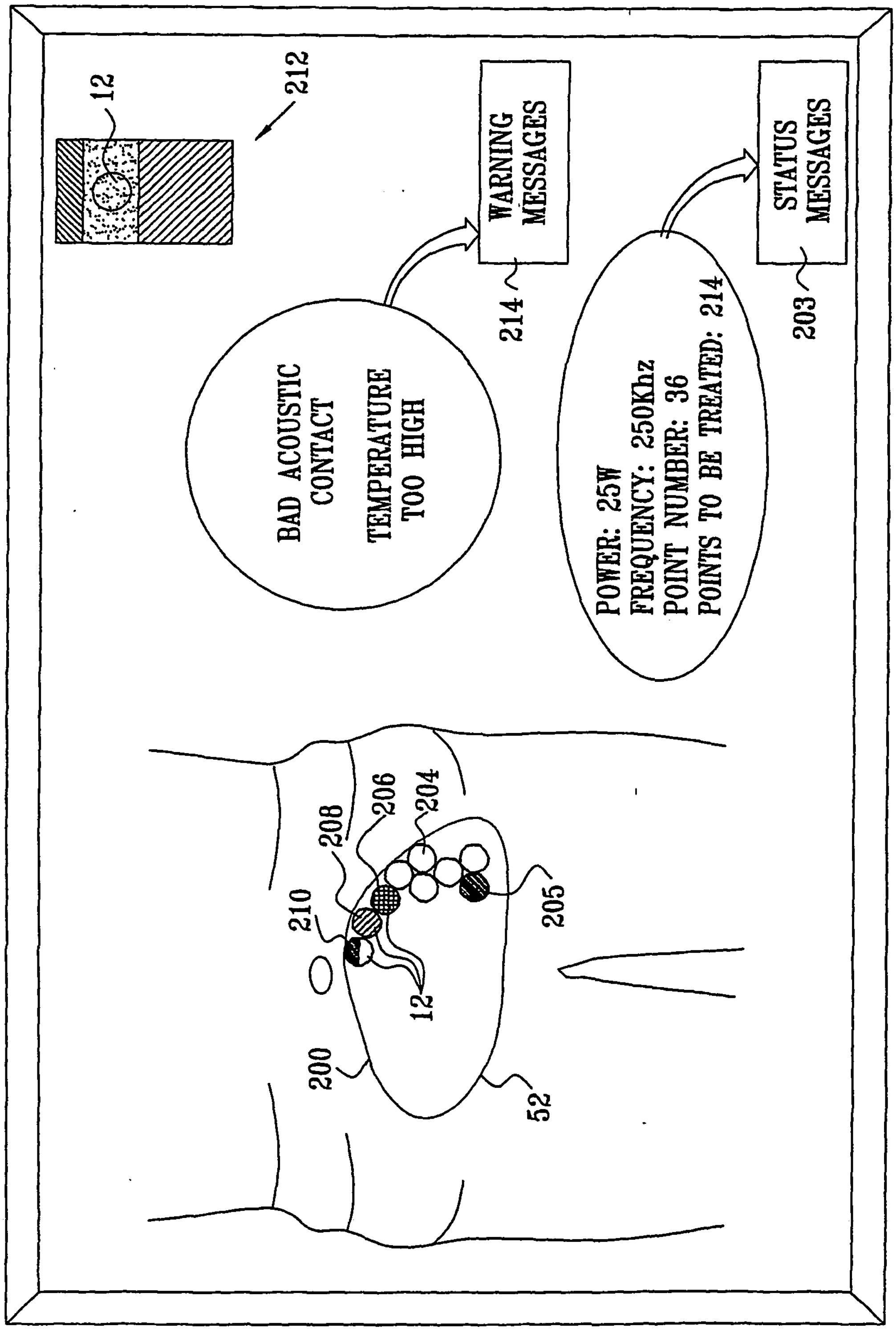

12
212
WARNING MESSAGES
214
BAD ACOUSTIC CONTACT
TEMPERATURE TOO HIGH
STATUS MESSAGES
203
POWER: 25W
FREQUENCY: 250Khz
POINT NUMBER: 36
POINTS TO BE TREATED: 214
208
206
204
210
205
12
200
52

