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Description

Treatment device having an optical positioning unit

The invention relates to a treatment device having a source of acoustic waves, having means for
5 obtaining image information and having means for the graphical indication of the image information obtained.

A treatment device of this type is known, for example, from US 3 237 623, for eye operations for destroying cell groups which impair the eyesight of a
10 patient. Using an ultrasonic locating unit, the tissue to be destroyed is detected and the distance of the tissue to be destroyed from the inner and outer surface of the wall of the eye is determined. The exact point on the inner eye surface below which the tissue to be destroyed
15 is located can also be located using an ophthalmoscope which is accommodated by the source of acoustic waves. In this way, the tissue to be destroyed can be identified optically and the effects of the radiation on the tissue to be destroyed can be observed during the treatment. The
20 ophthalmoscope is primarily used in this case for the identification of tissue and the observation of the progress of the treatment.

Treatment devices of the type mentioned at the beginning are nowadays also employed in pain therapy to
25 apply focused acoustic waves to a painful body region of a patient, the focused acoustic waves generally being applied to the pain centre, that is to say the point of maximum pain. As a result of the effect of the focused acoustic waves, the patient is pain-free, at least for a
30 certain time, following the treatment. It is usually the case that the treating doctor, in the preparation phase of the treatment, looks for the pain centre in the painful body region indicated by the patient, in that the doctor applies weak focused acoustic waves to the body
35 region indicated and systematically moves the source of acoustic waves, whilst displacing the focus zone of the



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acoustic waves, systematically over the body region indicated by the patient. In this case, the patient communicates to the doctor how severe the pain sensation is for the momentary position of the source or of the focus zone of the acoustic waves. The optimum position, at which the pain centre is located in the focus zone of the acoustic waves, is found when the pain sensation is a maximum.

The means contained in treatment devices of the type mentioned at the beginning for obtaining image information, and means for the graphic display of the image information obtained, which are mostly an ultrasonic location unit, mostly represent only an orientation aid during the alignment of the focus zone to the pain centre, since the pain centre itself is often not visible in the image information obtained. The simplification of the alignment procedure which can be achieved by the means for obtaining image information and the means for the graphic display of the image information obtained are therefore not related in an acceptable way to the costs which are entailed by these means, so that consideration has also already been given to dispensing with such means altogether.

Treatment devices having sources of acoustic waves and having ultrasonic sound and/or X-ray locating units are disclosed, for example, by DE 44 00 997 A1 and DE 38 35 318 C1.

The invention is based on the object of designing a treatment device of the type mentioned at the beginning in such a way that its source of acoustic waves can be aligned in a simple and cost-effective way in relation to the body region of a patient to be treated.

According to the invention, this object is achieved by means of a treatment device having a source of acoustic waves which has a transparent portion, having optical means for obtaining image information from a body surface of a patient to be treated, the beam path of which means passes through the transparent portion of the



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source of acoustic waves, and having means for the graphical indication of the image information obtained. The invention is based on the consideration that the doctor can determine in a simple and rapid way the

5 approximate position of the pain centre by palpating the body region indicated by the patient and can mark the position of the pain centre on the body surface of the patient, for example by means of a cross applied using a wax pencil. With the aid of the means for obtaining image

10 information and the means for the graphical indication of the image information obtained, the doctor aligns the source of acoustic waves onto this cross in such a way that the acoustic axis of the source passes at least approximately through the cross and hence through the

15 pain centre. The final alignment, which now follows, of the source of acoustic waves and hence of the focus zone of the acoustic waves onto the pain centre, with the cooperation of the patient, is substantially simpler and substantially shorter in comparison with the prior art,

20 specifically without the costly means for obtaining image information, for example in the form of an ultrasonic locating unit, being necessary. In this arrangement, it is essential that the source has a transparent portion, since otherwise during the application of the source to

25 the body surface the cross would be covered by the source itself and would not be visible to the means for obtaining image information.

DE 41 20 074 A1 has disclosed a treatment device having a device for monitoring and for controlling the

30 position of the body of a patient during a treatment using focused acoustic waves. In this case, following the positioning of the source of acoustic waves in relation to the body of the patient, a cross, for example, is projected onto the body surface of the patient, outside

35 the body zone to be treated, and is marked, for example using a felt marker pen. If the marking and the projected cross are no longer coincident during the treatment of the patient with acoustic waves, the treatment is inter-

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rupted and the patient and the source are once more aligned in relation to each other.

