(93)

The invention relates to a lithotrite which may be constructed for a lower cost than those using shock wave generation by means of a spark gap and location of the calculus by radioscopy and having, with respect to these known apparatus, different substantial advantages and in particular more accurate and reliable location of the calculus and simplified use.

In a known apparatus, described in DE-A-2 722 252, shock waves are generated by electric discharges effected at the focal point of an elliptic reflector and are focused at the second focal point of the ellipse. The energy of the focal spot will only be sufficient for destroying an intra-renal calculus (pressures of the order of 10^8 Pascal are required) if the transmission takes place in a liquid (water) perfectly free of gas, which is an important restriction of use. This process further requires the expensive electrodes of the spark gap to be changed at each treatment or even during treatment. The focal spot produced is relatively large. Finally, location of the position of the focal region is effected by means of an auxiliary echography device whose transducer or transducers are necessarily disposed at a certain distance of the elliptic reflector.

Furthermore, DE-A-3 119 295 describes a lithotrite of the type defined in the preamble of the independent claims 1 and 2. For locating the position of the focal region, this document proposes either the use of an auxiliary echography device such as described in the above-mentioned document

(24)

DE-A-2 722 252 or the use of the main transducer itself to form a part of the auxiliary echography device.

The purpose of the invention is to improve these known devices in the way described in the characterizing part of the independent claims 1 and 2 respectively. For both cases, it proposes the use of an auxiliary transducer, distinct from the main transducer, having the form of a spherical cap, but fixed thereto and emitting, during the intervals between the main pulses.

Claim 1 further describes a particularly adapted arrangement of the auxiliary transducer along the axis of the spherical cap. Thus, during movement of the main transducer for bringing the focal spot into the desired region of the calculus, the auxiliary transducer supplies at all times an image of the calculus and of the focal spot, which allows the desired localization to be achieved easily and accurately.

According to another feature of the invention, described in claim 2, the apparatus comprises in particular means for causing the main transducer to emit, during the intervals between the main pulses, control pulses having a substantially reduced power, at the same rate as the pulses normally emitted by the auxiliary transducer, which then does not emit itself the corresponding echos received by the auxiliary transducer which can be processed for controlling the localization and the distribution of the energy of the main pulses.

Other features, as well as the advantages of the invention will be clear from the following description.

In the accompanying drawings :

Figure 1 is the general diagram of an apparatus according to a preferred embodiment of the invention ;

Figure 2 shows schematically, in perspective, the main transducer and its mobile support device ;

Figure 3 shows the wave forms at different points of the circuits of the apparatus ; and

Figure 4 shows the image obtained on the display screen which the apparatus comprises.

In Figure 2 is shown a transducer 1 in the form of a spherical skull cap supported by a device allowing it to move along three orthogonal axes X, Y and Z. This device has been shown schematically, construction thereof being within the scope of a man skilled in the art.

Along the axis of the spherical skull cap is disposed an auxiliary transducer 2 of a general cylindrical shape, whicb passes through skull cap 1 and is fixed thereto. A water pocket P is interposed between the skull cap 1 and surface S of the body of the patient, this latter being assumed lying down on a horizontal surface. Skull cap 1 is for example 200 to 300 mm in diameter and is formed from a large number (300 or 400) of piezoelectric elements 10, 11, etc... (Figure 1) isolated from each other and juxtaposed so as to form a mosaic. These elements are metallized on both their faces, one of the metallizations being connected to ground and the other to energization connections through an emitter 3.

This latter supplies an electric signal A (Figure 3) formed of high frequency (500 KHz for example) pulse bursts of short duration (for example 1 microsecond). Each burst will for example comprise a number of pulses between 1 and 10 and these pulses correspond to a very high peak power (of the order of 100 Kw for example). Such power may be obtained by means of a pulse emitter using well known technologies, either with power transistors, or with thyristors. All the elements may be energized in parallel or groups of elements placed in series may be energized.

An input 31 of emitter 3 symbolizes adjustment of the power emitted and an input 32 adjustment of the pulse shape. These adjustments allow the shape of the signal produced at the level of the focal spot, in the center F of the sphere, to be controlled. This sphere may, with this technique, be very small (diameter of two or three millimeters for example) and may have a strictly fixed position for a given position of the transducer.

In Figure 1, it can be seen that the auxiliary transducer 2 is itself connected, on the one hand, to an electric

pulse emitter 21 and on the other hand, to a reception amplifier 22 followed by an analog-digital converter 23 itself followed by a memory 24. The emitter 21 is synchronized by a pulse generator 211 which supplies 256 pulses (square wave B, Figure 3) in a time (1/10 of a second for example) less than the pulse period A. This time corresponds to the time required for a complete sweep of a predetermined angular sector θ (Figure 1) by the beam emitted by the transducer 2, thus for forming in the sweep plane, an image of calculus K.

