US 20070239076A1

(19) United States

(12) Patent Application Publication

ZIMMER

(10) Pub. No.: US 2007/0239076 A1

(43) Pub. Date: Oct. 11, 2007

(54) METHOD AND APPARATUS FOR INJECTING ULTRASOUND INTO TISSUE

(75) Inventor: Bernd ZIMMER, Neu-Ulm (DE)

Correspondence Address:
GREENBLUM & BERNSTEIN, P.L.C.
1950 ROLAND CLARKE PLACE
RESTON, VA 20191 (US)

(73) Assignee: ZIMMER ELEKTROMEDIZIN GMBH, Neu-Ulm (DE)

(21) Appl. No.: 11/558,119

(22) Filed: Nov. 9, 2006

(30) Foreign Application Priority Data

Nov. 11, 2005 (DE) 102005053918.1

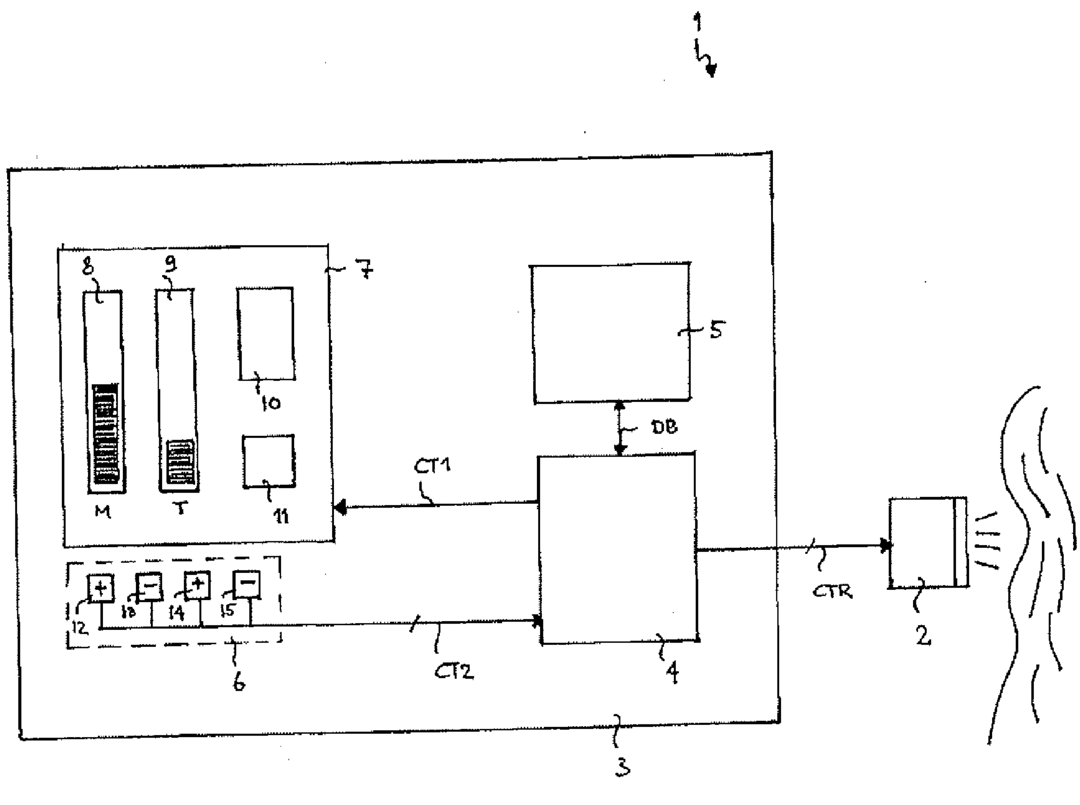
Publication Classification

(51) Int. Cl.
A61H 1/00 (2006.01)
A61B 8/00 (2006.01)

(52) U.S. Cl. 601/2; 600/439

(57) ABSTRACT

In a method for driving an injection device for injecting ultrasound into a tissue, the ultrasound has a predetermined thermal effect and a predetermined mechanical effect in the tissue. Ultrasound pulses are successively injected utilizing the injection device. Each ultrasound pulse comprises a pulse width and a duty ratio of the ultrasound pulses is set as a function of the thermal and mechanical effects of the ultrasound pulses.