5 A particularly preferred embodiment of the invention provides that the treatment device has a marker which is arranged on the acoustic axis of the source, is picked up by the means for obtaining image information, which are preferably located in the transparent portion of the source, and is displayed by the means for the graphical indication of the image information obtained.

10 The positioning of the source in relation to the body of the patient is then carried out in such a way that the image of the marker arranged on the acoustic axis coincides in the image information on the graphic indicating means with the image of the cross applied by the

15 doctor and located on the body surface of the patient. It is ensured in this way that the acoustic axis of the source of acoustic waves runs through the area of the patient to be treated and at least approximately through the pain centre.

20 According to a further particularly preferred embodiment of the invention, a video camera is used as the optical means for obtaining image information, which camera preferably has an additional light source. Video cameras represent cost-effective and technically suitable

25 means for obtaining images and for identifying optical markings, such as a cross, for example, on the body surface of a patient. Since large treatment heads, which, for the introduction of acoustic waves into a body area of a patient, rest on the patient during treatment via a

30 coupling diaphragm which is flexible and transparent and closes a space filled with an acoustic propagation medium in a fluid-tight manner, can reduce the incidence of light into the area which is picked up by the video camera, in spite of the transparent coupling diaphragm,

35 the additional light source is advantageous for obtaining meaningful images from the body surface of the patient.

According to a variant of the invention, the means for obtaining image information are designed in

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such a way that they can be removed from that portion of the source of acoustic waves which accommodates them. This permits the optional use of other means, for example of an eyepiece, or of the video camera.

5 According to an embodiment of the invention, a monitor is used for indicating image information obtained. Television monitors or else computer monitors, which are found on a computer with an appropriate graphics card with a video input, come into consideration. It has proven to be particularly advantageous to
10 use monitors which are already present in medical practice, which enables additional costs for the acquisition of an appropriate monitor to be avoided.

 The invention will be explained below using the
15 example of a treatment device which is provided for the treatment of pain and is shown in the attached drawings, in which:

 Figure 1 shows a treatment device according to the invention in a representation which is partly sectioned and partly like a block diagram, and
20

 Figure 2 shows the treatment device according to Figure 1 in a partly sectional representation with indications of distance.

 The treatment device according to the invention
25 has, according to Figure 1, a source of focused acoustic waves which is designated as a whole by 10 and which is fitted via a holder 11 on an adjusting unit 12, which is indicated only schematically. The latter allows the adjustment of the source 10 in the direction of the axes
30 x, y, z of the three-dimensional coordinate system indicated in Figure 1. Connected to the adjusting unit 12 is an operating and supply unit 13 which contains all the units necessary for operating the source 10 and is provided with a keyboard for operating the treatment
35 device. The source 10 contains a central transparent portion, to be described in more detail, and rests, with a likewise transparent coupling diaphragm 14, on the body surface of a patient P, in order to be able to introduce

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the focused acoustic waves which are produced during the operation of the treatment device into the body of the patient P, who is, for example, complaining of pains in a body area B.

5 As can be seen from Figure 1, the source 10 of focused acoustic waves contains an electromagnetic pressure pulse source 16, not shown in more detail, and an acoustic concave lens 17. The concave lens 17 focuses the pressure pulses proceeding from the pressure pulse
10 source 16 onto a focus F, which in practice is a three-dimensional focus zone. The focus F lies on the acoustic axis A of the source 10, which corresponds to the central axis M of the source 10, to which axis the latter is of approximately rotationally symmetrical design. The
15 pressure pulse source 16 and the concave lens 17 are accommodated in a housing 18 which is closed in a liquid-tight manner at its end remote from the pressure pulse source 16 by means of the elastic, flexible coupling diaphragm 14. The pressure pulse source 16 is, for
20 example, an electromagnetic pressure pulse source, as is described in terms of construction and function in EP-A-0 188 750 and EP-A-0 301 630. The high-voltage pulse generator which is necessary for the operation of the pressure pulse source 16 is a component part of the
25 operating and supply unit 13, to which the pressure pulse source 16 is connected via a corresponding line.

At its other end, that adjacent to the pressure pulse source 16, the housing 18 has a mounting flange 19 which serves for the purpose of fastening the source 10
30 to a mounting ring 20 of the carrier 11 with the aid of screws, only the centre lines of two screws being indicated by chain-dotted lines in Figure 1.

