

BODY PULSTATING APPARATUS AND METHOD

Cross Reference to Related Application

[0001] None.

Field of the Invention

- 5 [0002] The invention relates to a medical device operable with a thoracic therapy garment and method to apply repetitive compression forces to the body of a person to aid blood circulation, loosen and eliminate mucus from the lungs and trachea and relieve muscular and nerve tensions.

Background of the Invention

- 10 [0003] Clearance of mucus from the respiratory tract in healthy individuals is accomplished primarily by the body's normal mucociliary action and cough. Under normal conditions these mechanisms are very efficient. Impairment of the normal mucociliary transport system or hypersecretion of respiratory mucus results in an accumulation of mucus and debris in the lungs and can cause severe medical complications such as hypoxemia, hypercapnia, chronic
15 bronchitis and pneumonia. These complications can result in a diminished quality of life or even become a cause of death. Abnormal respiratory mucus clearance is a manifestation of many medical conditions such as pertussis, cystic fibrosis, atelectasis, bronchiectasis, cavitating lung disease, vitamin A deficiency, chronic obstructive pulmonary disease, asthma, immotile cilia syndrome and neuromuscular conditions. Exposure to cigarette smoke, air
20 pollutants and viral infections also adversely affect mucociliary function. Post surgical patients, paralyzed persons, and newborns with respiratory distress syndrome also exhibit reduced mucociliary transport.

- [0004] Chest physiotherapy has had a long history of clinical efficacy and is typically a part of standard medical regimens to enhance respiratory mucus transport. Chest physiotherapy
25 can include mechanical manipulation of the chest, postural drainage with vibration, directed cough, active cycle of breathing and autogenic drainage. External manipulation of the chest

and respiratory behavioral training are accepted practices. The various methods of chest physiotherapy to enhance mucus clearance are frequently combined for optimal efficacy and are prescriptively individualized for each patient by the attending physician.

[0005] Cystic fibrosis (CF) is the most common inherited life-threatening genetic disease

5 among Caucasians. The genetic defect disrupts chloride transfer in and out of cells, causing the normal mucus from the exocrine glands to become very thick and sticky, eventually blocking ducts of the glands in the pancreas, lungs and liver. Disruption of the pancreatic glands prevents secretion of important digestive enzymes and causes intestinal problems that can lead to malnutrition. In addition, the thick mucus accumulates in the lung's respiratory

10 tracts, causing chronic infections, scarring, and decreased vital capacity. Normal coughing is not sufficient to dislodge these mucus deposits. CF usually appears during the first 10 years of life, often in infancy. Until recently, children with CF were not expected to live into their teens. However, with advances in digestive enzyme supplementation, anti-inflammatory therapy, chest physical therapy, and antibiotics, the median life expectancy has increased to

15 30 years with some patients living into their 50s and beyond. CF is inherited through a recessive gene, meaning that if both parents carry the gene, there is a 25 percent chance that an offspring will have the disease, a 50 percent chance they will be a carrier and a 25 percent chance they will be genetically unaffected. Some individuals who inherit mutated genes from both parents do not develop the disease. The normal progression of CF includes

20 gastrointestinal problems, failure to thrive, repeated and multiple lung infections, and death due to respiratory insufficiency. While some persons experience grave gastrointestinal symptoms, the majority of CF persons (90 percent) ultimately succumb to respiratory problems.

[0006] Virtually all persons with cystic fibrosis (CF) require respiratory therapy as a daily

25 part of their care regimen. The buildup of thick, sticky mucus in the lungs clogs airways and traps bacteria, providing an ideal environment for respiratory infections and chronic

inflammation. This inflammation causes permanent scarring of the lung tissue, reducing the capacity of the lungs to absorb oxygen and, ultimately, sustain life. Respiratory therapy must be performed, even when the person is feeling well, to prevent infections and maintain vital capacity. Traditionally, care providers perform Chest Physical Therapy (CPT) one to four times per day. CPT consists of a person lying in one of twelve positions while a caregiver “claps” or pounds on the chest and back over each lobe of the lung. To treat all areas of the lung in all twelve positions requires pounding for half to three-quarters of an hour along with inhalation therapy. CPT clears the mucus by shaking loose airway secretions through chest percussions and draining the loosened mucus toward the mouth. Active coughing is required to ultimately remove the loosened mucus. CPT requires the assistance of a caregiver, often a family member but a nurse or respiratory therapist if one is not available. It is a physically exhausting process for both the CF person and the caregiver. Patient and caregiver non-compliance with prescribed protocols is a well-recognized problem that renders this method ineffective. CPT effectiveness is also highly technique sensitive and degrades as the giver becomes tired. The requirement that a second person be available to perform the therapy severely limits the independence of the CF person.

[0007] Persons confined to beds and chairs having adverse respiratory conditions, such as CF and airway clearance therapy, are treated with pressure pulsating devices that subject the person's thorax with high frequency pressure pulses to assist the lung breathing functions and blood circulation. The pressure pulsating devices are operatively coupled to thoracic therapy garments adapted to be worn around the person's upper body. In hospital, medical clinic, and home care applications, persons require easy application and low cost disposable thoracic garments connectable to portable air pressure pulsating devices that can be selectively located adjacent the left or right side of the persons.