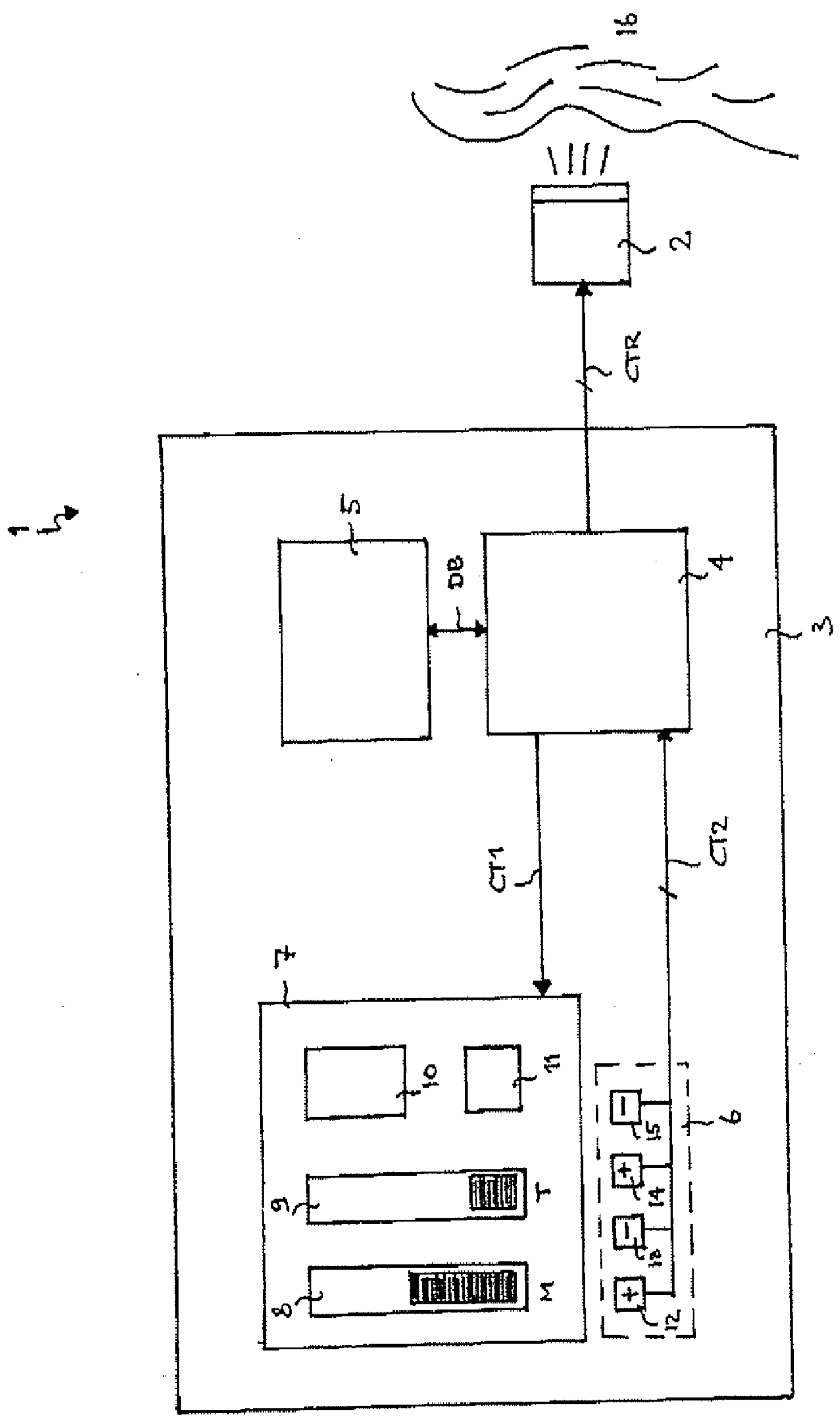


Figure 1

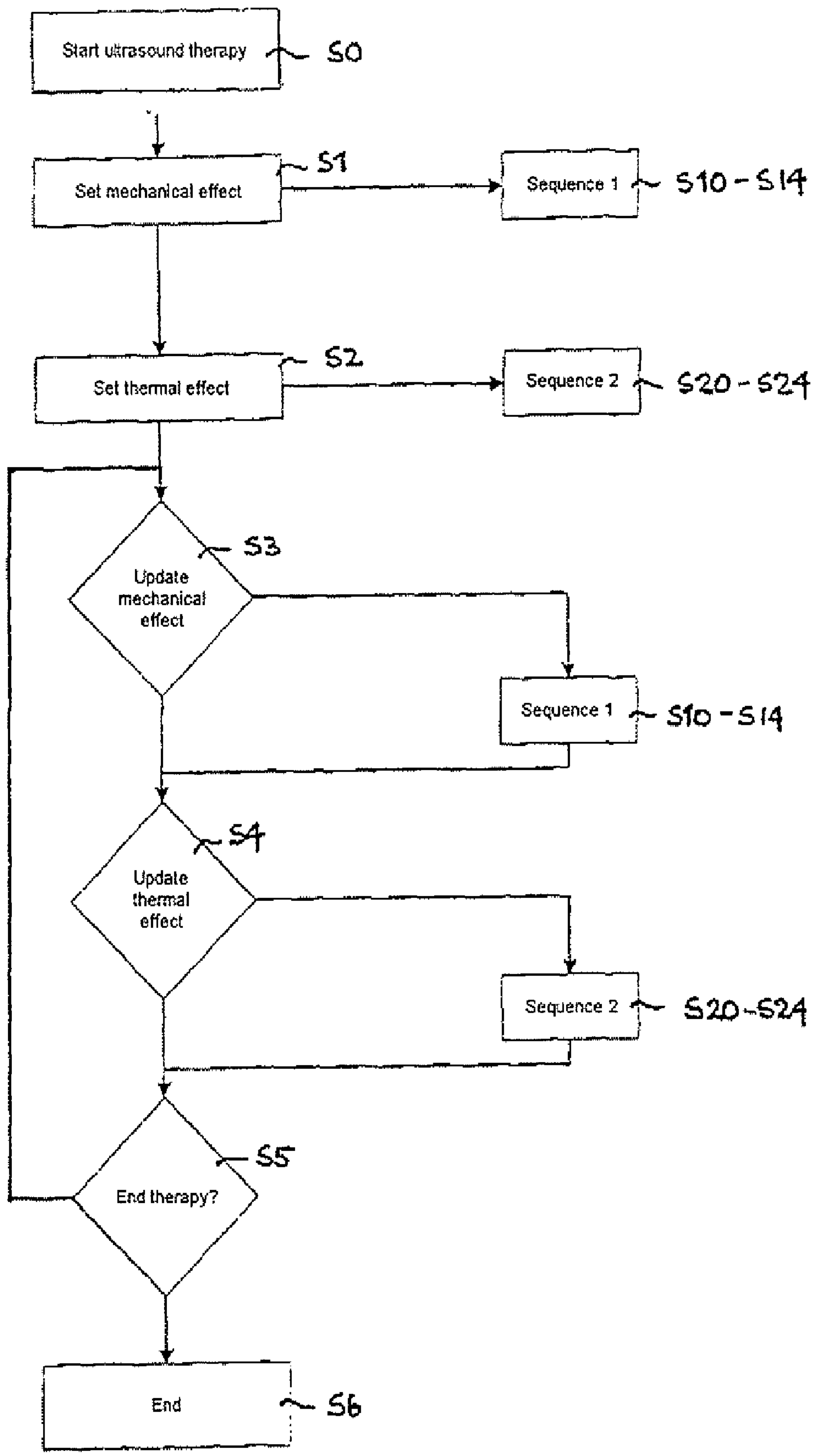

Start ultrasound therapy
S0
Set mechanical effect
S1
Sequence 1
S10 - S14
Set thermal effect
S2
Sequence 2
S20 - S24
Update mechanical effect
S3
Sequence 1
S10 - S14
Update thermal effect
S4
Sequence 2
S20-S24
End therapy?
S5
End
S6

