

TITLE OF INVENTION: VIBROACOUSTIC DEVICE AND METHOD FOR TREATING RESTRICTIVE PULMONARY DISEASES AND IMPROVING DRAINAGE FUNCTION OF LUNGS

TECHNICAL FIELD

[0001] The present invention relates to a therapeutic device and methodology for the treatment of restrictive pulmonary diseases (such as Acute Lung Injury and Acute Respiratory Distress Syndrome) and obstructive pulmonary diseases, amongst others, using vibroacoustic effects which are applied to a patient's chest.

BACKGROUND

[0002] Patients with obstructive pulmonary diseases such as cystic fibrosis, bronchiectasis, bronchial asthma and Chronic Obstructive Pulmonary Disease ("**COPD**") often find it difficult to breathe and experience shortness of breath. This can be attributed to the poor drainage function of the patients' bronchi. Likewise, post-operative patients and especially those on mechanical ventilation also suffer from impaired breathing due to reduced and/or absent cough reflex.

[0003] For over a century, postural drainage and percussion have been widely used as a form of chest physiotherapy to improve bronchial drainage and sputum evacuation. However, such manual techniques are uncomfortable, labour intensive, time-consuming and may not be suitable for patients who have undergone thoracic or cardiovascular surgery.

[0004] Various apparatus such as the “Percussionaire”, “CoughAssist” pneumatic vests and vibrating devices have since been developed for the treatment of such obstructive pulmonary diseases.

[0005] For instance, the pneumatic device described in US Patent No. 7,115,104 by N P Van Brunt and D J Gagne produces high frequency chest wall oscillations for the purpose of improving lung airway clearance. The device is used in combination with an inflatable vest secured to the chest of the patient. On the other hand, the device disclosed in US Patent No. US 8,443,796 by A Hughes delivers acoustic vibrations into the airways while the patient breathes through a mouthpiece. Nevertheless, the efficacy of these devices and techniques have been limited as these devices cannot be effectively used for intubated patients and those with chest-wall injuries or wounds. Further, they also require relatively long treatment duration of at least 10 to 20 minutes per session. Such long treatment sessions may cause discomfort to patients, especially those who feel fatigued and/or breathless from their subsisting lung diseases and/or ailments.

[0006] There is also presently no therapeutic device which uses vibroacoustic influence for the treatment of restrictive pulmonary diseases such as Acute Lung Injury (“**ALI**”) or Acute Respiratory Distress Syndrome (“**ARDS**”). Currently, the treatment regimen for patients with ALI and ARDS typically consists of “Lung Recruitment Manoeuvres” using a ventilator to prevent the collapse and/or deflation of the alveoli. However, this form of treatment is dangerous and cannot therefore be used for all types of patients.

[0007] This is because such Lung Recruitment Manoeuvres involve the periodic increase of Positive End Expiratory Pressure (“**PEEP**”), creating a high peak airway pressure, in order to spread and expand the alveoli in the lungs. The residual pressure is then used to prevent alveolar deflation and/or collapse.

Due to the high levels of PEEP applied to open the alveoli, patients are inevitably exposed to the risks of damage to the lung parenchyma, development of multiple micro-atelectasis, and even potential pulmonary barotrauma (lung tissue rupture).

[0008] Therefore, an urgent need exists for a safe and effective method for treating restrictive pulmonary diseases. Further, there is also a need for an improved bronchial drainage technique which is effective while minimizing any discomfort or inconvenience caused to the patient. It is also desirable to have a comprehensive device that can be used in the treatment of both restrictive and obstructive pulmonary diseases for all types of patients, while preventing further complications at the same time.

[0009] Accordingly, the present invention seeks to obviate or mitigate all of the above limitations of the prior art by providing an efficacious solution to overcome the various shortcomings in the current treatment regimes.

SUMMARY OF THE INVENTION

[0010] The device in accordance with the present invention meets the above identified needs. It is thus an object of the invention to provide a method to effectively deliver vibroacoustic influence to promote the opening of atelectatic alveoli in the treatment of restrictive pulmonary diseases.