FIG. 3B

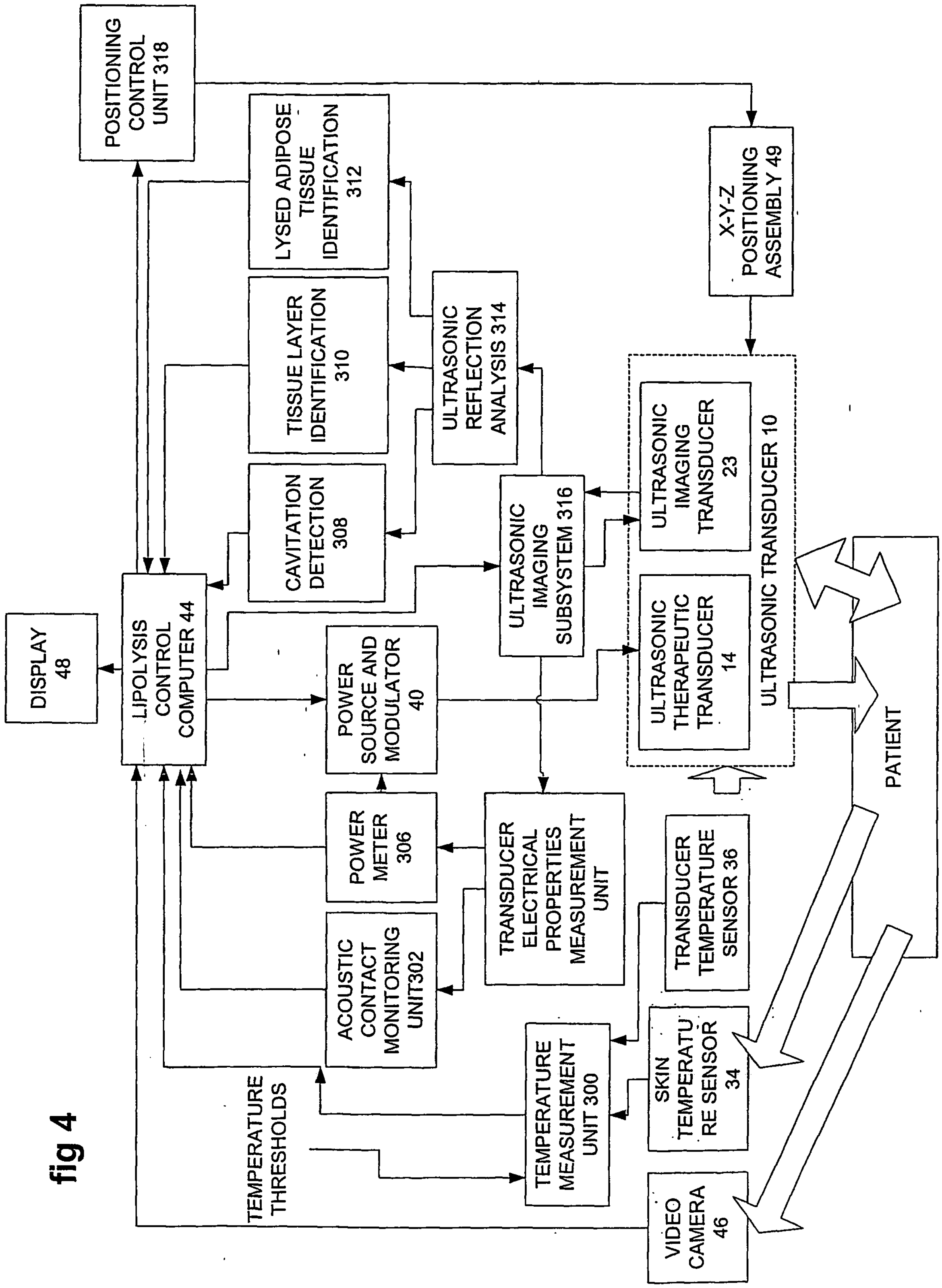