Figure 3A

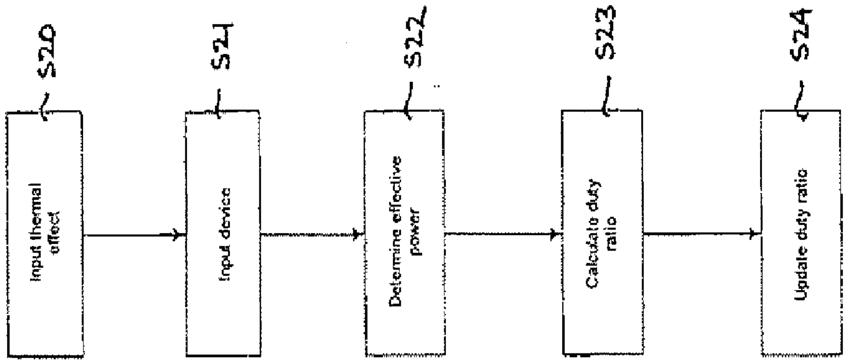


Figure 3C

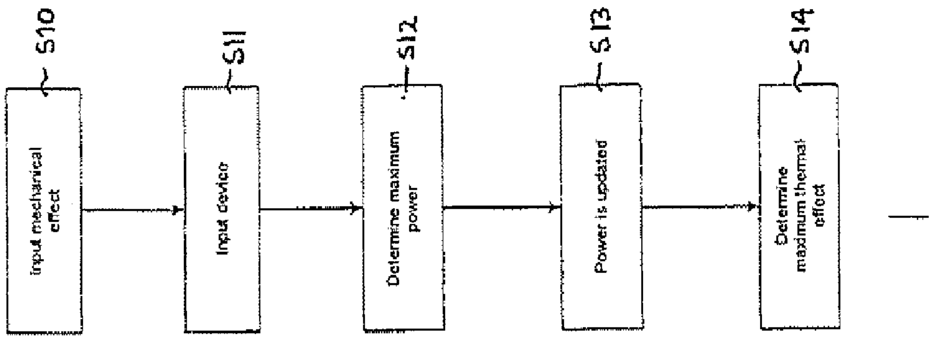


Figure 3B

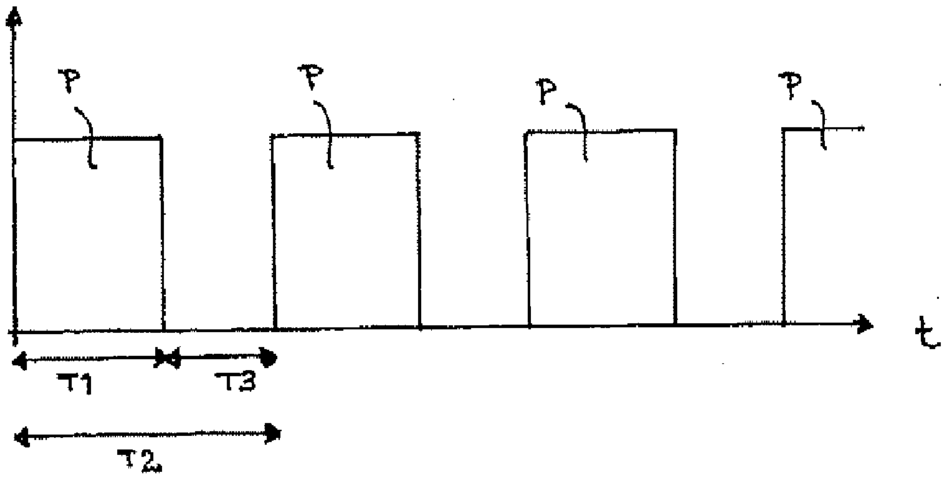


Figure 2

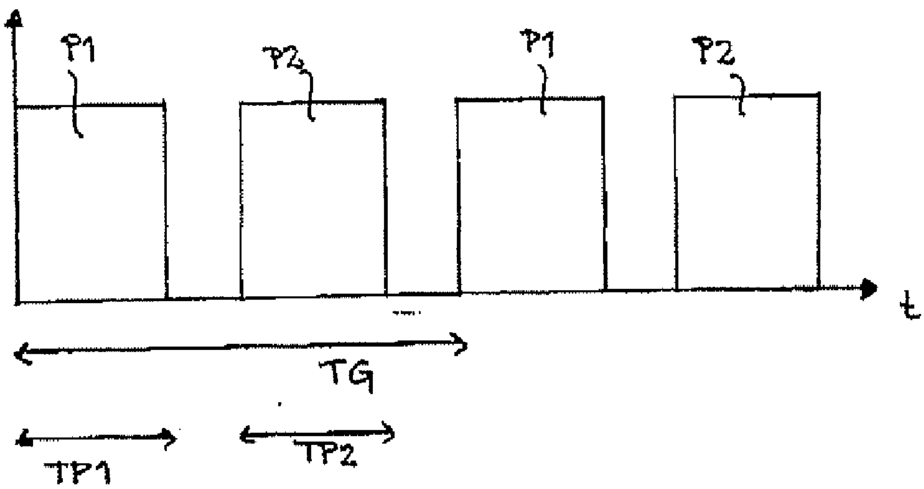


Figure 4

METHOD AND APPARATUS FOR INJECTING ULTRASOUND INTO TISSUE

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method and an apparatus for the injection of ultrasound into tissue parts to be treated, using ultrasound pulses.