[0011] According to one aspect of the invention, a method is provided for the treatment of restrictive pulmonary diseases such as pneumonia, interstitial lung disease, ALI and ARDS, which occur when there is a built up of atelectasis in the lung tissue. The application of vibroacoustic effects on the lungs have yielded good results in the prevention of atelectasis, and enables the alveoli to

be maintained in an open state without the need for aggressive Lung Recruitment Manoeuvres. When used against the background of residual pressure (i.e. constant low positive airway pressure sufficient to maintain the alveoli in an open state), the vibrations and resonance effect promote the unfolding of the alveoli. The use of high peak airway pressure is therefore not required. This technique can be described as “Vibroresonance-Recruitment-Manoeuvre”.

[0012] Further, the Vibroresonance-Recruitment-Manoeuvre can be combined with the use of artificial pulmonary ventilation or non-invasive ventilation, depending on the severity of the patient’s condition. For instance, where the patient breathes through a mask against the backdrop of Constant Positive Pressure Airway Pressure (“**CPAP**”). In mild cases, it may be sufficient to apply the Vibroresonance-Recruitment-Manoeuvre technique to breathing exercises and/or the use of breathing simulators to maintain the alveoli in an open state and prevent alveolar deflation and/or collapse.

[0013] Another positive effect of the Vibroresonance-Recruitment-Manoeuvre technique is the increased hydrostatic fluid redistribution in patients. As a result of lying in a supine position for long periods of time, fluids gradually collect in the lower-back departments of the patients’ lungs and interstitial tissue due to gravity. To improve the ventilation of the lower lung departments and redistribution of the fluids, patients often undergo kinetic therapy. From time to time, the patient is turned from one side to another, and is even made to lie face-down for long periods of time. However, this method is time-consuming and can be extremely uncomfortable for patients, especially when there is significant respiratory distress.

[0014] When used in combination with kinetic therapy, the application of vibroacoustic effects on those departments of lungs situated in a higher

position enables the redistribution of fluids by gravity to be accelerated. Further, the vibroacoustic influence also promotes the opening of the atelectatic alveolus and drainage along the adducting bronchi. This further improves the drainage of fluids in the lungs and interstitial tissue within a shorter period of time.

[0015] As described above, not only does the present invention increase the lung breathing volume of patients suffering from restrictive lung diseases, it also prevents hypostatic pneumonia and complications in patients with COPD due to the built up of fluids in intubated patients.

[0016] It is another object of the present invention to provide a vibroacoustic apparatus to improve the drainage function of the bronchi, using a sufficiently wide frequency range of between 20 Hz to 300 Hz. Using acoustic spectrum measurements, the resonant frequency of the lungs was observed to be between the range of 20 Hz to 300 Hz in general. As such, the wide frequency range produced by the device would allow the vibroacoustic effects to be propagated effectively to the various components of the lungs, and thereby increase the efficacy of the treatment.

[0017] To improve the bronchial drainage, vibroacoustic influence is applied to the patient's chest. The complex modulating signal generated by the device has a number of effects, including vibration, reverberation, excitation and resonance, which contributes to the release and movement of sputum. The vibrations are propagated to the lung parenchyma, causing the loosening of bronchial mucus from the bronchial walls. Under the influence of vibrations, more sections of the lung parenchyma are exposed to greater frequency fluctuations which promotes the movement of sputum from the small and medium-sized bronchi to the larger bronchi and eventually out of the lungs.

[0018] The present invention thus replaces manual chest massages via other percussion-oriented methods and/or devices, and significantly increases the effectiveness of sputum evacuation. As a result, the duration of each treatment session can be reduced to less than 5 minutes per session.

[0019] Depending on the severity of the patient's condition, the vibroacoustic influence can be synchronised with the patient's respiratory cycles for greater effectiveness, while minimizing the exposure of other damaged organs to vibratory effects. For example, the treatment can be customised for patients with cerebral edema as well, amongst others.

[0020] In the ideal embodiment of the invention, the device comprises of a main module connected to a set of interchangeable transducers. The electric signals generated by the main module are then modulated in frequency and amplitude, and converted into acoustic waves and vibrations. The sinusoidal shape of the main carrier signal allows for maximum physiological effect, while the complex shape of the modulating signal provides a number of effects including resonance, percussion and sawtooth modulation. The modulating signals within a wide frequency range allows various components of lung tissues to be reached at different frequencies and amplitudes, thereby maximising the efficiency of the treatment.

