

[54] **STONE DISINTEGRATOR**

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[51] Int. Cl. **A61b 17/22; A61n 1/06; A61n 1/08**

[58] Field of Search **128/328, 421**

[56] **References Cited**

UNITED STATES PATENTS

2,609,499	9/1952	Gilson	128/421 X
3,557,793	1/1971	Ediny, et al.	128/328
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FOREIGN PATENTS OR APPLICATIONS

1,218,112	6/1966	Germany	128/328
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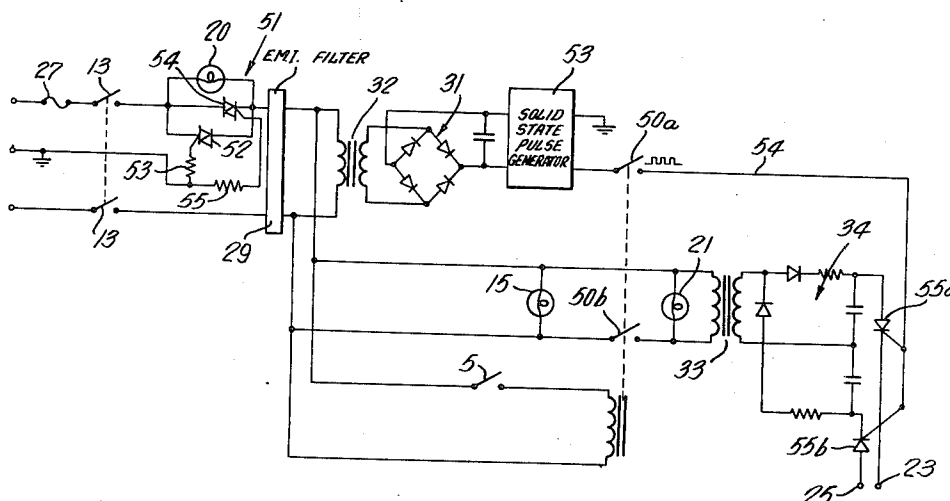
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[57] **ABSTRACT**

This invention relates to an instrument for disintegrating calculi in the urinary tract by hydraulic impacts formed by electrical discharges in the liquid medium surrounding the calculi. Instruments employing this general principle are well known and they usually consist of a lithotrite having two electrodes, and a pulse forming network connected to the electrodes to provide electrical energy for forming discharge between the lithotrite electrodes. In the lines connecting the pulse forming network to the lithotrites, the prior art instruments include spark gaps. These gaps have the disadvantages of being temperature and humidity dependent and of providing a great deal of service and maintenance problems. In accordance with the invention, the spark gaps are replaced by solid state switch devices such as thyristors. The switching devices are controlled by a solid state pulse generator, and the repetition rate and intensity of the electrical discharges can be varied by varying the repetition rate and pulse duration of the pulse generator.