[0008] Artificial pressure pulsating devices for applying and relieving pressure on the thorax of a person have been used to assist in lung breathing functions, and loosening and

eliminating mucus from the lungs of CF persons. Subjecting the person's chest and lungs to pressure pulses or vibrations decreases the viscosity of lung and air passage mucus, thereby enhancing fluid mobility and removal from the lungs. An example of a body pulsating method and device disclosed by C. N. Hansen in U.S. Pat. No. 6,547,749, incorporated herein

5 by reference, has a case accommodating an air pressure and pulse generator. A handle pivotally mounted on the case is used as a hand grip to facilitate transport of the generator.

The case including the generator must be carried by a person to different locations to provide treatment to individuals in need of respiratory therapy. These devices use vests having air-accommodating bladders that surround the chests of persons. An example of a vest used with

10 a body pulsating device is disclosed by C. N. Hansen and L. J. Helgeson in U.S. Pat. No.

6,676,614. The vest is used with an air pressure and pulse generator. Mechanical

mechanisms, such as solenoid or motor-operated air valves, bellows and pistons are disclosed in the prior art to supply air under pressure to diaphragms and bladders in a regular pattern or pulses. Manually operated controls are used to adjust the pressure of the air and air pulse

15 frequency for each person treatment and during the treatment. The bladder worn around the thorax of the CF person repeatedly compresses and releases the thorax at frequencies as high as 25 cycles per second. Each compression produces a rush of air through the lobes of the lungs that shears the secretions from the sides of the airways and propels them toward the mouth where they can be removed by normal coughing. Examples of chest compression

20 medical devices are disclosed in the following U.S. patents.

[0009] W. J. Warwick and L. G. Hansen in U.S. Pat. Nos. 4,838,263 and 5,056,505 disclose

a chest compression apparatus having a chest vest surrounding a person's chest. A motor-driven rotary valve located in a housing located on a table allows air to flow into the vest and vent air therefrom to apply pressurized pulses to the person's chest. An alternative pulse

25 pumping system has a pair of bellows connected to a crankshaft with rods operated with a dc electric motor. The speed of the motor is regulated with a controller to control the frequency

of the pressure pulses applied to the vest. The patient controls the pressure of the air in the vest by opening and closing the end of an air vent tube. The apparatus must be carried by a person to different locations to provide treatment to persons in need of respiratory therapy.

[0010] M. Gelfand in U.S. Pat. No. 5,769,800 discloses a vest design for a cardiopulmonary resuscitation system having a pneumatic control unit equipped with wheels to allow the control unit to be moved along a support surface.

[0011] N. P. Van Brunt and D. J. Gagne in U.S. Pat. Nos. 5,769,797 and 6,036,662 disclose an oscillatory chest compression device having an air pulse generator including a wall with an air chamber and a diaphragm mounted on the wall and exposed to the air chamber. A rod pivotally connected to the diaphragm and rotatably connected to a crankshaft transmits force to the diaphragm during rotation of the crankshaft. An electric motor drives the crankshaft at selected controlled speeds to regulate the frequency of the air pulses generated by the moving diaphragm. A blower delivers air to the air chamber to maintain a positive pressure above atmospheric pressure of the air in the chamber. Controls for the motors that move the diaphragm and rotate the blower are responsive to the air pressure pulses and pressure of the air in the air chamber. These controls have air pulse and air pressure responsive feedback systems that regulate the operating speeds of the motors to control the pulse frequency and air pressure in the vest. The air pulse generator is a mobile unit having a handle and a pair of wheels.

[0012] C. N. Hansen in U.S. Pat. No. 6,547,749 also discloses a body pulsating apparatus having diaphragms operatively connected to a dc motor to generate air pressure pulses directed to a vest that subjects a person's body to high frequency pressure forces. A first manual control operates to control the speed of the motor to regulate the frequency of the air pressure pulses. A second manual control operates an air flow control valve to adjust the pressure of the air directed to the vest thereby regulating the vest pressure on the person's body. An increase or decrease of the speed of the motor changes the frequency of the air

pressure pulses and the vest pressure on the person's body. The second manual control must be used by the person or caregiver to adjust the vest pressure to maintain a selected vest pressure.

[0013] C. N. Hansen, P. C. Cross and L. H. Helgeson in U.S. Pat. No. 7,537,575 discloses a

5 method and apparatus for applying pressure and high frequency pressure pulses to the upper body of a person. A first user programmable memory controls the time of operation of a motor that operates the apparatus to control the duration of the supply of air under pressure and air pressure pulses to a vest located around the upper body of the person. A second user programmable memory controls the speed of the motor to regulate the frequency of the air
10 pressure pulses directed to the vest. A manual operated air flow control valve adjusts the pressure of air directed to the vest thereby regulating the vest pressure on the person's upper body. An increase or decrease of the speed of the motor changes the frequency of the air pressure pulses and changes the vest pressure on the person's upper body. The manually operated air flow control valve must be used by the person or caregiver to maintain a selected
15 vest pressure. The vest pressure is not programmed to maintain a selected vest air pressure.

[0014] N. P. Van Brunt and M. A. Weber in U.S. Pat. No. 7,121,808 discloses a high frequency air pulse generator having an air pulse module with an electric motor. The module includes first and second diaphragm assemblies driven with a crankshaft operatively connected to the electric motor. The air pulse module oscillates the air in a sinusoidal
20 waveform pattern within the air chamber assembly at a selected frequency. A steady state air pressure is established in the air chamber with a blower driven with a separate electric motor. A control board carries electronic circuitry for controlling the operation of the air pulse module. Heat dissipating structure is used to maximize the release of heat from the heat generated by the electronic circuitry and electric motors.