[0021] According to one embodiment, the patient will be maintained in a position to allow the affected areas of the lungs to be elevated while vibroacoustic effect is applied by manually placing the vibroacoustic transducer over the surface of the chest. The compression-type dynamic head of the vibroacoustic transducer is contained in a plastic housing with holes for ventilation, and the vibrating membrane in the dynamic head has no direct contact with the irradiated surface. The dynamic head unit is framed with a soft

elastic protective cover, which greatly reduces the sound and vibration level transmitted to the operator's hands. The anterior part is made of silicone for a comfortable adherence to the chest.

[0022] When the vibroacoustic transducer is activated, the vibrating membrane produces fluctuations in air pressure. Sealing nozzle between the membrane and the irradiated surface form a chamber of high acoustic pressure. Due to the relatively high frequency and sufficiently high amplitude vibrations of the membrane, the vibrations can be effectively transmitted to and within the patient's chest even in the absence of an airtight seal. In this regard, the vibroacoustic transducer can be applied through cloth pads, medical sheets, napkins and clothing.

[0023] In a further embodiment, the invention may include an attachment which consists of two arms connected by a hinge mechanism, in which transducers are located in the two arms ("**Vibrowrap**"). Special closed-type heads are used as the transducers which has a design similar to vibro-transducers or bass shakers. The Vibrowrap is fastened to the upper regions of the patient's chest, and can therefore also be used for bedridden patients or those with chest wall injuries. The configuration of the Vibrowrap is such that it covers less than half of the patient's chest. The inner surface of the Vibrowrap is covered with a layer of silicone to ensure a dense and comfortable adherence to the surface of the chest. To reduce the risk of bacterial contamination, all surfaces of the Vibrowrap are made of materials which are easy to clean and can be disinfected. Depending on the age and built of the patient, the number of transducers and their output capacity may be adjusted accordingly.

[0024] In another embodiment, the Vibrowrap can be configured in such a way as to allow the vibroacoustic effects to be applied to one lung when the patient is placed in a lateral position.

[0025] In another embodiment, the Vibrowrap can be fastened to the patient's back and the vibroacoustic effects can be applied to both lungs on the same plane when the patient is resting in a prone position

[0026] To reduce ambient noise and control the quality of the vibroacoustic effects, the invention further comprises of in-built optical sensors. These sensors can be installed in the vibroacoustic transducers or in the arms of the Vibrowrap. An automatic pause is activated when the optical sensors detect an absence of contact with the patient's body. This feature further prevents the transducers from premature wear when the device is in an idle state.

[0027] In another embodiment of the invention, vibroacoustic transducers are used in combination with the Vibrowrap to increase the area of exposure and/or provide a greater amplitude of pressure fluctuations in the lungs. A larger contact area with the patient's chest reduces any discomfort caused by high pressure concentration.

[0028] In the preferred embodiment of the invention, the device is equipped with at least three types of patient profiles and at least ten pre-installed treatment program or pre-determined settings or modes for the treatment of different pulmonary diseases and/or conditions, as may have been described above or otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The following descriptions, considered together with the accompanying drawings will provide a more detailed explanation of the invention. The

components in the drawings are not necessarily drawn to scale, with emphasis instead being placed upon clearly illustrating the principles of the present invention, wherein:

[0030] Fig. 1 is an overview of the general principle of operation of the device.

[0031] Fig. 2 is a flow diagram of an alternative embodiment of the device in Fig. 1. This diagram can be expanded or simplified, according to the various options selected.

[0032] Fig. 3 shows an overview of the approximate frequency emphasis of a particular treatment program for the prevention of pulmonary complications.

[0033] Fig. 4 shows the changes in the frequency of the modulating signal over time.

[0034] Fig. 5 is a cross sectional view of one embodiment of the vibroacoustic transducer in accordance with the present disclosure.

[0035] Fig. 6 is a cross sectional view of one embodiment of the Vibrowrap in accordance with the present disclosure showing the use of 3 tactile transducers in each arm of the Vibrowrap.

[0036] Fig. 7 is a cross sectional view of one embodiment of the vibroacoustic transducer which shows the surface of the detachable sealing nozzle having a recess for placement on the side of the patient's chest.

DETAILED DESCRIPTION

[0037] The present invention provides a vibroacoustic device which generates electric signals of a variable or floating frequency between 20 Hz to 300 Hz, which are converted by transducers into acoustic waves (i.e. sound) and vibrations. The amplitude, wave shape, range and frequency of the signals can be varied according to the patient's requirements. The device identifies the type of vibroacoustic transducer connected to the main unit, and automatically adjusts the signal characteristics, output power and intensity of exposure as required.