6 Claims, 6 Drawing Figures



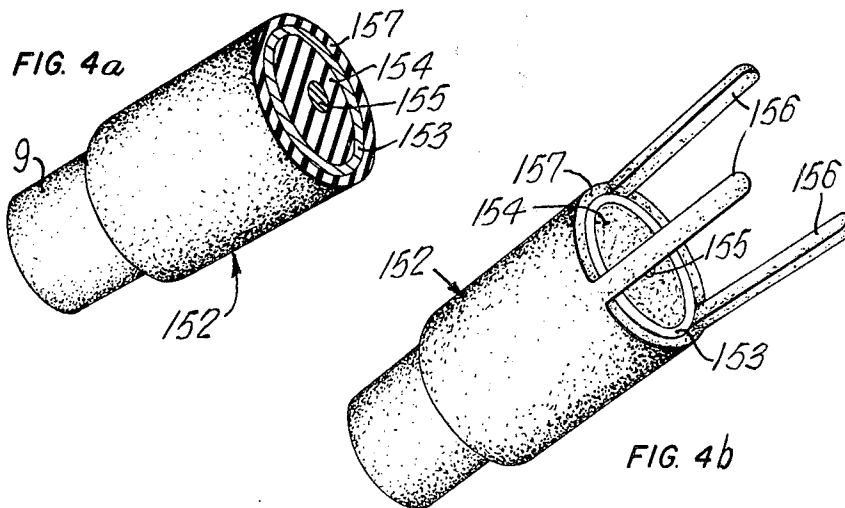
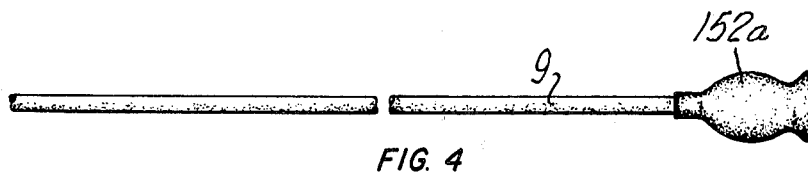