Summary of the Invention

[0015] The invention is a medical device and method to deliver high-frequency thoracic wall oscillations to promote airway clearance and improve bronchial drainage in humans. The primary components of the device include an air pulse generator with user programmable

5 time, frequency and pressure controls, an air inflatable thoracic garment, and a flexible hose coupling the air pulse generator to the thoracic garment for transmitting air pressure and pressure pulses from the air pulse generator to the thoracic garment. The air pulse generator has an air displacer assembly that provides consistent and positive air displacement, air

10 pressure and air flow to the thoracic garment. The air displacer assembly has two rigid one-piece members or displacers that angularly move relative to each other to draw air from an air flow control valve and discharge air pressure pulses at selected frequencies to the thoracic garment. An alternative air displacer assembly has one rigid one-piece displacer that

15 angularly moves to draw air from an air flow control valve and discharge air pressure pulses at selected frequencies to the thoracic garment to subject the thoracic wall of a person to high-frequency oscillations. Diaphragms and elastic members are not used in the air

20 displacer assembly. A power drive system including separate eccentric crankshaft power transmissions angularly move the rigid displacers in opposite directions. These eccentric crankshafts power transmissions are driven by a variable speed electric motor regulated with a programmable controller. The air pulse generator is shown mounted on a portable pedestal

25 having wheels that allow the generator to be moved to different locations to provide therapy treatments to a number of persons. The portable pedestal allows the air pulse generator to be located adjacent opposite sides of a person confined to a bed or chair. The pedestal includes a linear lift that allows the elevation or height of the air pulse generator to be adjusted to accommodate different locations and persons. The thoracic therapy garment has an elongated

flexible bladder or air core having one or a plurality of elongated generally parallel chambers for accommodating air. An air inlet connector joined to a lower portion of the air core is

releasably coupled to a flexible hose joined to the air pulse outlet of the air pulse generator.

The thoracic therapy garment may be reversible with a single air inlet connector that can be accessed from either side of a person's bed or chair. The air pulse generator includes a

housing supporting air pulse generator controls for convenient use. The air pulse generator

5 controls include a control panel having user interactive controls for activating an electronic memory program to regulate the time or duration of operation of the air pulse generator, the frequency of the air pulses and the pressure of the air pulses directed to the therapy garment.

The pressure of the air established by the air pulse-generator is coordinated with the

frequency of the air pulses whereby the air pressure is substantially maintained at a selected

10 pressure when the pulse frequency is changed.

Description of the Drawing

[0016] Figure 1 is a perspective view of a thoracic therapy garment located around the thorax of a person connected with a hose to a pedestal mounted air pulse generator;

Figure 2 is a front elevational view, partly sectioned, of the thoracic therapy garment of Figure 1 located around the thorax of a person;

Figure 3 is an enlarged sectional view of the right side of the thoracic therapy garment of Figure 2 on the thorax of a person;

Figure 4 is a diagram of the user programmable control system for the air pulse generator of Figure 1;

Figure 5 is a top plan view of the air pulse generator;

Figure 6 is a front elevational view of the air pulse generator shown in Figure 5;

Figure 7 is an end elevational view of the right end of the air pulse generator shown in Figure 5;

Figure 8 is an end elevational view of the left end of the air pulse generator shown in Figure 5;

Figure 9 is a sectional view taken along line 9-9 of Figure 6;

Figure 10 is a perspective view of the air pulse displacer assembly of the air pulse generator of Figure 5;

Figure 11 is a sectional view taken along line 11-11 of Figure 9;

Figure 12 is an enlarged sectional view taken along line 12-12 of Figure 9;

Figure 13 is a perspective view of the air pulse generator of Figure 5 with parts of the housing removed;

Figure 14 is a perspective view taken along line 14-14 of Figure 9;

Figure 15 is a sectional view taken along the line 15-15 of Figure 5 showing the air pulse displacer assembly in the closed position;

Figure 16 is a sectional view similar to Figure 15 showing the air pulse displacer assembly in the open position;

Figure 17 is a perspective view of an alternative power transmission assembly for rotating the crankshafts that angularly move the displacers of the air pulse displacer

5 assembly; and

Figure 18 is a right end elevational view of the power transmission assembly of Figure 17.

Description of Invention

[0017] A human body pulsing apparatus 10 for applying high frequency pressure pulses to
10 the thoracic wall of a person, shown in Figure 1, comprises an air pulse generator 11 having a housing 12. A movable pedestal 29 supports generator 11 and housing 12 on a surface, such as a floor. Pedestal 29 allows respiratory therapists and patient care persons to transport the entire human body pulsating apparatus to different locations accommodating a number of persons in need of respiratory therapy and to storage locations. Air pulse generator 11 can
15 be separated from pedestal 29 and used to provide respiratory therapy to portions of a person's body.

[0018] Human body pulsing apparatus 10 is a device used with a thoracic therapy garment 30 to apply pressure and repetitive high frequencies pressure pulses to a person's thorax to provide secretion and mucus clearance therapy. Respiratory mucus clearance is applicable to
20 many medical conditions, such as pertussis, cystic fibrosis, atelectasis, bronchiectasis, cavitating lung disease, vitamin A deficiency, chronic obstructive pulmonary disease, asthma, and immobile cilia syndrome. Post surgical patients, paralyzed persons, and newborns with respiratory distress syndrome have reduced mucociliary transport. Air pulse generator 11 through hose 61 provides high frequency chest wall oscillations or pulses to a person's thorax
25 enhance mucus and airway clearance in a person with reduced mucociliary transport. High

frequency pressure pulses subjected to the thorax in addition to providing respiratory therapy to a person's lungs and trachea.