[0002] In medical technology, ultrasound is used on the one hand as a diagnostic aid for imaging processes, and on the other hand is also used therapeutically. Ultrasound produces density waves in the tissue, which act as vibration and as heat. Ultrasound injection thus on the one hand achieves a mechanical effect which acts like micromassage in soft-tissue, and in the process, for example, stimulates the release of tissue hormones and influences the metabolism and muscle state. The stimulating effect of this mechanical component of therapeutic ultrasound can have a positive influence on tissue regeneration. The thermal component of the therapeutic ultrasound leads to tissue heating which is used, for example, during thermotherapy.

[0003] Therapeutic ultrasound is used both continuously and in pulse form. In the case of continuous injection, a suitable oscillation generator continuously produces ultrasound waves at a predetermined ultrasound frequency. In the case of pulsed ultrasound, pulses of ultrasound are produced. These pulses of ultrasound then have a pulse width or pulse length in the time domain, while the ultrasound is injected at the respective ultrasound frequency.

[0004] This is followed by a time interval with an injection pause, in which no injection whatsoever takes place. The number of such ultrasound pulses per unit time results in a pulse repetition frequency. The limit case of injection pauses turning to zero results in continuous ultrasound.

[0005] The therapeutic effect of the injected ultrasound in this case depends in particular on the selected ultrasound frequency, the duration of application, and also on the nature of the injected ultrasound pulses. By way of example, possible pulse parameters are the pulse width, the pulse length, the ultrasound frequency, the amplitude of the ultrasound and the pulse repetition frequency. The person carrying out the therapy has to in this case decide what power and in what signal form the therapeutic ultrasound must be used, and in some cases this is difficult to assess. Precise setting of the treatment depth in a tissue by ultrasound application is also frequently difficult.

[0006] Proposals have already been made in the past to inject ultrasound energy at different ultrasound frequencies from a plurality of ultrasound transmitters at the same time into a tissue that is to be treated. Published German application for patent No. 103 06 795 A1 discloses a corresponding ultrasound device in which a plurality of ultrasound beams at different frequencies act at a common focus area in the tissue at the same time. However, this results in the disadvantage of a high level of implementation complexity with a plurality of ultrasound sources and operation by the person carrying out the therapy, who must himself define a large number of parameters, such as the frequency, pulse lengths and injection power.

BRIEF DESCRIPTION OF THE INVENTION

[0007] One object of the present invention is thus to provide a method for the injection of ultrasound which can be matched particularly easily to the respective therapeutic requirements by the person carrying out the therapy.

[0008] The object is achieved in accordance with the invention by means of a method for driving an injection means for the injection of ultrasound into a tissue having a predetermined thermal effect and a predetermined mechanical effect in the tissue, with ultrasound pulses each having a pulse width being injected successively, and with the duty ratio of the ultrasound pulses being set as a function of the thermal and mechanical effect of the ultrasound.

[0009] The object is also achieved in accordance with the invention by means of method for driving an injection means for the injection of ultrasound into a tissue having a predetermined thermal effect at a predetermined tissue depth in the tissue, with ultrasound pulses being injected successively with a respective pulse width and at a respective ultrasound frequency, and with the pulse width ratio of the ultrasound pulses being set as a function of the predetermined tissue depth and the ultrasound frequencies.

[0010] The object is also achieved in accordance with the invention by means of an apparatus for the injection of ultrasound into a tissue, comprising:

[0011] an input device for setting at least one mechanical, thermal effect and/or a treatment depth of the ultrasound in the tissue:

[0012] a control device, which is designed in such a manner that the invnetive method is carried out, with the duty ratio for ultrasound pulses, pulse width ratios and/or frequency ratios being determined and with the control device producing appropriate control signals; and

[0013] at least one ultrasound head, which is activated and deactivated as a function of the control signals and emits ultrasound pulses.

[0014] According to the invention, the respective person carrying out the therapy can preset both a thermal effect and a desired mechanical effect in the tissue to be treated, in accordance with his therapy requirements.

[0015] According to the invention, ultrasound pulses are then sequentially injected into the tissue, with, in particular, their duty ratio, that is to say the ratio of the period duration to the time period in which ultrasound power is being injected when ultrasound is emitted on a periodically pulsed basis, being determined automatically. Ultrasound heads having suitable oscillation generators are known as injection means. Sound heads with piezo-oscillation generators are frequently used.

[0016] In one embodiment of the inventive method, the following steps may be carried out:

[0017] Predetermination of a mechanical effect parameter for the mechanical effect;

[0018] Predetermination of a thermal effect parameter for the thermal effect;

[0019] Definition of the duty ratio as a function of the thermal effect parameter and of the mechanical effect parameter; and

[0020] Activation and deactivation of the injection means for the injection of ultrasound pulses with the defined duty ratio.

[0021] Pulse widths and sequences may be achieved according to the invention by switching the injection means on and off, or by activation and deactivation of the injection means.

[0022] In this case, the amplitude of the emitted ultrasound power is preferably used as the mechanical effect parameter. This is generally stated in W/cm^2 and depends essentially on the amplitude of the sound waves. The biological effect of this mechanical component of the ultrasound is based on reversible microcavitation and liquid movements in the tissue. The amplitude is thus an advantageous mechanical effect parameter which can be clearly understood by a person carrying out the therapy.