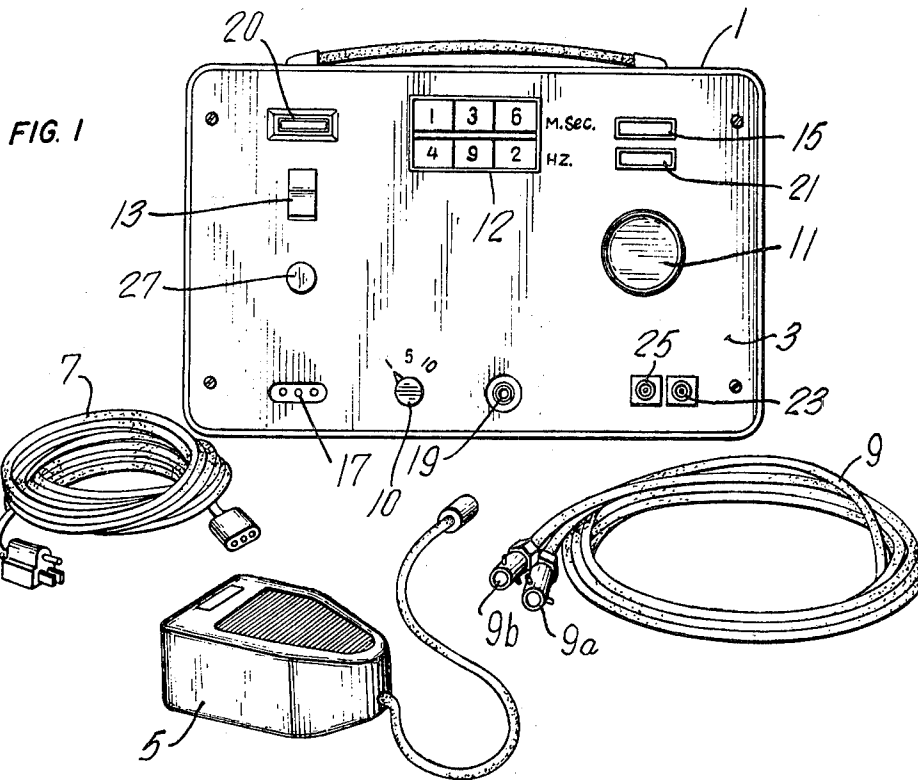
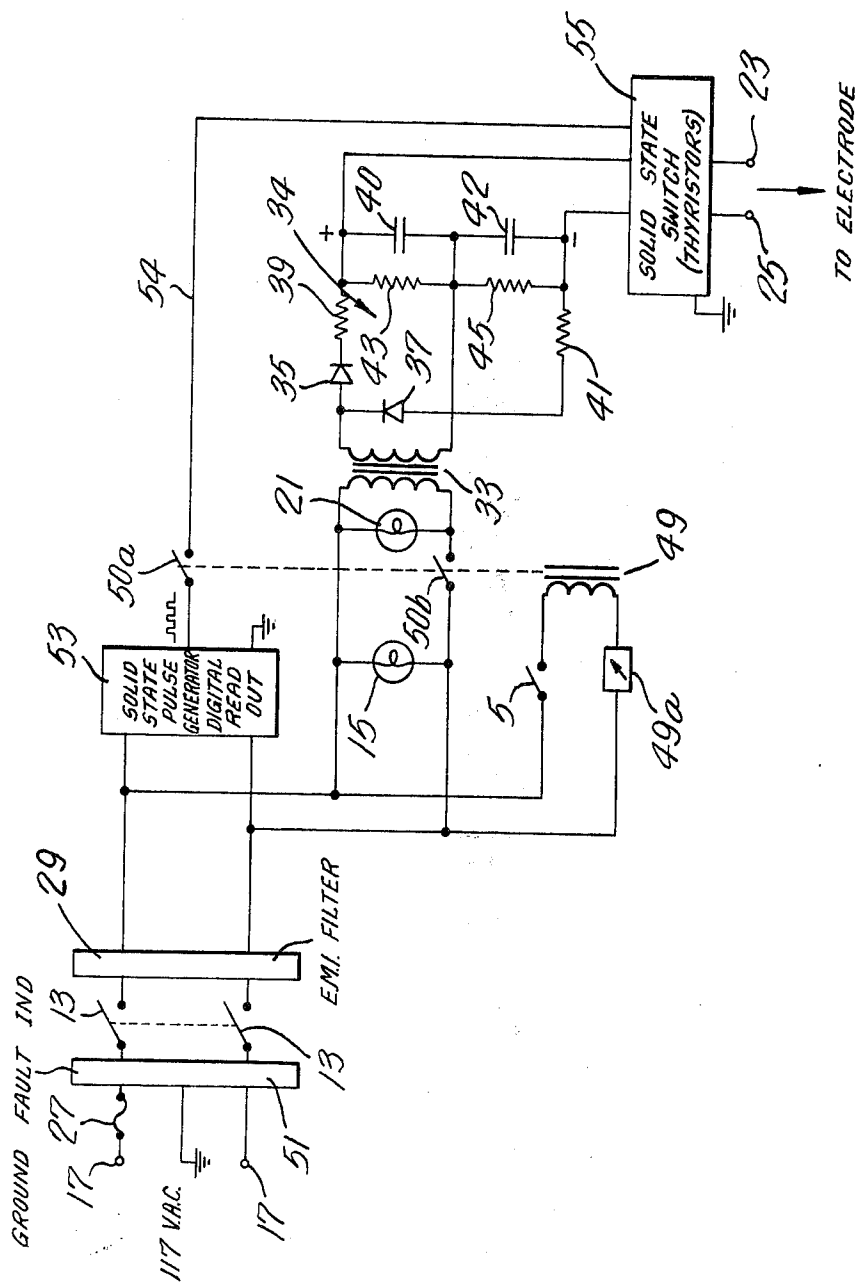