[0019] As shown in Figures 1 and 4, housing 12 is a generally rectangular member having a front wall 13 and side walls 26 and 27 joined to a top wall 16. An arched member 17 having a horizontal handle 18 extended over top wall 16 is joined to opposite portions of top wall 16 whereby handle 18 can be used to manually carry air pulse generator 11 and facilitate mounting air pulse generator 11 on pedestal 29. A control panel 23 mounted on top wall 16 has interactive controls 24 to program time, frequency and pressure of air directed to the therapy garment 30. Other control devices including switches and dials can be used to program time, frequency and pressure of air transmitted to therapy garment 30. The controls 24 are readily accessible by the respiratory therapists and user of pulsing apparatus 10.

[0020] Private care homes, assisted living facilities and clinics can accommodate a number of persons in different rooms or locations that require respiratory therapy or high frequency chest wall oscillations as medical treatments. Air pulse generator 11 can be manually moved to required locations and connected with a flexible hose 61 to a thoracic therapy garment 30 located around a person's thorax. Air pulse generator 11 can be selectively located adjacent the left or right side of a person 60 who may be confined to a bed or chair.

[0021] Pedestal 29 has an upright gas operated piston and cylinder assembly 31 mounted on a base 32 having outwardly extended legs 33, 34, 35, 36 and 37. Other types of linear expandable and contractible devices can be used to change the location of generator 11.

Caster wheels 38 are pivotally mounted on the outer ends of legs 33-37 to facilitate movement of body pulsating apparatus 10 along a support surface. One or more wheels 38 are provided with releasable brakes to hold apparatus 10 in a fixed location. An example of a pedestal is disclosed by L. J. Helgeson and Michael W. Larson in U.S. Pat. No. 7,713,219, incorporated herein by reference. Piston and cylinder assembly 31 is linearly extendable to elevate air pulsator 10 to a height convenient to the respiratory therapist or user. A gas

control valve having a foot operated ring lever 39 is used to regulate the linear extension of piston and cylinder assembly 31 and resultant elevation of pulsator 10. Air pulse generator 11 can be located in positions between its up and down positions. Lever 39 and gas control valve are operative associated with the lower end of piston and cylinder assembly 31.

5 [0022] A frame assembly 41 having parallel horizontal members 42 and 43 and a platform 44 mounts housing 12 on top of upright piston and cylinder assembly 31. The upper member of piston and cylinder assembly 31 is secured to the middle of platform 44. The opposite ends 46 of platform 44 are turned down over horizontal members 42 and 43 and secured thereto with fasteners 48. Upright inverted U-shaped arms 51 and 52 joined to opposite ends of
10 horizontal members 42 and 43 are located adjacent opposite side walls 26 and 27 of housing 12. U-shaped handles 56 and 57 are joined to and extend outwardly from arms 51 and 52 provide hand grips to facilitate manual movement of the air pulse generator 11 and pedestal 29 on a floor or carpet. An electrical female receptacle 58 mounted on side wall 27 faces the area surrounded by arm 51 so that arm 51 protects the male plug (not shown) that fits into
15 receptacle 58 to provide electric power to air pulse generator 11. A tubular air outlet sleeve is mounted on side wall 26 of housing 12. Hose 61 leading to thoracic therapy garment 30 telescopes into the sleeve to allow air, air pressure and air pulses to travel through hose 61 to thoracic therapy garment 30 to apply pressure and pulses to a person's body.

[0023] Thoracic therapy garment 30, shown in Figure 3, is located around the person's
20 thoracic wall 69 in substantial surface contact with the entire circumference of thoracic wall 69. Garment 30 includes an air core 35 having one or more enclosed chambers 40 for accommodating air pulses and air under pressure. The pressure of the air in the chambers retains garment 30 in firm contact with thoracic wall 69. Air core 35 has a plurality of holes that vent air from chambers 40. Thoracic therapy garment 30 functions to apply repeated
25 high frequency compression or pressure pulses, shown by arrows 71 and 72, to the person's lungs 66 and 67 and trachea 68. The reaction of lungs 66 and 67 and trachea 68 to the

pressure pulses causes repetitive expansion and contraction of the lung tissue resulting in secretions and mucus clearance therapy. The thoracic cavity occupies only the upper part of the thoracic cage which contains lungs 66 and 67, heart 62, arteries 63 and 64, and rib cage 70. Rib cage 70 also aids in the distribution of the pressure pulses to lungs 66 and 67 and trachea 68.

[0024] As shown in Figure 4, air pulse generator 11 has a case 100 located within housing 12.

An electric motor 101 mounted on case 100 operates to control the time duration and frequency of the air pulses produced by generator 11 and directed to garment 30. A sensor 102, such as a Hall effect sensor, is used to generate a signal representing the rotational speed

of motor 101. A motor speed control regulator 103 wired with an electric cable 104 to motor 101 controls the operating speed of motor 101. An electric power source 105 wired to motor speed control regulator 103 supplies electric power to regulator 30 which controls the

electric power to electric motor 101. The electric power source can be conventional grid

electric power and/or a battery. Other devices can be used to determine the speed of motor

101 and provide speed data to controller 106. A sensor-less commutation control of a 3-phase dc motor can be used to control the rotational speed of motor 101. A controller 106 having user programmable controls with memory components and a look-up data table wired with an electric cable 107 to motor speed control regulator 103 controls the time of operation of

motor 101, the speed of motor 101 and the pressure of air directed to garment 30 shown by

arrow 143. The signal generated by sensor 102 is transmitted by cable 108 to controller's

look-up data table that coordinates the speed of motor 101 and resulting frequency of the air pulse with a selected air pressure to maintain a selected air pressure when the speed of motor

101 and frequency of the air pulses are changed. The look-up table is an array of digital data of the speed of motor 101 and air pressures created by the air pulse generator predetermined

and stored in a static program storage which is initialized by changes in the speed of motor

101 to provide an output to stepper motor 126 to regulate air flow control member 122 to

maintain a preset or selected air pressure created by air pulse generator 11. The look up table may include identifying algorithms designed to take several data inputs and extrapolate a reasoned response.