[0023] The ultrasound power which is effectively emitted into the tissue may be used as the thermal effect parameter. The power from the injected ultrasound, which is generally converted to friction, leads to increased Braunian movement and molecular friction, thus resulting in a temperature increase in the tissue. The respective heating depends not only on the amplitude of the ultrasound waves but also on the frequency and the total energy introduced, as well as on the application duration.

[0024] The maximum possible thermal effect may be determined from the predetermined mechanical effect or the corresponding effect parameter.

[0025] In one embodiment of the inventive method, the ultrasound pulses are at different ultrasound frequencies. The ultrasound pulses which are thus injected successively with a respective duty ratio that is governed according to the invention allow particularly precise determination of the penetration depth, and thus a form of therapy which can easily be adjusted in terms of the thermal, mechanical and local effect of the ultrasound.

[0026] An alternative embodiment of the method according to the invention for driving an injection means for the injection of ultrasound into a tissue having a predetermined thermal effect at a predetermined tissue depth in the tissue consists in that ultrasound pulses with a respective pulse width and at a respective ultrasound frequency are injected successively, with the pulse width ratio of the ultrasound pulses being set as a function of the predetermined tissue depth and of the ultrasound frequencies.

[0027] The following method steps may therefore be preferably carried out:

[0028] a) Predetermination of a tissue depth for a thermal effect of the ultrasound in the tissue,

[0029] b) Predetermination of at least one first and one second ultrasound frequency, with each ultrasound frequency being associated with a respective penetration depth in the tissue;

[0030] c) Definition of the pulse width ratio as a function of the thermal effect and of the associated penetration depths; and

[0031] d) Activation and deactivation of the injection means for the sequential injection of ultrasound pulses with the defined pulse width ratio.

[0032] In this case, each ultrasound frequency is preferably associated with a respective penetration depth in the tissue, and two different ultrasound frequencies are selected in such a manner that a predetermined treatment depth region is located between the two associated penetration depths in the tissue.

[0033] It is particularly preferable to select a frequency ratio of the different ultrasound frequencies in such a manner that a predetermined treatment depth is achieved in the tissue. The sequential injection of a plurality of ultrasound pulses at different frequencies according to the invention has the particular advantage that the required ultrasound power to achieve a plurality of treatment depths during therapy need not be increased in practice. This is the situation when only a single, fixed predetermined ultrasound frequency is injected in a pulsed form.

[0034] The thermal effect parameter and the mechanical effect parameter, the duty ratio, the frequency ratio and/or the treatment depth are/is preferably displayed on a display.

[0035] In one particularly preferred embodiment of the inventive method, respective duty ratios, pulse widths, frequency ratios, amplitudes and/or tissue types are stored in a databank. The method according to the invention thus allows particularly simple and specific treatment based on the therapeutic requirements, which essentially comprise the desired thermal and mechanical effect, and may depend on the respective body part to be treated.

[0036] In one aspect of the invention, an apparatus for the injection of ultrasound into a tissue, comprises an input device for setting at least one mechanical, one thermal effect and/or a treatment depth of the ultrasound in the tissue, a control device, which determines the duty ratio for ultrasound pulses, pulse width ratios and/or frequency ratios and produces appropriate control signals, and at least one ultrasound head, which is activated and deactivated as a function of the control signals and emits ultrasound pulses.

[0037] The control device in this case carries out the inventive method for the injection of ultrasound.

[0038] In this case, at least one display means is preferably provided for the selected mechanical effect and/or the thermal effect. A display means, for example in the form of a barchart, can thus reliably indicate to the person carrying out the therapy the selected or predetermined mechanical and thermal effect parameters which lead to the internally defined duty ratio and/or frequency ratio of the ultrasound pulses. This thus allows particularly simple and clear control of a corresponding ultrasound appliance.

[0039] The ultrasound head may be in the form of a multiple-frequency head.

[0040] A memory device may be provided and may be coupled to the control device, and may be used to store therapy forms and tissue types, duty ratios and ultrasound frequency details for selected mechanical effects. It is thus possible to program an appropriate parameter set relating to the duty ratios, frequencies and possibly further parameters for every combination of desired thermal and mechanical effect. In this case, on the one hand it is also possible to use empirical values obtained from experimental series, or alternatively the control device calculates the duty ratio using a predetermined determination algorithm. The thermal and mechanical effect is associated in a preferred manner with a duty ratio by the duty ratio being proportional to the ratio between the mechanical and the thermal effect parameters.

[0041] The invention also relates to a computer program product having a computer program which is stored in a machine-legible form in a memory means and causes the method according to the invention to be carried out on a computer, and in which the computer emits appropriate control signals for controlling the injection means, via an interface. A computer program product may, for example, be a floppy disk, a CD-ROM or some other memory medium which provides the method steps according to the invention for computer-implemented execution, in a coded form.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] Further advantageous refinements and developments of the invention are the subject matter of the dependent claims and of the exemplary embodiments which will be described in the following text with reference to the figures, in which:

[0043] FIG. **1** is a block diagram of an apparatus for the injection of ultrasound.

[0044] FIG. **2** are examples of signal waveforms of ultrasound pulses.

[0045] FIG. **3** is a flowchart illustrating the inventive method.

[0046] FIG. **4** is a schematic illustration of ultrasound pulses produced according to the invention.

[0047] Unless stated to the contrary, identical or functionally identical elements have been provided with the same reference symbols in the figures.

DETAILED DESCRIPTION OF THE INVENTION

[0048] FIG. **1** shows a block diagram of an apparatus according to the invention for the injection of ultrasound. In the exemplary embodiment illustrated here, the apparatus **1** has an ultrasound head **2** which is connected to a controller **3**. The controller **3** may be in a computer-implemented form, for example, and supplies control signals CTR to the ultrasound head **2**, which accordingly emits ultrasound into a tissue **16**.