FIG. 2



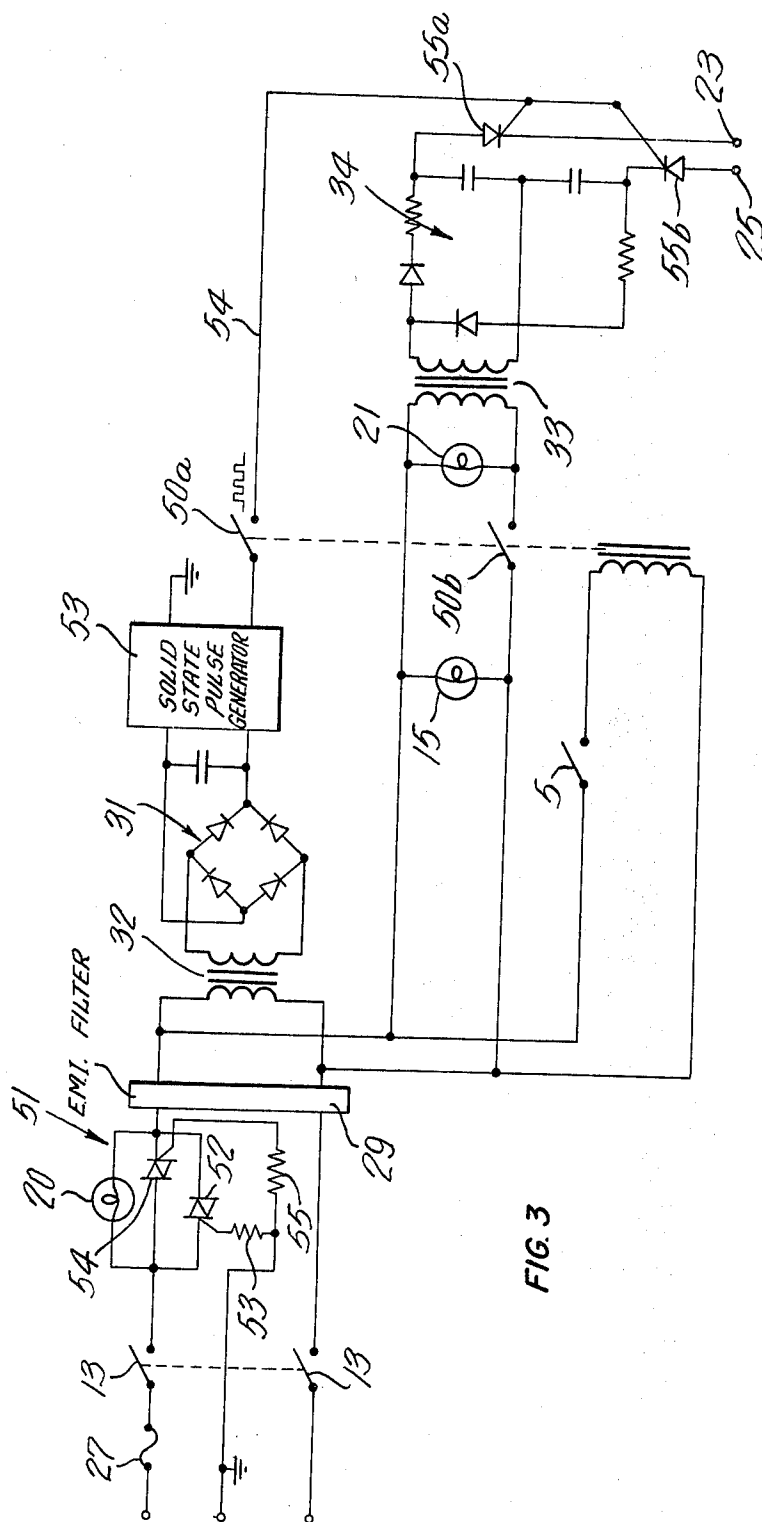


FIG. 3

STONE DISINTEGRATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an instrument for disintegrating calculi in the urinary tract by hydraulic impacts formed by electrical discharge in the liquid medium which surrounds the calculi, wherein capacitors, which charge lithotrites to form the electrical discharge, are discharged through circuits employing solid state devices.

2. Statement of the Prior Art

It is known in the art to use hydraulic impacts due to electrical discharge to disintegrate calculi in the urinary tract as is shown in U.S. Pat. No. 3,557,793, issued Jan. 26, 1971, J. G. Ediny et al, inventors, and U.S. Pat. No. 3,735,764, issued May 29, 1973, O. G. Balev et al, inventors. However, in both of these patents, the capacitors of the charging circuit for charging the electrodes of the lithotrites consist of spark gap arrangements. The spark gaps have the disadvantages of being temperature and humidity dependent so that, with the same setting on the output of the instruments, different intensity and frequency of hydraulic shock waves will be provided under different temperature, humidity and conditions. In addition, the spark gaps of the instruments require more service and maintenance than any other parts.