The space which is located between the pressure pulse source 16 and the concave lens 17, and the space
35 located between the concave lens 17 and the coupling diaphragm 14 are in each case filled with an acoustic propagation medium. In the case of the exemplary embodiment described, both spaces contain the same acoustic

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propagation medium, namely water 23 and 24. The two spaces filled with water 23 and 24 are, in the case of the exemplary embodiment described, separated from each other by the concave lens 17. However, they can also be
5 connected to each other, particularly if both spaces contain the same acoustic propagation medium.

The concave lens 17 is a solid lens of biconcave shape which is formed from a material, for example polystyrene, in which the propagation speed of sound is
10 greater than in the water 23 and 24 which is provided as acoustic propagation medium, and which is moreover held in the housing 18 by a retaining ring 31.

The coupling diaphragm 14 has an opening 15 which has the form of a nozzle. A hose 8 connects the nozzle 15
15 of the coupling diaphragm 14 to a pump 28, which is in turn connected via a hose 9 to a supply container 29 which is partially filled with the acoustic propagation medium water 24. Here, the pump 28 can be operated in such a way that, as required, on the one hand it pumps
20 water 24 into the space between the concave lens 17 and the coupling diaphragm 14, and on the other hand pumps water 24 out of the space between the concave lens 17 and the coupling diaphragm 14. In this way, the volume of the space between the concave lens 17 and the elastic and
25 flexible coupling diaphragm 14 can be optionally enlarged or reduced.

Inserted into an opening 41 of a cylindrical tubular inner wall 21 of the housing 18 is a cup-like tube 22, which, at least in the area of its bottom 26, is
30 formed from a transparent material, for example Plexiglas. The tube 22 is accommodated in an axially displaceably and liquid-tight manner in the opening 41 of the inner wall 21, it being possible for sealing means, not shown in Figure 1, to be provided. A video camera 27,
35 not shown in more detail in Figure 1, is inserted into the tube 22 at some distance from its bottom 26. The optical axis O of the video camera 27 coincides with the acoustic axis A of the source 10. The focal length of the

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objective of the video camera 27 can be adjusted via a control and computing unit 32 which is connected to the video camera by means of a video signal line 30. The objective is additionally surrounded by an annular light source 25, in order to obtain useable video pictures in the event of insufficient incident light. In this case, the light source does not necessarily have to be of annular design. The bottom 26 of the tube 22 is additionally provided with an optical marker which lies on the acoustic axis A of the source 10.

The control and computing unit 32 comprises, in the present exemplary embodiment, a commercially available PC, to which a monitor 33 and a keyboard, not shown in Figure 1, are connected.

The central opening 41 of the source 10, which is present within the inner wall 21 and in which the tube 22 is located, constitutes the already mentioned transparent area, from which the water 24 is expelled by means of the tube 22 in order to avoid negative influences on the image quality. For this purpose, with the source 10 applied to the body surface of the patient P which is indicated in Figure 1, the tube 22 is pushed to such an extent into the opening 41 of the inner wall 21 that its bottom 26 rests on the body surface of the patient P, with the interposition of the coupling diaphragm 14. For this purpose, a further adjusting unit 34 is provided, by means of which the tube 22 is adjustable in the axial direction. The adjusting unit 34 contains an electric motor 35 which is provided with a pinion 36 and cooperates with a rack 42 provided on the tube 22. The adjusting unit 34 is assigned a position transmitter 37 which supplies a signal corresponding to the axial position of the tube 22, which indicates the distance d_1 (see Figure 2) of the bottom 26 of the tube 22 from a reference point BP lying on the acoustic axis A of the source 10. This signal is fed to the control and computing unit 32. The distance d_F of the focus F from the reference point BP of the source 10 is stored in the operating and supply unit

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13 of the source 10, and is made available to the control and computing unit 32 via a control line.

5 The tube 22 can additionally be rotated about the acoustic axis A by means of an adjusting unit 38. The adjusting unit 38 contains an electric motor 39 which is provided with a pinion and interacts with a component which is provided with a toothed rim 40, is rotatably accommodated in the housing 18 and is connected in a rotationally fixed manner to the tube 22 via the rack 42,
10 which engages in a groove in the component.

The electric motors 35 and 39 of the adjusting units 34 and 38 are connected to the operating and supply unit 13 via corresponding lines.