[0049] The controller has a control device **4** which is coupled to a memory **5** via a suitable bus DB. An input device **6** is also provided, by means of which a desired mechanical effect parameter and a desired thermal effect parameter for the respective ultrasound therapy can be entered, for example by someone carrying out the therapy. A display device **7** uses, for example, barcharts **8**, **9** to display the selected effect parameters, and has further indications or displays **10**, **11**, by means of which, for example, it is possible to display the penetration depth, the coupling of the ultrasound waves to the tissue **16** or further details relating to the specific ultrasound therapy. The display device **7** and the input device **6** are coupled to the control device **4** via suitable control lines CT**1**, CT**2**. The two barcharts **8**, **9** in this case indicate to the operator or to the person carrying out the therapy the selected thermal biological effect T on the tissue **16** that is subject to the therapy, in the form of the effective power P_{eff} in suitable units, such as W/cm^2, as well as the selected mechanical biological effect M, on the tissue **16** to be irradiated, in the form of the amplitude of the power P_{peak}, likewise in W/cm^2. The required penetration depth can likewise be set, as well as the overall treatment duration.

[0050] Depending on the effect parameters P_{peak} and P_{eff}, the control device **4** calculates or determines advantageous duty ratios for the pulsed emission of ultrasound waves at a frequency which is likewise predetermined. In this case, by way of example, association tables are stored in the memory **5** and associate combinations of ultrasound frequencies, of the effective power P_{eff} and of the maximum amplitude of the power P_{peak} with a respective duty ratio T**1**/T**2**.

[0051] By way of example, FIG. **2** illustrates one possible time sequence of ultrasound pulses P. The ultrasound head **2** emits ultrasound pulses P with a period length T**2**, with one ultrasound pulse at the predetermined frequency, for example of 800 MHz, being emitted during a time T**1**. This is followed by a time period T**3** with no ultrasound emission. The ratio T**1**/T**2** indicates the duty ratio.

[0052] FIGS. **3**A-**3**C show a flowchart of the method according to the invention. The method steps and calculation steps are essentially carried out by the control device **4** for the controller **3**, which is illustrated in FIG. **3**. The major steps for carrying out a therapeutic ultrasound application are shown in the sequence S**0**-S**6**.

[0053] The ultrasound therapy is started in step S**0**. The step S**1** comprises the setting of the desired mechanical effect which is intended to be achieved by the ultrasound therapy. FIG. **3**B shows the corresponding steps S**10**-S**14**. The person carrying out the therapy enters the mechanical effect M in step S**10**, via the keys **12**, **13** on the input device **6** (step S**11**), and this is at the same time displayed qualitatively as a barchart **8** on the display **7**. The person carrying out the therapy then enters the amplitude P_{peak} of the power to be injected. The ultrasound power which results from this is determined from it in step S**12**, and is updated in step S**13**. The maximum possible thermal effect is determined in step S**14**, and is obtained from the effective power P_{eff}, which in turn depends on the selected amplitude P_{peak}.

[0054] The desired thermal effect T is selected in the next step S**2** on the basis of the power, selected by the person carrying out the therapy, to be emitted into the tissue. The desired thermal effect T is entered in step S**20** as a thermal effect parameter in the form of P_{eff}. This is transmitted to the control device **4** from the input device **6** in step S**21**. The appropriate effective power is determined from the selected desired power or dose (step S**22**).

[0055] In the next step S**23**, the control device **4** determines an appropriate duty ratio T**1**/T**2** for pulsed ultrasound injection. In this case, the ratio P_{peak}/P_{eff} corresponds to the duty ratio T**1**/T**2**. The corresponding association of the thermal and mechanical effect T, M with the duty ratio T**1**/T**2** taking account of the respective ultrasound frequency is stored in the memory **5**. Finally, the combination of ultrasound frequency and duty ratio T**1**/T**2** determined in this way is updated in step S**24**, and is transmitted via control signals CTR to the ultrasound head **2**.

[0056] This now results in pulsed injection of ultrasound which corresponds exactly to the therapeutic requirements of the operator, without the operator or the person carrying out the therapy having to give particular consideration as to how the pulse sequence must be set with respect to the duty ratio T**1**/T**2**.

[0057] If the mechanical effect M is varied during the therapy in a step **S3** by variation of the selected effect parameter, this also results in the desired thermal effect T being varied or updated by variation of the effect parameter, once again resulting in a sequence as is illustrated in FIG. **3**C.

[0058] Once the tissue subject to the therapy has been irradiated appropriately, the therapy is ended (step **S5**) and the ultrasound injection ceases (step **S6**).

[0059] The steps illustrated in FIG. **3**A, in particular the updates to the respective mechanical and thermal effect (steps **S3**, **S4**) can also be carried out in a programmed form, so that the control device **4** reads an appropriate therapy sequence from the memory **5**, and injects ultrasound via the ultrasound head **2**. To this extent, a check can be carried out in step **S5** to determine whether all of the therapy steps have already been carried out, or whether the steps **S3**-**S4** should be carried out once again.

[0060] In addition to the automatic determination and selection of the duty ratio T**1**/T**2** from the appropriate effect parameters for the purpose of carrying out the therapy, in terms of the mechanical and thermal effect M, T in the tissue, the invention provides for a particularly good depth effect to be achieved, and for a predetermined range of treatment depths to be irradiated specifically by the emission of ultrasound pulses at different frequencies.