SUMMARY OF THE INVENTION

In order to overcome the disadvantages of the instruments known in the art, an instrument is provided wherein the spark discharge circuits employ solid state devices. Specifically, the solid state devices employed are solid state switches, preferably switches known as thyristors.

The thyristors are driven by a solid state pulse generator. In this way, the pulse width and frequency of the driving signal can be made continuously variable, and it is also possible to provide a digital readout of the signal driving the switches.

By varying the pulse width and frequency of the pulse generator, the intensity and repetition rate of the lithotrite discharge is made adjustable, and the different intensity and discharge rates can be made selectable by providing appropriate switches on the front face of the instrument.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood by an examination of the following description together with the accompanying drawings, in which:

FIG. 1 is a front view of an instrument front panel in accordance with the invention and including various items for connection thereto;

FIG. 2 is a block diagram in schematic form of the circuit for operating and controlling the instrument;

FIG. 3 is a circuit diagram in schematic form of the circuit for operating and controlling the instrument;

FIG. 4 is a preferred form of the lithotrite in accordance with the invention; and

FIGS. 4a and 4b are detailed views of the lithotrite of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, the instrument is designated

generally at 1 and comprises a front panel 3. The instrument preferably includes a foot pedal switch 5, the purpose of which will be discussed below. Connecting cables 7 and 9 constitute the remaining required peripheral items.

The front panel includes a continuously variable intensity-adjusting control 11. Varying the control 11 will change the pulse width of a solid state pulse generator as will be discussed in relation to FIGS. 2 and 3, and the meter 12 gives a digital indication of the pulse width and the frequency of the pulse generator. Power is switched to the instrument through ON/OFF switch 13, and lamp 15 is turned on when power is switched on. Power is brought to the instrument through power cable 7, which is plugged in, at one end, to a wall socket for 117v 60 Hz, and at the other end to socket 17 in the instrument. Socket 19 receives the plug at the end of the foot pedal switch cable. When the foot pedal switch 5 is activated, a circuit is completed to cause electrical discharges as will be discussed below. At the same time, lamp 21 will be turned on. Switch 10 selects the interval of continuous operation of the instrument as will be explained below.

Solid state switches (not shown) are connected to terminals 23 and 25. Connectors 9a and 9b on cable 9 are connected to terminals 23 and 25. The other end of cable 9 contains a lithotrite.

Fuse 27 is included with the instrument for purposes of safety as is well known to one skilled in the art.

The front face of the instrument also includes a ground fault indicator light 20. This light will come on whenever there is a ground fault in the instrument.

Referring now to FIG. 2, the circuit consists of an EMI filter 29 which receives the input power from plug 17. The power is supplied, through ON/OFF switch 13, to solid state pulse generator 53. The solid state pulse generator contains controls for varying the frequency of the pulse generator as well as the pulse duration of each cycle as is well known in the art. In addition, the solid state pulse generator will drive digital readout meters to give a visual readout of both the pulse frequency and the pulse duration.

The input voltage from the EMI filter is also applied, in a parallel arrangement, to timer relay 49. Relay 49 controls the operation of switch 50, consisting of two parts 50a and 50b. A third parallel path provides power to the lamps 15 and 21. As can be seen, the lamp 15 will be turned on when switch 13 is closed. Lamp 21 requires that both switch 13 and switch 50b be turned on before this lamp will be turned on.

In a third parallel arrangement, power is applied to transformer 33. The output winding of transformer 33 is connected to a pulse forming network indicated generally at 34. The pulse forming network consists of a full wave rectifier made up of diodes 35 and 37. Capacitors 40 and 42 are charged through resistors 39 and 41 respectively to provide output pulses. Preferably, 39 is equal in value to 41, and 40 is equal in value to 42 so that time constant of 39 and 40 is equal to the time constant of 41 and 42.