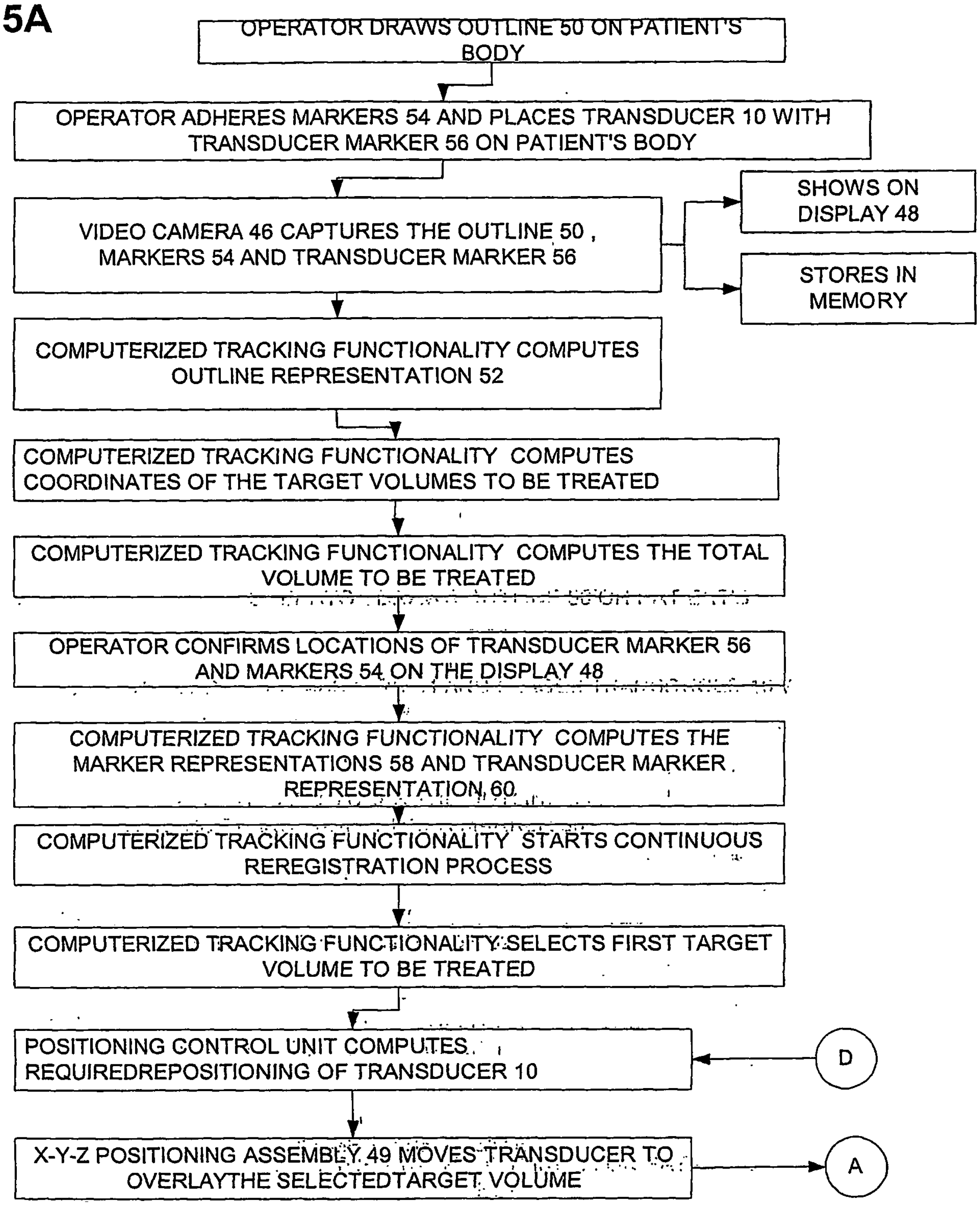