[0061] The penetration depth Z of the ultrasound depends essentially on the selected ultrasound frequency f, and generally falls as the frequency rises. The expression the 3 dB depth is referred to, at which the intensity I(z) of the ultrasound radiation in the tissue has fallen by 50%. At 800 KHz, the ultrasound intensity in muscle tissue falls to 50% after about 2.9 cm. This 3 dB depth is, however, only 0.77 cm at 3 MHz. The decrease in intensity as a function of the tissue depth is generally based on an exponential relationship:

$$I(z)=I_0\, e^{-\alpha\cdot f\cdot z}, \qquad \text{(Equation 1)}$$

[0062] I_0 being the effective value at the depth z=0, α being a decay parameter which is tissue-dependent, and f being the ultrasound frequency.

[0063] For heat generation at a tissue depth z as a result of injected ultrasound waves, it can be shown that there is an optimum ultrasound frequency for every tissue depth that it is desired to heat. The heat generated depends on the decrease in the power density as a function of the tissue depth and the ultrasound frequency. In this case it is possible to convert more power to heat at high frequencies than at low frequencies, up to a specific depth, for example 2 cm in the case of skeletal musculature. However, beyond the tissue depth of 2 cm, lower frequencies produce more heat than higher frequencies. The tissue depth at which the greatest amount of heat is generated can thus be selected by adjustment of the ultrasound frequency.

[0064] In general, lower frequencies between 0.5 and 1.5 MHz have their optimum effect in terms of heat generation at a relatively great depth. At frequencies from 3 MHz, the optimum depth is in the order of magnitude of 1 cm, and is still only slightly dependent on the frequency. Investigations by the applicant have shown that an advantageous frequency range of between 0.7 and 2.5 MHz is a good setting for the heat generated by ultrasound.

[0065] Ultrasound oscillators and ultrasound heads for the emission of ultrasound waves are normally designed for a single ultrasound frequency. In general, however, it is also possible to emit integer multiples of this fundamental frequency from the ultrasound head. Typical frequencies are multiples of 800 KHz, that is to say 1.6 and 2.4 MHz. The optimum depths for heat generation are in this case 4.17 cm at 0.8 MHz and 1.39 cm at 2.4 MHz. In order to efficiently treat a tissue layer located between these depths with heat by the application of ultrasound, it would, however, have to be possible to produce an intermediate value between 0.8 and 2.4 MHz. This is generally not possible.

[0066] The invention now provides, in order to simulate the optimum depth for heat development by ultrasound, for ultrasound pulses to be injected alternately at the fundamental frequency of 0.8 MHz, and three times this frequency, that is to say 2.4 MHz. This results in an optimum depth for conversion to heat at a depth between the limit depths of 1.39 cm and 4.17 cm, provided that the switching between the injected frequencies takes place more quickly than the thermal time constant in the tissue. The thermal time constant predetermines the time in which the temperature of a heat store, for example a tissue area in this case, is still only about 63% of the initial temperature as a result of heat losses.

[0067] In order, for example, to simulate an optimum depth for heat generation of 2.78 cm, an ultrasound pulse is injected for a time of one second at 0.8 MHz, for example, followed alternately, according to the invention, by a pulse at 2.4 MHz for one second. This results in the optimum depth being 2.78 cm=(4.17 cm+1.39 cm)/2. In this simple case, the duty ratio is T**1**/T**2**=1 for each ultrasound pulse. In principle, a desired treatment depth can be selected using the following equation:

$$Z(TG)=\frac{1}{TG}[Z(TP1)\cdot TP1+Z(TP2)\cdot TP2] \qquad \text{(Equation 2)}$$

[0068] In this case, Z(TG) is the desired treatment depth, TG=TP**1**+TP**2** is the duration of an ultrasound cycle according to the invention, TP**1** and TP**2** are the pulse lengths of the two ultrasound pulses P**1**, P**2** at a respective frequency f**1**, f**2**. Z(TP**1**) is the optimum effective depth, that is to say the tissue depth at which the maximum power density is converted to heat, for the ultrasound pulse P**1**, and analogously Z(TP**2**) for TP**2**.

[0069] FIG. **4** illustrates corresponding ultrasound pulse sequences produced according to the invention. Ultrasound pulses P**1** and P**2** with a respective pulse duration of TP**1** and a respective frequency of f**1** and f**2** are provided alternately, in order to achieve a treatment depth based on Equation 2. FIG. **4** furthermore shows a respective duty ratio for the ultrasound pulses P**1**, P**2** which is not equal to 1.

[0070] Thus, according to the invention, not only is it possible to set the treatment depth precisely but also the desired thermal and mechanical effect for the therapy. In order to carry out a therapy at a treatment depth which is predetermined by the user and generally by the use of frequencies which are predetermined by the ultrasound head, the operator just has to enter the effect parameters and treatment depth on the controller. Corresponding ultrasound pulse lengths, frequencies and duty ratios are then determined automatically by the controller **3** according to the invention.

[0071] In particular, the present invention makes it possible to implement the requirements defined by the person carrying out the therapy for the ultrasound therapy in a particularly simple manner. The automatic determination of the duty ratio of the ultrasound pulses to be injected, as well as the pulse duration and frequency, in order to define the desired treatment depth, is carried out automatically. The method according to the invention for sequential injection of ultrasound pulses at different frequencies makes it possible to define continuously variable treatment depths, even when only a limited number of different ultrasound frequencies are provided. It is thus also possible to reduce the number of ultrasound heads required in a therapy practice.

[0072] Although the present invention has been explained in more detail with reference to preferred exemplary embodiments, it is not restricted to these but can be modified in many ways. The described signal waveforms should be regarded only as examples. Different ultrasound frequencies may be used, of course, and different known display means may be used for the effect parameters. Variables derived from P_{peak} and P_{eff} may also be used as effect parameters, for example the respective emitted power, which is quoted in J/cm^2. In particular, the controller according to the invention can also directly generate ultrasound signals which have signal waveforms according to the invention. To this extent, the control signals can also themselves be understood as ultrasound signals. A computer-implemented embodiment of the invention as a computer program is, of course, also possible.