[0025] Screen 24 of control panel 23 may have three user interactive controls 109, 110 and

5 111. Control 109 is a time or duration of operation of motor 101. For example, the time can be selected from 0 to 30 minutes. Control 110 is a motor speed regulator to control the air pulse frequency for example between 5 and 20 cycles per second or Hz. A change of the air pulse frequency results in either an increase or decrease of the air pressure in garment 30. The pressure of the air in garment 30 is selected with the use of average or bias air pressure

10 control 111. The changes of the time, frequency and pressure may be manually altered by applying finger pressure along the controls 109, 110 and 111. Control panel may include a start symbol 112 operable to connect air pulse generator 11 to an external electric power source. Set and home symbols 113 and 114 may be used to embed the selected time, frequency, and pressure in the memory data of controller 106. A cable 116 wires controller

15 106 with control panel 23. One or more cables 117 wire control panel 23 to controller 106 whereby the time, frequency and pressure signals generated by slider controls 109, 110 and 111 are transmitted to controller 106. Other types of panels and devices, including tactile switches in the form of resistive or capacitive technologies and dials can be used to provide user input to controller 106.

20 [0026] The air pressure in garment 30 is regulated with a first member shown as a proportional air flow control valve 118 having a variable orifice operable to restrict or choke the flow of air into and out of air pulse generator 11. Valve 118 has a body 119 having a first passage 121 to allow air to flow through body 119. An air flow control member or restrictor 122 having an end extended into the first passage regulates the flow of air through passage 121 into tube 131.

25 Body 119 has a second air bypass passage 123 that allows a limited amount of air to flow into tube 131. The air in passage 123 bypasses air flow restrictor 122 whereby a minimum amount

of air flows into air pulse generator 11 so that the minimum therapy treatment will not go down to zero. A filter 124 connected to the air inlet end of body 119 filters and allows ambient air to flow into and out of valve 118. Air flow restrictor 122 is regulated with a second member shown as a stepper motor 126. Stepper motor 126 has natural set index points called steps that remain fixed when there is no electric power applied to motor 126. Stepper motor 126 is wired with a cable 127 to controller 106 which controls the operation of motor 126. An example of a stepper motor controlled metering valve is disclosed by G. Sing and A. J. Horne in U.S. Patent Application Publication No. US 2010/0288364. The stepper motor control is described by L. J. Helgeson and M. W. Larson in U.S. Provisional Patent Application Serial No. 61/573,238, incorporated herein by reference. Other types of air flow meters having electronic controls, such as a solenoid control valve, a rotatable grooved ball valve or a movable disk valve, can be used to regulate the air flow to air pulse generator 11. An orifice member 128 has a longitudinal passage 129 located in tube 131. Orifice member 128 limits the maximum air flow into and out of air pulse generator 11 to prevent excessive air pressure in garment 30.

[0027] As shown in Figures 5 to 9, 11 and 13, air pulse generator housing 100 has a front wall 132, and a rear wall 133 with first pumping chambers 137 and 140 between walls 132 and 133. An interior wall 134 and end wall 136 attached to opposite ends of walls 132 and 133 enclose chambers 137 and 140. As seen in Figure 14, interior wall 134 has a plurality of passages 138 and 139 to allow air to flow from chamber 148 into chambers 137 and 140. Wall 134 can have additional passages, openings or holes to allow air to flow from chamber 148 into chambers 137 and 140. End wall 136 has an outwardly projected tubular boss 141 having a passage 142 to allow air, shown by arrow 143, to flow out of air pulse generator 11 into hose 61 and to garment 30. The frequency of the air flow pulses is regulated by varying the operating speed of motor 101. Air flow control valve 118 largely regulates the pressure of the air discharged from the air pulse generator 11 to garment 30.

[0028] A second housing 144 joined to adjacent interior wall 134 accommodates a cover 146 enclosing a manifold chamber 148, shown in Figures 9 and 13. A plurality of fasteners 147 secure housing 144 and cover 146 to interior wall 134. A tubular connector 149 mounted on cover 146 and connected to tube 131 allows air to flow from air flow restrictor valve 118 into manifold chamber 148. Passages 138 and 139 are open to manifold chamber 148 and pumping chambers 137 and 140 to allow air to flow from manifold chamber 148 into pumping chambers 137 and 140.

[0029] As shown in Figures 9 and 10, an air displacer assembly 151 operates to draw air into pumping chambers 137 and 140. Air displacer assembly 151 has two rigid air displacers 152 and 153 operable to swing or pivot between first and second positions to pump and pulse air directed to garment 30. The air displacer assembly may be a single displacer operable to pivot between first and second positions to provide air pressure pulses to garment 30. The single displacer includes the structures and functions of displacer 152 angularly moved with power transmission 179. The opposite sides of rear section 159 of displacer 152 have outwardly extended axles or pins 154 and 156. Pin 154 is rotatably mounted with a bearing 157 on end wall 136. Pin 156 is rotatably mounted on interior wall 134 with a bearing 158. A single pivot member may be used to pivotally mount displacer 152 on housing 100.