POSITIONING CONTROL UNIT 318
LYSED ADIPOSE TISSUE IDENTIFICATION 312
X-Y-Z POSITIONING ASSEMBLY 49
TISSUE LAYER IDENTIFICATION 310
ULTRASONIC REFLECTION ANALYSIS 314
CAVITATION DETECTION 308
ULTRASONIC IMAGING SUBSYSTEM 316
ULTRASONIC IMAGING TRANSDUCER 23
ULTRASONIC THERAPEUTIC TRANSDUCER 14
ULTRASONIC TRANSDUCER 10
DISPLAY 48
LIPOLYSIS CONTROL COMPUTER 44
POWER SOURCE AND MODULATOR 40
POWER METER 306
TRANSDUCER ELECTRICAL PROPERTIES MEASUREMENT UNIT
ACOUSTIC CONTACT MONITORING UNIT302
TRANSDUCER TEMPERATURE SENSOR 36
PATIENT
SKIN TEMPERATURE SENSOR 34
TEMPERATURE MEASUREMENT UNIT 300
TEMPERATURE THRESHOLDS
VIDEO CAMERA 46

fig 4

fig 5A


OPERATOR DRAWS OUTLINE 50 ON PATIENT'S BODY
OPERATOR ADHERES MARKERS 54 AND PLACES TRANSDUCER 10 WITH TRANSDUCER MARKER 56 ON PATIENT'S BODY
VIDEO CAMERA 46 CAPTURES THE OUTLINE 50 , MARKERS 54 AND TRANSDUCER MARKER 56
SHOWS ON DISPLAY 48
STORES IN MEMORY
COMPUTERIZED TRACKING FUNCTIONALITY COMPUTES OUTLINE REPRESENTATION 52
COMPUTERIZED TRACKING FUNCTIONALITY COMPUTES COORDINATES OF THE TARGET VOLUMES TO BE TREATED
COMPUTERIZED TRACKING FUNCTIONALITY COMPUTES THE TOTAL VOLUME TO BE TREATED
OPERATOR CONFIRMS LOCATIONS OF TRANSDUCER MARKER 56 AND MARKERS 54 ON THE DISPLAY 48
COMPUTERIZED TRACKING FUNCTIONALITY COMPUTES THE MARKER REPRESENTATIONS 58 AND TRANSDUCER MARKER REPRESENTATION 60
COMPUTERIZED TRACKING FUNCTIONALITY STARTS CONTINUOUS REREGISTRATION PROCESS
COMPUTERIZED TRACKING FUNCTIONALITY SELECTS FIRST TARGET VOLUME TO BE TREATED
POSITIONING CONTROL UNIT COMPUTES REQUIREDREPOSITIONING OF TRANSDUCER 10
D
X-Y-Z POSITIONING ASSEMBLY 49 MOVES TRANSDUCER TO OVERLAYTHE SELECTEDTARGET VOLUME
A