The transducer 2 is advantageously of the type described in French patent applications FR-A-2 487 664 filed on the 29 July 1980 for : Echography probe with sectorial sweep comprising two coupling liquids, and FR-A-2 487 665 filed on the 29 July 1980 for : Echography probe with mechanical sectorial sweep, that is to say that it comprises an oscillating piezoelectric element 200 controlled by a motor 201, itself controlled by an electronic circuit which has been symbolized by a rectangle 4. This electronic circuit supplies signals (M, Figure 3) for controlling the motor 201 housed in the case of transducer 2 and is adapted so that a complete oscillation of the motor corresponds to the above defined duration required for formation of an image (1/10 sec). A short predetermined time interval after the end of square wave B, switch 33 being assumed in position I, circuit 4 sends out a 1/100 second pulse, for example, transmitted to the input 36 of emitter 3 for initiating the emission of a pulse burst A. During this initiating pulse, the oscillation element 200 remains immobile at the end of the sweep so that the probe does not receive corresponding echos.

It is possible to omit the connection between generator 211 and emitter 21 by putting switch 210 in position II. In this operating mode, emitter 21 is no longer in service and transducer 2 is only used for reception. On the other hand, with switch 33 assumed to be in position II at the same time as switch 210 (coupling between these two switches has not been shown), the emitter 3 is then syn-

(27)

chronized by generator 211, so that it emits pulses C (Figure 3) at the same rate as the above-mentioned pulses B.

Emitter 3 thus energizes, when the switches are in position II, transducer 1 with a signal C formed of sequences of 256 pulses for example. The corresponding echos are received by transducer 2, so that an image of the zone of concentration of the energy then emitted by transducer 1 is obtained, as will be explained further on.

Pulses B emitted by emitter 21 and pulses C emitted by emitter 3 are of low power (a few watts peak). The power of emitter 21 is adjustable and that of emitter 3 is, at the time of switching switch 33 to position II, considerably reduced for example by a substantial reduction of the supply voltage for the emitter 3, which reduction is controlled by said switching in a way known per se and not shown.

The signals received at 22, whatever their nature, are, after analog-digital conversion in 23, stored line by line in memory 24, a writing adressing device 25, controlled by circuit 4, causing the respective deflection angles of the beam emitted and/or received by transducer 2 to correspond with the respective lines of the memory. A device 26 for rapid reading of the memory energizes the X and Y deflection coils of cathode ray tube 28, so the brilliancy control electrode receives the corresponding contents from memory 24, transformed into an analog signal by a digital-analog converter 27.

The practical construction of all the circuits described and shown is within the scope of a man skilled in the art.

The apparatus which has just been described operates in the following way :

As was mentioned above, in normal operation, the switches are in position I and ultrasonic pulses corresponding to pulses A are generated by transducer 1 and focused at the center F of the sphere. During each square wave B, the sectorial sweep echography device formed by the transducer, the auxiliary emitter and the reception, processing and

display means 22 to 27, displays on the screen an image of the zone swept, so of the kidney and of the calculus K.

Furthermore, the display device is adapted, in a way known per se, for materializing on the screen of the cathode ray tube (for example by a cross) the theoretical position of a focal spot in the sectional plane shown, which plane passes through the axis of symmetry of transducer 1. (It is a question of echography of type B). The operator begins by moving transducer 1 along X, until the calculus appears clearly on the screen, then he moves it along Y and Z, until the cross coincides with the central region of the calculus image. At that time, the switches may be placed in position II ; the region of the focal spot is then made visible on the screen, with a luminosity proportional to the corresponding concentration of energy. Thus, a representation is obtained of what the distribution of the energy of the shock wave will be during firing, which allows the adjustments to be checked and perfected.

It is clear that the apparatus described allows the change in the calculus after each firing to be checked. It goes without saying that is may undergo different modifications and even be implemented in different ways without departing from the scope of the invention as described in the attached claims.

* C L M S *

Claims :

1. A lithotrite comprising means for generating shock waves concentrated in a focal region and means for locating the position of said focal region, said generating means comprising an ultrasonic pulse generator (1-3) comprising a main piezoelectric transducer (1) whose active surface is a spherical cap, said locating means comprising an echography device including an auxiliary pulse generator associated to an auxiliary transducer (2), characterized in that said auxiliary transducer is fixed to said spherical cap (1) and disposed along the axis thereof, and emits during the intervals between the main pulses, and in that the auxiliary echography device is of the type with sectorial sweep effected so as to form an image during said intervals in a plane of symmetry of said spherical cap.

2. A lithotrite comprising means for generating shock waves concentrated in a focal region and means for locating the position of said focal region, said generating means comprising an ultrasonic pulse generator (1-3) comprising a main piezoelectric transducer (1) whose active surface is a spherical cap, said locating means comprising an echography device including an auxiliary pulse generator associated with an auxiliary transducer (2), characterized in that said auxiliary transducer is fixed to said spherical cap (1), in that is emits during the intervals between the main pulses and in that means (210, 211, 33, 3) are provided for interrupting the emission of auxiliary pulses by the auxiliary transducer and causing said main transducer (1) to emit during the intervals between the main pulses (A), a plurality of control pulses (C) for controlling the focal spot, having a power substantially more reduced than that of the main pulses, at the same rate as those (B) normally emitted by the auxiliary transducer (2).