The common lead of the pulse forming network is connected, through solid state switch means 55 to terminal 23. The outer conductor of the lithotrite (see FIG. 4) is connected to terminal 23. The hot line of the pulse forming network is connected to terminal 25 through means 55. The center conductor of the lithotrite is connected to 25. Lead 54 connects the output

of the solid state generator to the solid state switch means 55.

As can be seen in FIG. 3, the solid state switch means preferably comprises thyristors 55a and 55b. The output of the solid state generator is connected to the gate electrodes of the thyristors. As is well known in the art, when a gating signal (a pulse from the solid state pulse generator) is supplied to the gate electrodes of the thyristors, then the thyristors are in the ON state and the output of the pulse forming network 34 is applied to terminals 23 and 25.

Although two thyristors are shown, it is of course realized that it may be possible to use only one thyristor in either one of the lines. Alternately, the two thyristors could be connected in series in the same line.

DC for driving the solid state generator is preferably provided from step-down transformer 32 and bridge rectifier 33 as is well known in the art.

The ground fault indicator 51 preferably comprises pairs of triac and resistor combinations 52, 53 and 54, 55. In addition, an indicator light 20 is included in the ground fault indicator circuit.

Bleeding resistors 43 and 45 are safety devices as is known in the art.

The timer relay 49 is preferably one of the type which latches for a given period of time, as determined by the setting on timing device 49a, before releasing. In the preferred embodiment, the relay will latch for periods of 1, 5 or 10 seconds. It is of course understood that different latching periods could be selected, and that the latching period could be made continuously selectable rather than discretely selectable as suggested in the above. Timing relays of this nature are well known in the art and require no further description here.

In operation, the circuit works as follows: When switch 13 is closed, power is provided to lamp 15 so that this lamp turns on. At the same time, power is provided to the input windings of transformer 32. When the switch 5 is closed (by stepping on the foot pedal) power is supplied to relay 49 so that the parts 50a and 50b of the switch 50 are closed. This provides power to the lamp 21 to turn it on, and at the same time, allows the output of the pulse generator 53 to be fed to thyristors 55a and 55b.

The voltage at the input to 33 is stepped up, and the output of the transformer is applied to the pulse forming network. Capacitors 40 and 42 charge up through their respective charging resistors 39 and 41 until they reach a voltage sufficient to cause a spark across the spark gap plates. The capacitors will, of course, be discharged through the thyristors when the thyristors are in the ON state — i.e., when pulses are applied to their gate electrodes — to provide pulses. The pulses, formed by the pulse forming networks, are then passed to the electrodes of the lithotrites, and a spark is discharged between these electrodes in the medium surrounding the calculi. This is what causes the electrohydraulic impact.

The intensity of the electrical discharge caused by the spark discharge is varied by varying the pulse width of the pulses of the generator 53. Decreasing the pulse width will decrease the intensity of the electrical discharge and vice-versa.

The repetition rate of the discharges is controllable by varying the frequency of the solid state pulse generator. There will, of course, be a one to one relationship

between the repetition rate of the generator and the repetition rate of the discharges.

A series of discharges will take place for the full period as set by the timing relay 49. After this full period has elapsed, in order to recommence operation, it will be necessary to once again step on the foot pedal. The light 21 on the front panel will light up whenever the instrument is in operation and will be extinguished when relay 49 releases to open switches 50a and 50b.

In considering the operation of the ground fault indicator 51, it is clear that, when there is a ground available, light 20 will not be lit up. However, when there is no ground, then triacs power will pass through the light 20, and this condition will then be indicated on the front face of the instrument and power to the instrument will be removed.

It will be appreciated that different combinations of intensity and repetition rate will have different effects on the calculi under attack. Thus, it is noted that round smooth calculi can be more quickly attacked for an initial fissure by providing a high intensity, lower repetition rate discharge. Other shapes and form of calculi may be more successfully attacked with different combinations.