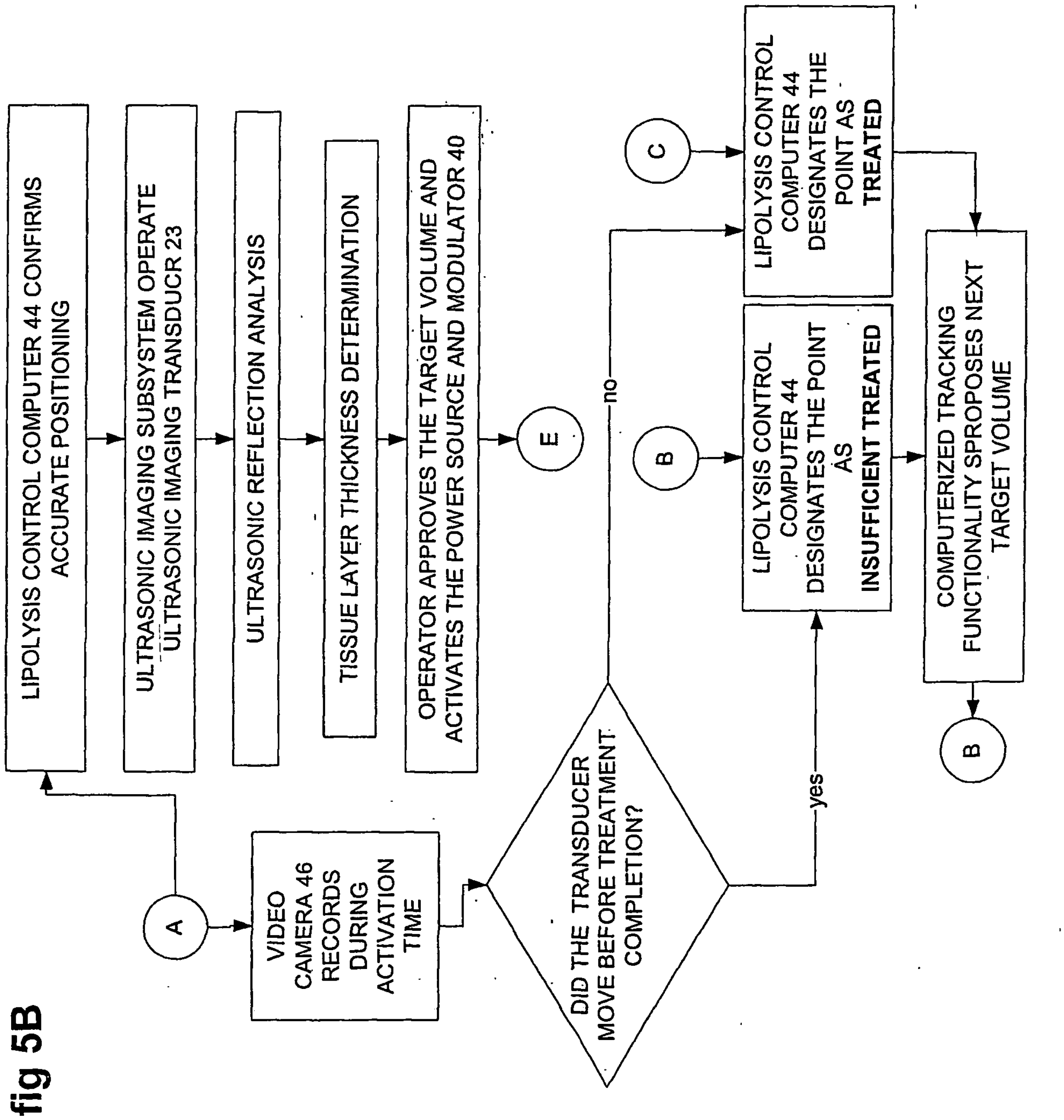

A
LIPOLYSIS CONTROL COMPUTER 44 CONFIRMS ACCURATE POSITIONING
ULTRASONIC IMAGING SUBSYSTEM OPERATE ULTRASONIC IMAGING TRANSDUCR 23
ULTRASONIC REFLECTION ANALYSIS
TISSUE LAYER THICKNESS DETERMINATION
OPERATOR APPROVES THE TARGET VOLUME AND ACTIVATES THE POWER SOURCE AND MODULATOR 40
E
VIDEO CAMERA 46 RECORDS DURING ACTIVATION TIME
DID THE TRANSDUCER MOVE BEFORE TREATMENT COMPLETION?
no
yes
C
LIPOLYSIS CONTROL COMPUTER 44 DESIGNATES THE POINT AS TREATED
B
LIPOLYSIS CONTROL COMPUTER 44 DESIGNATES THE POINT AS INSUFFICIENT TREATED
COMPUTERIZED TRACKING FUNCTIONALITY SPROPOSES NEXT TARGET VOLUME
B