Displacer 152 is a rigid member that does not change its geometric shape when pivoting about the fixed transverse axis between the open and closed positions, shown in Figures 15 and 16. Displacer 152 has a generally rectangular shape with a transverse rear ridge 159 and a semi-cylindrical front section 161. A generally flat middle section 162 joins rear ridge 159 to front section 161. The entire outer periphery has a recess or groove 165 accommodating a seal assembly 163. As shown in Figure 12, groove 165 has a rectangular shape open to the outer end of outer section 161 of displacer 152. Rear ridge 159 and middle section 162 of displacer 152 each have a groove 165 for retaining seal assembly 163. As shown in Figure 12, seal assembly 163 has a rigid component rib 164 and low density elastic foam component

169. Seal assembly 163 comprises a high density polymer rib 164 partly located in groove 165. The outer surface of rib 164 is in sliding engagement with the inside surface 166 of wall 134. There is also sliding engagement of rib 164 with the concave curved inside surfaces 167 and 168 of walls 132 and 133, as shown in Figures 11 and 14. Returning to Figure 9, seal assembly 163 is in sliding engagement with the inside surfaces of walls 132, 133, 134 and 136. Returning to Figure 12, the foam component of seal assembly 163 is a close cell elastomeric foam material spring 169 located in the base of groove 165. The spring 169 forces rib 164 into sealing engagement with surface 166 of wall 134. The biasing force of foam material spring 169 also compensates for structural tolerances and wear of rib 164.

10 Other types of seals and spring biasing forces can be used with displacer 152 to engage walls 132, 133, 134 and 136.

[0030] As shown in Figure 11, the middle section 162 of displacer 152 has a plurality of holes 171 providing openings that allow air to flow, shown by arrow 176, from chamber 137 to pulsing chamber 177 located between displacers 152 and 153. A check valve 172 mounted on middle section 162 allows air to flow from chamber 137 to chamber 177 and prevents the flow of air from chamber 177 back to chamber 137. Check valve 172 is a one-piece flexible member having a stem 173 pressed into a hole in middle section 162 and an annular flexible flange 174 covering the bottoms of holes 171 to prevent the flow of air from chamber 177 back to chamber 137 when the pressure of the air in chamber 177 is higher than the air pressure in chambers 137, 140 and 148. Other types and locations of check valves can be used to control the flow of air from chambers 137 and 140 into chamber 148.

[0031] As shown in Figures 9, 10 and 11, the power drive system includes an anti-backlash device operable without lost motion to angularly move the first and second displacers between first and second positions. The anti-backlash device comprises an arm 178 located above middle section 162 of displacer 152. A first end of arm 178 is pivotally connected to a support 179 with a pivot pin 181. Support 179 is fastened to the rear section 159 of displacer

152. The pivot axis of pin 181 is parallel with the pivot axis of pins 154 and 156. The second or front end 182 of arm 178 extends in a downward direction toward the top of middle section 162 adjacent the semi-cylindrical section 161. Front end 182 has an upright recess 183 and a bottom wall 184 spaced above the top of middle section 162 of displacer 152. An upright bolt 186 located within recess 183 and extended through bottom wall 184 is threaded into a hole 188 in middle section 162 of displacer 152. A coil spring 187 located between the head of bolt 186 and bottom wall 184 of arm 178 biases and pivots arm 178 toward the top of displacer 152. Arm 178 and coil spring 187 provide crankshaft 189 with anti-backlash functions and compensate for wear and thermal expansion. Arm 178 cooperates with a power transmission mechanism 179 to pivot air displacer 152 for angular movement between open and closed positions.

[0032] Power transmission mechanism 189 is operatively associated with displacer 152 and arm 178 to angularly move displacer 152 toward and away from displacer 153 to draw air into chamber 137 and compress and pulse air in chamber 177. Power transmission mechanism 189 is a crankshaft having a shaft 191 with one end rotatably mounted on end plate 136 with a bearing 192. The opposite end of shaft 191 is rotatably mounted on interior plate 134 with a bearing 193. Other structures can be used to rotatably mount shaft 191 on housing walls 134 and 136. Crankshaft includes a crank pin 194 offset from the axis of rotation of shaft 191. A first pair of cylindrical roller members 196 rotatably mounted on crank pin 194 engage a first pad 197 retained in a recess in middle section 162 of displacer 152. A second pair of cylindrical roller members 198 rotatably mounted on crank pin 194 engage a second pad 199 retained in a recess in middle section 162 of displacer 152. Roller members 196 and 198 are axially spaced on opposite sides of arm 178. As seen in Figure 10, a roller member 201 rotatably mounted on the middle of crank pin 194 engages the bottom surface 202 of arm 178. Roller member 201 is spaced above the top of displacer 152. Rotation of shaft 191 moves crank pin 194 in a circular path whereby rollers members 196

and 198 angularly moves displacer 152 downwardly to the closed position and roller member 201 angularly moves displacer 152 upwardly to the open position. Spring 187 maintains arm 178 in continuous engagement with roller member 201 and creates reaction forces on pads 197 and 199 through roller members 196 and 198 thereby eliminating clearance, backlash or
 5 lost motion between arm 178 and roller member 201.