[0038] At the start of the treatment session, the operator is able to select the age category and body type of the patient. Depending on the selected age category, the device automatically limits the maximum output power, thus providing additional safeguards against excessive vibroacoustic exposure to young children or patients above the age of 60. The intensity of exposure is also automatically adjusted depending on the physique of the patient. For example, the intensity is reduced for patients with hyposthenic body types, whereas the intensity of exposure increases accordingly for patients with a higher body mass index.

[0039] After the appropriate treatment program has been selected, the device allows the operator to further control and regulate the intensity of exposure within the framework of pre-set limits, which have been determined by age and body type.

[0040] An embodiment of the device as shown in Fig. 1 consists of a main unit **10** which further comprises of a control panel **11**, program archive **12**, Waveform Generator **13**, and two controllable power amplifiers (AMP A) **17** and

(AMP B) **18**. The main unit is connected to a set of transducers **21** and **22**. Optionally, Synchronisation Module **29** can be used in the device, which synchronises the treatment program with the patient's breathing. The synchronisation of certain treatment programs with the patient's breathing may increase the effectiveness of the treatment.

[0041] When in use, the Microprocessor Control Unit (MCU) **14** generates a sequence of electrical or analog signals based on the program selected on the control panel **11**. These signals are then synthesised by the DDS (Channel B) **15** and DDS (Channel A) **16** and modulated to produce sinusoidal signals of the required form and frequency. The signals arrive at the input terminals of the power amplifiers (AMP A) **17** and (AMP B) **18** and are boosted according to the amplification factor of the specific program. This ensures that the signals are sufficiently amplified to the levels required for the efficient operation of the transducers. The amplified signals then pass through the protection modules **19** and **20** before arriving at the transducers **21** and **22**. The protection module is designed to disconnect the outputs of the main unit **10**, in the event of malfunction. The transducers **21** and **22** then convert the signals into acoustic waves and vibrations **23** and **24**.

[0042] The device has two independent channels, and the signals arriving at the transducers **21** and **22** may differ from each other, depending on the patient profile, pathology and treatment program selected.

[0043] The operation of the device is controlled by the Central Processor Unit (CPU) **26** located in the control panel **11**. The user inputs are supplied to the CPU and operational status is displayed to the operator via the touchscreen display **25**.

[0044] Fig. 2 is a flow diagram which shows the major components in the control panel referenced as **11** in Fig. 1. The touchscreen display **25** allows the operator to select the required program from the pre-installed programs stored in the program archive **12**, navigate the main menu, and input commands to control and operate the device. For instance, the maximum output capacity level can be lowered or otherwise adjusted for children and elderly patients or those who are recovering from surgery. This safety feature reduces the possible adverse effects of vibration on the chest and organs for such patients. Further, patient records and treatment information may be stored in the Solid State Drive (SSD) Storage **27** to create a patient database. To begin treatment, an appropriate program is selected from one of the pre-installed programs stored in the program archive **12** using the touchscreen display **25**.

[0045] The optional Synchronisation Module **29**, which provides synchronization with the patient's breathing, consists of a Breath Detector **30** that detects the respiratory phases by signals from the Impedance Meter **31** and the Air Pressure Meter **32**. The Impedance Meter **31** is connected to sensors **34** that measure the impedance of the chest muscles that determines the phases of breathing. A pressure sensor **33** is connected to the Air Pressure Meter **32**, which is further connected to the breathing circuit of a ventilator (not shown). This sensor is only used on patients connected to the ventilator.

[0046] The graph in Fig. 3 shows the approximate frequency emphasis when the program for prevention of pulmonary complications is selected. The y-axis in Fig. 3 indicates the percentage of the total duration of treatment, while the x-axis measures the frequencies of the wave emitted by the device. Fig. 3 shows that during treatment, wave frequencies from 20 – 40Hz are most commonly produced as compared to wave frequencies above 60Hz.

[0047] Acoustic waves with lower frequencies between 20 - 60Hz are able to penetrate the lungs most deeply and ensure that the alveoli and tracheobronchial tree are kept open. Therefore, such wave frequencies between 20 - 60Hz are effective for treating ARDS, ALI and severe pneumonia.