15 In order to treat the patient, the latter is initially laid down in a suitable position on a treatment table, not shown. The treating doctor firstly palpates the painful body area indicated by the patient and marks, for example with a cross which is not visible in Figures 1 and 2, that point on the body surface of the patient
20 below which the pain centre Z is located, according to the statements of the patient. The patient P is subsequently aligned on the treatment table in such a way that the body area marked with a cross of the body surface is located approximately in the area of the
25 acoustic axis A of the source 10. Using the video signals from the video camera 27, which are indicated on the monitor 33 connected to the control and computing unit 32, the treating doctor can align the source 10, using the operating and supply unit 13, such that the images K' and MR' of the cross applied by the doctor to the body
30 surface of the patient P and the optical marker of the bottom 26 of the tube 22 coincide on the monitor 33. The acoustic axis A of the source 10 then passes through the cross and at least approximately also through pain centre
35 Z of the patient P.

In order to position the focus F of the source 10 such that its distance from the body surface is at least approximately equal to the distance of the pain centre Z

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from the body surface, the doctor proceeds as follows: he or she establishes the distance d_2 , which remains at least approximately constant during the treatment, of the pain centre Z from the body surface of the patient P, for example by means of an estimation or by means of ultrasonic diagnosis, and by varying the distance d_1 of the reference point BP from the bottom 26 of the tube 22, which in this case is resting on the body surface of the patient P, sets the distance of the focus F of the source 10 from the body surface such that it corresponds to the distance of the pain centre Z from the body surface. To this end, the current distance values d_1 , d_2 , d_F according to Figure 2 are indicated on the monitor 33, in addition to the video images from the video camera 27, only the distance d_1 generally being varied.

If, as in the present exemplary embodiment according to Figure 2, the focus F of the source 10 comes to lie behind the pain centre Z of the patient, the distance d_1 must be increased to such an extent that the sum of the distances d_1 and d_2 is equal to the distance d_F . If this is true, the focus F of the pressure pulses is located at the pain centre Z of the patient. During the setting of the focus position, the pump 28 is driven by the control and computing unit 32 in such a way that it pumps water 24 out of the supply container 29, via the hoses 8 and 9, into the space between the concave lens 17 and the coupling diaphragm 14, as a result of which the volume of said space increases and the source 10 is moved away from the body surface. At the same time, the tube 22 in the cylindrical tubular inner wall 21 of the housing 18 is readjusted via the adjusting unit 34, possibly with limitation of the force acting between the tube 22 and the body surface, such that the bottom 26 of said tube is always resting snugly on the body surface of the patient P. The control and computing unit 32 thus always has available to it the current distance d_1 via the position transmitter 37. The pumping process remains active until, as a result of the supply of water 24 into the space

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between the concave lens 17 and the coupling diaphragm 14, the source 10 has been moved away from the body surface, as a result of the volume enlargement of the space, to such an extent that the sum of the distances d_1 and d_2 is equal to the distance d_F .

If, following the positioning of the source 10 over the pain centre of the patient P, the focus F of the source 10 comes to lie in front of the pain centre of the patient P, then in this case water 24 is pumped out of the space between the concave lens 17 and the coupling diaphragm 14 into the supply container 29, so that the volume of the space between the concave lens 17 and the coupling diaphragm 14 decreases and the focus F of the source 10 moves towards the pain centre Z of the patient. At the same time, the tube 22 is readjusted such that the distance d_1 of the bottom 26 of the tube 22 from the reference point BP decreases continuously, until the sum of the distances d_1 and d_2 is once more identical to the distance d_F of the focus F from the reference point BP of the source 10.

Once the images K' and MR' of the cross and of the marker on the bottom 26 of the tube 22 have been brought into coincidence in the manner described, and the necessary distance of the focus F from the body surface has been set, the doctor carefully displaces the source 10 in relation to the body of the patient P, with the cooperation of the patient and whilst emitting focused acoustic waves of reduced intensity, until the focus F is actually located at the pain centre Z. - The actual treatment can now begin.

The optical marker on the bottom 26 of the tube 22 is, incidentally, not necessary if a mark identifying the position of the acoustic axis A is inserted into the video image in an electronic way in a manner known per se.

In the case of the exemplary embodiment described, the tube 22, and with it the video camera 27 in the opening 41 of the inner wall 21 of the housing 18,

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are adjusted about the acoustic axis A via the adjusting unit 38 and in the direction of the acoustic axis A via the adjusting unit 34. However, it is of course also possible for the tube 22, and with it the video camera
5 27, to be adjusted manually about the acoustic axis A or along the acoustic axis A. The capability of rotating the tube 22 about the acoustic axis A can in this case also be dispensed with, since it is not strictly necessary in order to bring the images K' of the cross and MR' of the
10 marker on the bottom 26 of the tube 22 into coincidence.