fig 5B

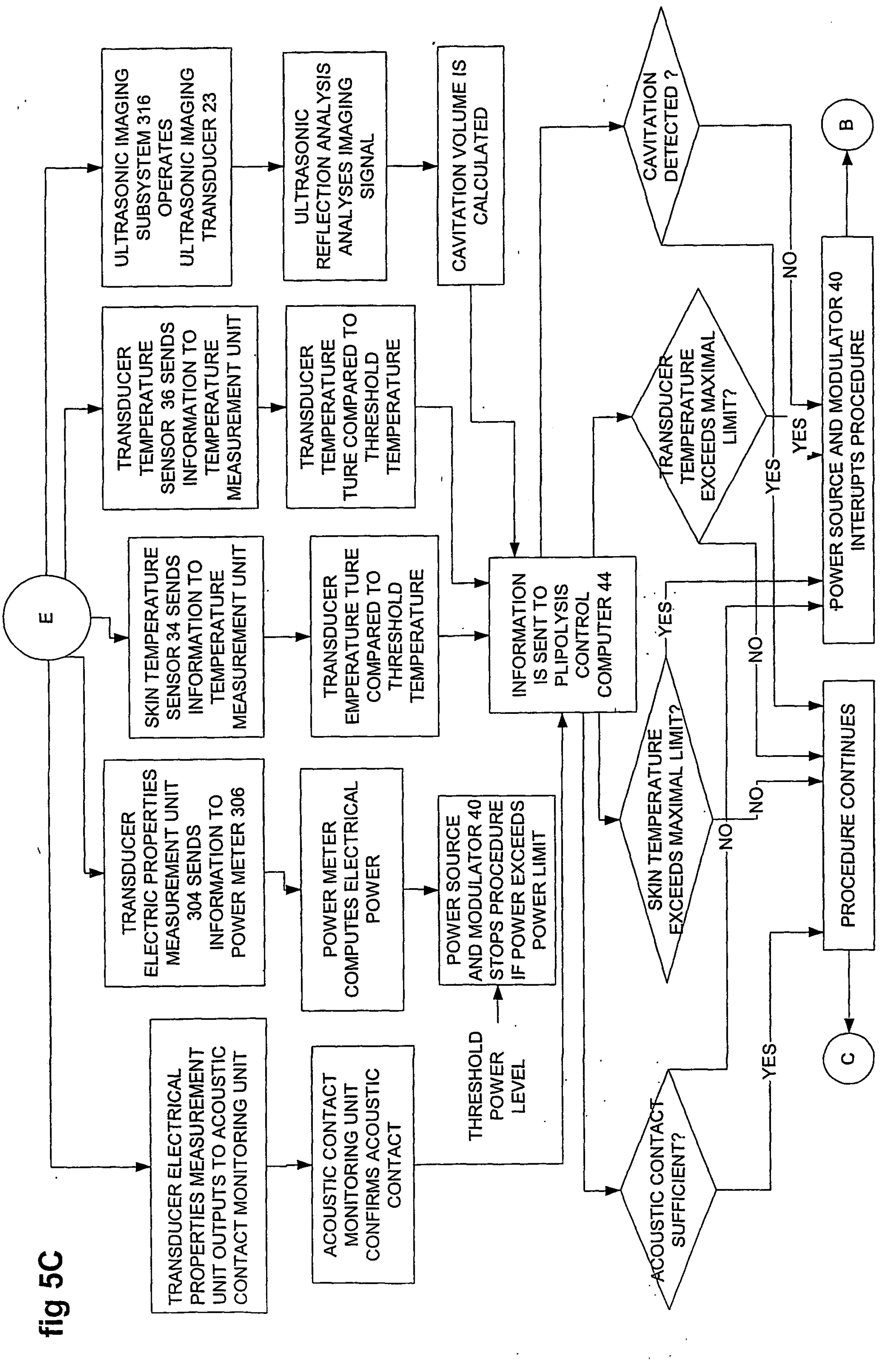

E
TRANSDUCER ELECTRICAL PROPERTIES MEASUREMENT UNIT OUTPUTS TO ACOUSTIC CONTACT MONITORING UNIT
ACOUSTIC CONTACT MONITORING UNIT CONFIRMS ACOUSTIC CONTACT
TRANSDUCER ELECTRIC PROPERTIES MEASUREMENT UNIT 304 SENDS INFORMATION TO POWER METER 306
POWER METER COMPUTES ELECTRICAL POWER
POWER SOURCE AND MODULATOR 40 STOPS PROCEDURE IF POWER EXCEEDS POWER LIMIT
THRESHOLD POWER LEVEL
SKIN TEMPERATURE SENSOR 34 SENDS INFORMATION TO TEMPERATURE MEASUREMENT UNIT
TRANSDUCER EMPERATURE TURE COMPARED TO THRESHOLD TEMPERATURE
TRANSDUCER TEMPERATURE SENSOR 36 SENDS INFORMATION TO TEMPERATURE MEASUREMENT UNIT
TRANSDUCER TEMPERATURE TURE COMPARED TO THRESHOLD TEMPERATURE
ULTRASONIC IMAGING SUBSYSTEM 316 OPERATES ULTRASONIC IMAGING TRANSDUCER 23
ULTRASONIC REFLECTION ANALYSIS ANALYSES IMAGING SIGNAL
CAVITATION VOLUME IS CALCULATED
INFORMATION IS SENT TO PLIPOLYSIS CONTROL COMPUTER 44
ACOUSTIC CONTACT SUFFICIENT?
SKIN TEMPERATURE EXCEEDS MAXIMAL LIMIT?
TRANSDUCER TEMPERATURE EXCEEDS MAXIMAL LIMIT?
CAVITATION DETECTED ?
YES
NO
PROCEDURE CONTINUES
POWER SOURCE AND MODULATOR 40 INTERUPTS PROCEDURE
C
B

fig 5C

REFERENCES CITED IN THE DESCRIPTION

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patsnap

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外部链接	Espacenet		

摘要(译)

用于裂解脂肪组织的方法和系统，包括在该区域内的多个目标体积处引导超声能量，该目标体积包含脂肪组织，从而选择性地裂解目标体积中的脂肪组织并且通常不溶解脂肪组织中的脂肪组织。目标体积和计算机化跟踪多个目标体积，尽管身体运动。