[0033] Displacer 153 has the same structure as displacer 152. Axles or pins 203 pivotally mount the rear section of displacer 153. The axial axis of pins 203 is parallel to the axial axis of pins 154 and 156. The entire outer peripheral edges of displacer 153 has a seal 204 located in engagement with curved surfaces 206 and 207 of housing 101 as shown in Figures 15 and
 10 16 and the inside surfaces of plates 134 and 136. Seal 204 has the same rib and spring as seal 163 shown in Figure 12. The middle section of displacer 153 has holes associated with a check valve 208 to allow air to flow from chamber 140 into air pulse chamber 177 and prevent the air in chamber 177 from flowing back to chamber 140. Check valve 208 has the same stem and annular flexible flange as check valve 172 shown in Figure 11. An arm 209
 15 pivotally connected to a support 211 secured to the rear section of displacer 153 is operatively associated with a power transmission assembly 212. Power transmission assembly 212 operates to angularly move displacer 153 between closed and open positions as shown in Figures 15 and 16. Power transmission assembly 212 is a crankshaft having a shaft 213 and roller members 214 engaging pads 216 mounted on displacer 153. Power
 20 transmission assembly 212 has the same structure as power transmission assembly 189. A check valve 208 mounted on displacer 153 controls the flow of air from chamber 140 to chamber 142 and prevents the flow of air from chamber 142 back to chamber 140. Check valve 208 has the same structure as check valve 172 shown in Figure 11.

[0034] As shown in Figures 15 and 16, power transmission assembly 189 and 212 are
 25 driven in opposite rotational directions with a power train assembly 217. Power train assembly 217, driven by electric motor 101, has a first belt drive comprising a timing pulley

218 drivably connected to motor 101. Timing pulley 218 accommodates an endless tooth belt 219 trained around a driven tooth timing pulley 221. A second belt drive powered by pulley 221 rotates a first pulley 222 connected to shaft 191 and a second pulley 223

connected to shaft 213 in opposite directions as shown by arrows 224 and 226. The second

5 belt drive operates power transmission assembly 189 and 212 to turn their respective crankshafts in opposite rotational directions to concurrently angularly move displacers 152

and 153 to open and closed positions shown in Figures 15 and 16 thereby pulsing air in

chamber 177. Pulley 227 driven by pulley 221 accommodates an endless serpentine double-sided tooth belt 228 that rides on idler pulleys 229 and 231 and trains about opposite arcuate

10 segments of pulleys 222 and 223. The entire power train assembly 217 is located within

chamber 148 of second housing 144. The power train assembly 217 and power transmission

assemblies 189 and 212 comprise a power drive system operable to angularly move the air

displacers 152 and 153 to open and closed positions to cause air to flow from pumping

chambers 137 and 140 into pulsing chamber 177 and direct air pressure pulses out of pulsing

15 chamber 177 into hose 61 and garment 30.

[0035] In use, as shown in Figures 1 to 3, garment 30 is placed about the person's upper body or thoracic wall 69. The circumferential portion of garment 30 includes an air core 35 having one or more internal chambers 40 that is maintained in a comfortable snug fit on thoracic wall 69. The elongated flexible hose 61 is connected to air core 35 and air pulse generator 11.

20 Operation of air pulse generator 11 discharges air under pressure and high frequency air pressure pulses into hose 61 which are transferred to the internal chamber 40 of air core 35.

As shown in Figures 2 and 3, high frequency pressure pulses 72 are transmitted from air core 35 to the person's thoracic wall 69 thereby subjecting the person's thoracic wall 69 to

respiratory therapy. The person 60 or a care person sets the time, frequency and pressure

25 controls 109, 110, 111 associated with control panel 23 to program the duration of operation

of air pulse generator 11, the frequency of the air pressure pulses and the pressure of the air

created by air pulse generator 11. The time program controls the operation of motor 101 that operates air displacers 152 and 153. As shown in Figures 15 and 16, air displacers 152 and 153 angularly pivot relative to each other between open first positions to closed second positions. Air displacers 152 and 153 draw air into pumping chambers 137 and 140. The flow of air into pumping chambers 137 and 140 is regulated with air flow control valve 118. Adjustment of air flow control valve 118 with stepper motor 126 controls the pressure of the air discharged by generator 11 to air core 35 of garment 30. The flow of air into chamber 148 is limited by air flow orifice member 128 to control maximum air flow into chamber 148 and prevents excessive air pressure in garment 30. The air in pumping chambers 137 and 140 is forced through check valves 172 and 208 into pulsing chamber 177 located between air displacers 152 and 153. Angular movements of air displacers 152 and 153 toward each other pulses the air in pulsing chamber 177 and discharges air and air pulses through air outlet passage 142 into hose 61. Hose 61 transports air and air pulses to air core 35 of garment 30 thereby subjecting the person's thorax to pressure and high frequency pressure pulses.

[0036] As shown in Figure 13, motor 101 drives power transmission assembly 217 to rotate crankshafts 189 and 212 to concurrently angularly pivot air displacers 152 and 153 between open and closed positions. Arms 178 and 208 pivotally mounted air displacers 152 and 153 cooperate with crankshafts 189 and 212 to limit the angular movement of air displacers 152 and 153. The outer ends of arms 178 and 208 support coil springs 187 that provide crankshafts 189 and 212 with anti-lash functions and compensate for wear and thermal expansion.