[0048] Acoustic waves with higher frequencies between 61 - 240Hz are used to treat chronic obstructive pulmonary diseases as the frequency range coincides with the resonant frequency of the bronchial walls and tracheobronchial tree. As a result, the vibroacoustic effects produced are able to penetrate deep into the lungs to cause intensive vibration of the bronchi, and thereby encourage drainage of fluids in the lungs and interstitial tissues.

[0049] The device is further able to generate high-frequency acoustic waves between 241 - 300Hz, which do not penetrate into the greater depth of the thoracic segment. Such high-frequency waves are produced less often than the other types of waves frequencies. Nevertheless, they are still effective for mucociliary clearance of the smaller bronchi, especially for patients with severe conditions in the intensive care unit.

[0050] Fig. 4 shows the change in frequency in a fragment of the modulating signals when the program for prevention of pulmonary complications is in operation. This particular program uses a combination of fast and slow modulations for patients that require resuscitation. The graph in Fig. 4 illustrates the intervals of rapid changes in frequency over a period of 25 seconds.

[0051] For lower frequency waves between 20 – 60Hz, slow modulations are effective for treating severe pulmonary restriction, ARDS and severe forms of pneumonia, whereas moderate modulations of these lower frequency waves

are used for the treatment of pulmonary edema and perfusion-type respiratory failure.

[0052] As for higher frequency waves between 61 - 200Hz, slower modulations are used to treat acute broncho-obstructive disease and bronchial asthma. On the other hand, rapid modulations of such higher frequencies waves are more effective in treating obstructive pulmonary diseases and mild pneumonia.

[0053] Fig. 5 is a cross sectional view of one embodiment of the vibroacoustic transducer **500** in accordance with the present disclosure.

[0054] The handheld vibroacoustic transducer **500** comprises of a compression-type dynamic head contained in a plastic housing **512** and framed with a soft elastic protective cover **511**. A plurality of holes in the plastic housing **517** on the back part of the vibroacoustic transducer provide an opening for air outlet and ventilation. The vibrating membrane **513** in the dynamic head is made of plastic and has no direct contact with the irradiated surface. A protective grille **514** installed in front of the membrane further prevents accidental contact with the vibrating membrane. The front part of the transducer consists of a silicone seal **515** which can be removed for the purposes of cleaning and disinfecting the device.

[0055] The optical sensor **516** detects whether or not the vibroacoustic transducer is in contact with the patient's body. When the optical sensors detect that there is no contact between the patient and both transducers, the message is transmitted to the CPU **26** which temporarily deactivates the transducers by preventing the signals from reaching the transducers. This results in an automatic pause, and which is indicated on the touchscreen display **25**. The procedure resumes when there is contact with at least one of the transducers.

[0056] The vibroacoustic transducer **500** is connected to the main unit **10** via insulated flexible cables within (not shown), which enables a wide range of motion without having to move the main unit. The vibroacoustic transducer is held by the operator and manually applied to the surface of the patient's chest. It is preferable to protect the front part of the vibroacoustic transducer with protective disposable covers, made of materials such as polyethylene, before each treatment, to reduce any risk of bacterial contamination between patients.

[0057] There are several types of vibroacoustic transducers available for different age categories of patients. For example, child vibroacoustic transducers are specially configured for infants and young children while the universal vibroacoustic transducers are designed to be used on adults and children above the age of three.

[0058] The universal vibroacoustic transducer designed for an adult patient has a diameter of approximately 10 cm, and the amplitude of pressure fluctuations, when pressed to the surface of the chest at maximum capacity, can reach up to 70-75 mbar. As this amplitude may be insufficient for effective treatment in most cases, it is therefore preferable to use both transducers simultaneously to increase the area of exposure and total output capacity, while minimising any discomfort caused to the patient.

[0059] The child vibroacoustic transducer are of a smaller dimension, have a smaller effective surface area and a lower output capacity than the universal vibroacoustic transducer. The diameter of the child vibroacoustic transducer is generally approximately 7-8 cm. Despite the smaller surface area, the child vibroacoustic transducer is nevertheless still able to generate sufficient pressure of up to about 60 mbar, when it is operating at maximum power. Child vibroacoustic transducers specially designed for younger children under the

age of one have an even smaller diameter of approximately 4-6 cm and generate lower pressure of no more than 35 mbar.