Furthermore, the video camera 27 can be connected directly to a television monitor. In this case, the position transmitter 37 is connected to the operating and supply unit 13 of the source 10, which unit carries out
15 the distance calculations and drives the pump 28 appropriately.

In the case of the exemplary embodiment described, the concave lens 17 has a fixed focal length. However, there is also the possibility of using a vario-
20 lens, that is to say a lens having an adjustable focal length.

Moreover, the tube 22 can be removed from the source 10 of acoustic waves if required, it having to be ensured that a corresponding tube is inserted into the
25 source 10 in a manner not shown, in order to prevent the loss of water 24.

Moreover, the tube 22 does not necessarily have to be of cup-shaped design, but can also be of semicircular design, for example, particularly at its bottom.
30 Under certain circumstances, however, it is then necessary to take appropriate precautions so that no negative influences occur on the image quality of the video images.

Furthermore, the coupling diaphragm 14 does not
35 necessarily have to have only one nozzle 15 for the supply and discharge of water 24, and only one pump 28. Rather, a plurality of pumps, nozzles, hoses and, if expedient, valves which prevent reverse flow of the

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water, can be provided for the supply and the discharge of water into the space between the concave lens 17 and the coupling diaphragm 14.

If the two spaces, filled with water 23 and 24, of the source 10 are not separated from each other by the concave lens 17, as in the present exemplary embodiment, it is also possible for the housing 18 of the source 10 to be provided with appropriate supply and discharge nozzles in the area of the space between the pressure pulse source 16 and the concave lens 17, via which nozzles water 23 or 24 for increasing or decreasing the volume of the space between the concave lens 17 and the coupling diaphragm 14 is supplied or discharged.

In the case of the exemplary embodiment described above, the source 10 contains an electromagnetic pressure pulse source. However, the treatment device according to the invention can also contain another pressure pulse source, for example a piezoelectrically acting pressure pulse source. In addition, there is the possibility of providing, instead of a pressure pulse source, other sources of acoustic waves, for example an ultrasonic source, which generates ultrasound in the form of continuous sound, ultrasound bursts or ultrasound pulses.

Furthermore, there is also the possibility of carrying out the alignment of the source 10 over the body area of the patient P marked with a cross by the doctor not by using the operating and supply unit 13, but manually.

Moreover, the "depth measurement" for determining the distance d_1 of the reference point of the source 10 from the body surface of the patient P for setting the focus position can be omitted. Since the focus zone Z is in practice not of point-like design, but as a rule has an elongated, cigar-shaped form, it is possible for the doctor, following the optical positioning of the source 10 over the body area of the patient P marked with a cross, whilst applying focused acoustic waves of reduced intensity to the patient P, to vary the distance of the

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source 10 from the body surface of the patient P and thus
the distance of the focus zone F from the pain centre Z,
preferably along the acoustic axis A, in a careful and
stepwise manner until the patient P communicates to him
5 or her the maximum sensation of pain, and thus the focus
zone F comes to lie at least approximately on the pain
centre Z.



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Patent Claims

1. Treatment device having a source (10) of acoustic waves, which has a transparent portion (21), having optical means (27) for obtaining image information from a body surface of a patient (P) to be treated, the beam path of which means passes through the transparent portion of the source (10) of acoustic waves, and having means (33) for the graphical indication of the image information obtained.
2. Treatment device according to Claim 1, of which the means (27) for obtaining image information are accommodated in the transparent portion.
3. Treatment device according to either of Claims 1 and 2, which has a marker which is arranged on the acoustic axis (A) of the source (10), is picked up by the means (27) for obtaining image information and is displayed by the means (33) for the graphical indication of the image information obtained.
4. Treatment device according to one of Claims 1 to 3, which contains a video camera (27) as means for obtaining image information.
5. Treatment device according to Claim 4, of which the means (27) for obtaining image information exhibits a light source (25).
6. Treatment device according to one of Claims 1 to 5, of which the means (27) for obtaining image information can be removed from that portion of the source (10) of acoustic waves which accommodates them.
7. Treatment device according to one of Claims 1 to 6, which contains a monitor (33) as means for the indication of the image information obtained.

This Sheet Has Been Replaced