A lithotrite for use with the inventive instrument is illustrated in FIG. 4. The lithotrite is generally indicated as 152 and is shown attached to the connecting cable 9. It consists of an outer conductor sleeve 153, insulation 154, center conductor 155 and outer insulation 157. In accordance with a preferred embodiment of the invention, fingers 156 extend from the end of the lithotrite. The fingers are preferably flexible and transparent and are used to retain the calculi when the instrument is in use. As shown in FIG. 4b, the fingers are made of the same material as the outer insulation 157. As smooth calculi have a tendency to roll away when subjected to an electrical discharge, the use of the flexible fingers will retain the calculi close to the discharge so that the full effect of the discharge will be felt by the calculi. This could shorten the time required to disintegrate the calculi.

In operation, the instrument is used in association with a cystoscope equipped with fibre optics. The lithotrite is inserted in the urinary bladder, which is filled with washing fluid. The lithotrite is then visually manipulated until the top of the lithotrite 152 is in contact with the calculus. The flexible fingers 156 tend to keep the lithotrite from slipping off the stone, especially a smooth stone. Power will have been turned on beforehand, so that it will merely be necessary for the operator to step on foot pedal switch 5 to initiate an electrical discharge in the fluid medium surrounding the calculus.

If the calculus is smooth or large, the intensity of the discharge will be made high by adjusting the control 11 on the front panel of the instrument. When initial fissures in the calculus are noted, the intensity can be turned down. Electrical discharges are applied until the calculus is so disintegrated that it can be removed by flushing.

Although a specific embodiment has been discussed in the foregoing, this was for the purpose of describing, but not limiting, the invention. Various modifications, which will come readily to the mind of one skilled in the art, are within the scope of the invention as defined in the appended claims.

I claim:

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1. An instrument for attacking calculi in a liquid medium surrounding the calculi, comprising:

lithotrite means comprising a first electrode and a second electrode spaced from said first electrode; means for providing electrical energy to said electrodes to cause a spark discharge between said first and second electrodes in said liquid medium, said means comprising capacitive storage means connected to a first output terminal and a second output terminal;

a first lead connecting said first output terminal to said first electrode and a second lead connecting said second output terminal to said second electrode;

a first solid state switch in said first lead between said first output terminal and said first electrode;

a second solid state switch in said second lead between said second output terminal and said second electrode; and

pulse generator means connected to said first and second solid state switches for providing control signals to said first and second solid state switches, said pulse generator means having means for varying the pulse duration and the pulse repetition rate of said control signals.

2. An instrument as defined in claim 1 wherein said solid state switches comprise thyristors having gate electrodes and said

pulse generator means is connected to the gate electrodes of said thyristors;

whereby the intensity and repetition rate of said spark discharge are variable.

3. An instrument for attacking calculi in the urinary tract by electro-hydraulic impacts in a liquid medium surrounding the calculi, comprising:

a pulse forming network having an input circuit for

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receiving input voltage to said pulse forming network;

said pulse forming network comprising capacitive storage means connected to two output leads;

solid state switch means in each of said output leads; said instrument further comprising a lithotrite having a first electrode and a second electrode spaced from said first electrode;

means for connecting one of said output leads to said first electrode;

means for connecting the other output lead to said second electrode; and

pulse generator means connected to said solid state switch means for providing control signals to said solid state switch means, said pulse generator means having means for varying the pulse duration and pulse repetition rate of said control signals.

4. An instrument as defined in claim 3 wherein said solid state switches comprise thyristors having gate electrodes and said

pulse generator means is connected to the gate electrodes of said thyristors;

whereby the intensity and repetition rate of said spark discharge are variable.

5. An instrument as defined in claim 3, wherein said first and second electrodes of said lithotrite are co-axially arranged;

said first electrode comprising an inner conductor in said co-axial arrangement;

and said second electrode comprising an outer conductor in said co-axial arrangement.

6. An instrument as defined in claim 5, wherein said lithotrite comprises flexible fingers extending therefrom.

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