[0060] In some embodiments of the invention, the vibroacoustic transducer may comprise a quick-release detachable and replaceable sealing nozzle. The shape and elasticity of the front surface of the sealing nozzle may differ to allow for easy placement on the surface of the patient's chest. For example, a recess created on the front surface of the sealing nozzle **702** allows the vibroacoustic transducer to be applied to the sides of the patient chest. The quick-release mechanism **701** may be made of plastic snaps or neodymium magnets which allows the sealing nozzle **702** to be easily separated from the plastic housing of the vibroacoustic transducer and replaced.

[0061] In an alternative embodiment of the invention, the Vibrowrap **600** can be connected to the main unit **10** of the device through a cable instead of the vibroacoustic transducer(s). Unlike the vibroacoustic transducer, the Vibrowrap **600** produces a narrower frequency range and is fastened to the patient's chest using elastic straps.

[0062] Fig. 6 is a cross sectional view of one embodiment of the Vibrowrap **600** which consists of two arms **611** and **612** connected by a hinge mechanism **613**. A plurality of tactile transducers **614** are embedded on a flexible rectangular base located in both arms. Depending on the age and build of the patients, the number of transducers and their overall dimensions and capacity can be adjusted accordingly. The inner surface of the Vibrowrap **615** is covered with a layer of silicone to ensure a dense and comfortable adherence to the surface of the chest. The outer surface **616** may be made of artificial vinyl leather or medical leatherette. All surfaces of the Vibrowrap are made of material which are easy to clean and can be disinfected to reduce the risk of bacterial contamination

[0063] The configuration of the Vibrowrap is such that it covers less than half of the patient's chest. The Vibrowrap is fastened to the upper regions of the chest, and can therefore also be used for bedridden patients or those with chest wall injuries. A child-friendly or child Vibrowrap is also available for the treatment of children.

CLAIMS

What is claimed is:

1. A method for treating restrictive pulmonary diseases, the method comprising the steps of:
 - (a) generating electric signals which are modulated to produce sinusoidal signals of a wide frequency range of about 20 Hz to 300 Hz;
 - (b) converting said complex modulating signals into vibroacoustic waves and creating resonance effect; and
 - (c) propagating the vibroacoustic effects to the lung parenchyma

to promote the opening of deflated and/or collapsed alveoli, and thereby increasing the lung breathing volume of the patient in order to treat restrictive pulmonary diseases.
2. The method of Claim 1, wherein the amplitude and frequency of the signals and complex form of modulation may be varied for the treatment of different physiological effects.
3. A method of Claim 1, where the method may be applied in combination with the use of breathing exercises or breathing simulators, to maintain the alveoli in an open state, according to the severity of the patient's condition.

4. A device for treating restrictive pulmonary diseases and improving drainage function of the patient's lungs, the system comprising:
 - (a) a main unit, which further comprises a waveform generator for generating electric signals, a control panel, power amplifiers and a protection module which disconnects the output of the main unit in the event of malfunction; and
 - (b) at least one replaceable transducer connected to the main unit which converts said signals into acoustic waves and vibrations,wherein the vibroacoustic effects are applied to the surface of the patient's chest to treat the disease and/or improve fluid drainage in the lungs.
5. The device of Claim 4, wherein the electric signals generated have a wide frequency range of about 20 Hz to 300 Hz.
6. The device of Claim 4, further comprises a synchronisation module, located in the main unit, which synchronises the vibroacoustic effects with the patient's breathing to minimise the exposure of the other organs to the vibratory effects of the treatment.
7. The device of Claim 4, wherein the transducer comprises of a compression-type dynamic head contained in a plastic housing and framed with a soft elastic protective cover. The transducer is held by the operator and manually applied to the surface of the patient's chest. The structural configuration and output capacity of the transducer may vary according to the age category of the patient.

8. The device of Claim 7, wherein the handheld transducer further comprises a quick-release and detachable sealing nozzle which may differ in shape and elasticity to facilitate placement on all sides of the patient's chest.
9. A device of Claim 4, wherein a plurality of transducers are positioned within two flexible rectangular bases connected by a hinge mechanism, and which is affixed to and covers less than half of the patient's chest. The number of transducers and their output capacity may be adjusted according to the age and build of the patient.
10. The device of Claim 4, wherein the device identifies the type of transducer connected to the main unit, and automatically adjusts the signal characteristics, output power and intensity of exposure as required.