1. A method for driving an injection device for injecting ultrasound into a tissue; said ultrasound having a predetermined thermal effect and a predetermined mechanical effect in said tissue and said method comprising injecting successively ultrasound pulses utilizing said injection device, each of said ultrasound pulses comprising a pulse width; a duty ratio of said ultrasound pulses being set as a function of said thermal and mechanical effects of said ultrasound.

2. The method of claim 1, further comprising the steps of:

predetermining a mechanical effect parameter for said mechanical effect;

predetermining a thermal effect parameter for said thermal effect;

defining said duty ratio as a function of said thermal effect parameter and of said mechanical effect parameter; and

activating and deactivating said injection device for injecting said ultrasound pulses having said duty ratio.

3. The method of claim 1, wherein an amplitude of an emitted ultrasound power of said ultrasound pulses is utilized as said mechanical effect parameter or an effectively emitted power of said ultrasound pulses is utilized as said thermal effect parameter.

4. The method of claim 1, comprising determining a maximum thermal effect from said predetermined mechanical effect.

5. The method of claim 1, wherein said ultrasound pulses have different ultrasound frequencies.

6. The method of claim 1, wherein said duty ratio is set to unity.

7. The method of claims **1**, comprising displaying at least one of said thermal effect parameter, said mechanical effect parameter, said duty ratio, or said frequency ratio.

8. The method of claim 1, further comprising storing at least one of said duty ratios, said pulse widths, or said frequency ratios for at least one of a predetermined therapy forms or tissue types in a databank.

9. A method for driving an injection device for injecting ultrasound into a tissue; said ultrasound having a predetermined thermal effect at a predetermined tissue depth in said tissue and said method comprising injecting successively ultrasound pulses each having a respective pulse width and a respective ultrasound frequency; a pulse width ratio of said ultrasound pulses being set as a function of said predetermined tissue depth and said ultrasound frequencies.

10. The method of claim 9, further comprising the steps of:

predetermining said tissue depth for said thermal effect;

predetermining at least one first and one second ultrasound frequency, each of said ultrasound frequencies being associated with a respective penetration depth in said tissue;

defining said pulse width ratio as a function of said thermal effect and of said penetration depths; and

activating and deactivating said injection device with said pulse width ratio.

11. The method of claim 9, wherein each of said ultrasound frequencies is associated with a respective penetration depth in said tissue, and wherein two different of said ultrasound frequencies are selected in such a manner that a predetermined treatment depth region in said tissue is located between two associated penetration depths in said tissue.

12. The method of claim 9, comprising selecting said frequency ratio of said ultrasound frequencies such that said predetermined treatment depth in said tissue is achieved.

13. The method of claim 9, wherein said duty ratio is set to unity.

14. The method of claims **10**, comprising displaying at least one of said thermal effect parameter, said mechanical effect parameter, said duty ratio, said frequency ratio, or said treatment depth on a display.

15. The method of claim 9, further comprising storing at least one of said duty ratios, said pulse widths, or said frequency ratios for at least one of a predetermined therapy forms or tissue types in a databank.

16. An apparatus for injecting ultrasound into a tissue, comprising:

an input device for setting at least one of a mechanical effect, a thermal effect, or a treatment depth of ultrasound injected by said apparatus in a tissue:

a control device designed to carry out a method according to claim 1, wherein at least one of said duty ratios for said ultrasound pulses, said pulse width ratios, or said frequency ratios is determined and wherein said control device produces appropriate control signals; and

at least one ultrasound head activated and deactivated as a function of said control signals and emitting said ultrasound pulses.

17. The apparatus of claim 16, comprising at least one display for displaying at least one of said selected mechanical effect, said thermal effect or said treatment depth.

18. The apparatus of claim 16, wherein said ultrasound head is in the form of a multiple-frequency head.

19. The apparatus of claim 16, comprising a memory device which is coupled to said control device and presets duty ratios and ultrasound frequency details for selected mechanical and thermal effects, therapy forms and tissue types.

20. The apparatus of claim 16, wherein said control device determines said duty ratio utilizing a predetermined determination algorithm.

21. Computer program product comprising a computer program which is stored in a machine-legible form in a memory and causes a method according to claim 1 to be carried out on a computer emitting control signals for said injection device via an interface.

* * * * *

专利名称(译)	用于将超声注入组织的方法和设备		
公开(公告)号	US20070239076A1	公开(公告)日	2007-10-11
申请号	US11/558119	申请日	2006-11-09
[标]申请(专利权)人(译)	ZIMMER ELEKTROMEDIZIN		
申请(专利权)人(译)	ZIMMER ELEKTROMEDIZIN GMBH		
当前申请(专利权)人(译)	ZIMMER MEDIZINSYSTEME GMBH		
[标]发明人	ZIMMER BERND		
发明人	ZIMMER, BERND		
IPC分类号	A61H1/00 A61B8/00		
CPC分类号	A61B17/22004 A61B2017/00154 A61B2017/00172 A61N2007/0073 A61B2017/00194 A61B2017/00199 A61N7/00 A61B2017/0019		
优先权	102005053918 2005-11-11 DE		
其他公开文献	US8702630		
外部链接	Espacenet USPTO		

摘要(译)

在用于驱动用于将超声波注入组织的注射装置的方法中，超声波在组织中具有预定的热效应和预定的机械效果。利用注射装置连续注射超声脉冲。每个超声脉冲包括脉冲宽度，并且超声脉冲的占空比被设置为超声脉冲的热和机械效应的函数。