[0037] A modification of the air pulse generator 300, shown in Figures 17 and 18, is operable to establish air pressure and air pulses which are directed by hose 61 to garment 30 to apply repetitive forces to the thoracic wall of a person. Air pulse generator 300 has a housing including end walls 301 and 302. A displacer assembly 303 located between end walls 301 and 302 has a pair of displacers 304 and 306 pivotally mounted on end walls 301 and 302 for

angular movements relative to each other to draw air from a manifold chamber 308 into air pumping chambers 312 and 313. The air in pumping chambers 312 and 313 flows through check valves mounted on displacers 304 and 306 into a pulsing chamber 315 located between displacers 304 and 306. Displacers 304 and 305 have the same structure and functions as displacers 152 and 153 shown in Figures 9, 15 and 16 which are incorporated herein by reference. As shown in Figure 18, displacer 304 has an axle or pin 316 retained in a bearing 317 mounted in a cylindrical boss 318 joined to end wall 302. The opposite side of displacer 304 has an axle or pin rotatable mounted on end wall 301. Displacer 316 located below displacer 304 has an axle or pin 319 retained in a bearing 321 mounted in a cylindrical boss 322 joined to end wall 302. Displacers 304 and 306 angularly move relative to each other about laterally spaced parallel horizontal axes of pins 316 and 319. A housing or casing 302 joined to end wall 307 surrounds manifold chamber 308. A cover with an air inlet tubular member (not shown) attached to housing 307 encloses manifold chamber 308. End wall 302, shown in Figure 18, has passages or openings 309, 310 and 311 to air to flow from manifold chamber 308 into pumping chambers 312 and 313. Crankshafts 314 and 320 are power transmission mechanisms that operate to angularly move displacers 304 and 305 in opposite arcuate directions to draw air from chamber 308 through openings 309, 310 and 311 and into pumping chambers 312 and 313 and pulse air in pulsing chamber 315 whereby air pressure and air pulses are directed by hose 61 to garment 30.

[0038] A power transmission assembly 323 driven with an electric motor 324 rotates crankshafts 314 and 320 whereby the crankshafts concurrently angularly move displacers 304 and 306. Power transmission assembly 323 has a first power train 326 driving a second power train 327 that rotates crankshafts 314 and 320. First power train 326 has a drive timing pulley 328 mounted on motor drive shaft 329 engageable with an endless tooth belt 331 located around a driven timing pulley 332. Pulley 332 is secured to a shaft 333 retained in a bearing 334 mounted on a fixed support 336. Support 336 is attached to housing 307 with

fasteners 337 and 338. Second power train 329 has a drive timing pulley 339 mounted on shaft 333. A bearing 334 holds shaft 333 on support 336. Belt 341 extended around timing pulleys 339, 342 and 343 rotates pulleys 342 and 343 mounted on crankshafts 314 and 320 thereby rotating crankshafts 314 and 320 and angularly moving displacers 304 and 306

5 relative to each other. The movement of displacers 304 and 306 draws air into manifold chamber 308 and through openings 309 and 311 into pumping chambers 312 and 313. When the air pressure in pumping chambers 312 and 313 is greater than the air pressure in pulsing chamber 315, the air flows through the check valves from pumping chambers 312 and 313 into pulsing chamber 315. When the displacers 304 and 306 move toward each other, air
10 pressure and air pulses are forced into hose 61 and carried by hose 61 to the air core 35 of garment 30. The air pressure and air pulses in air core 35 of garment 30 subjects the thoracic wall of the person with repetitive forces.

[0039] The body pulsing apparatus and method has been described as applicable to persons having cystic fibrosis. The body pulsing apparatus and method is applicable to bronchiectasis
15 persons, post-surgical atelectasis, and stage neuromuscular disease, ventilator dependent patients experiencing frequent pneumonias, and persons with reduced mobility or poor tolerance of Trendelenburg position. Person with secretion clearance problems arising from a broad range of diseases and conditions are candidates for therapy using the body pulsating apparatus and method of the invention.

20 [0040] The body pulsating apparatus and method disclosed herein has one or more angularly movable air displacers and programmed controls for the time, frequency and pressure operation of the air pulse generator and method. It is understood that the body pulsating apparatus and method is not limited to specific materials, construction, arrangements and method of operation as shown and described. Changes in parts, size of parts, materials,
25 arrangement and locations of structures may be made by persons skilled in the art without departing from the invention.

Claims

1. An apparatus for applying pressure and high frequency pressure pulses to the thorax of a person comprising:

- a garment having an air core adapted to be located on the thorax of the person
- 5 for subjecting the thorax of the person to pressure and high frequency pressure pulses,
- a housing having an interior enclosed space, an air inlet passage for allowing air to flow into the enclosed space, and an air outlet passage for allowing air and air pressure pulses to exit from the enclosed space,
- a hose member connected to the garment and housing for transporting air and
- 10 air pressure pulses from the air outlet passage to the air core of the garment,
- a first air displacer located in said enclosed space,
- first pivot members pivotally mounting the first air displacer on said housing for angular movement in said enclosed space,
- a second air displacer located in said enclosed space,
- 15 second pivot members pivotally mounting the second air displacer on said housing for angular movement in said enclosed space,
- said first and second air displacers separating the enclosed space into first, second and third chambers,
- said first and second chambers being open to the air inlet passage for allowing
- 20 air to flow into the first and second chambers,
- said third chamber being located between said first and second air displacers and open to the air outlet passage for allowing air and air pressure pulses to flow out of the third chamber to the hose member connected to the garment and housing,
- an air flow control valve mounted on each first and second air displacer
- 25 operable to allow air to flow from the first and second chambers into the third chamber and prevent air to flow from the third chamber into the first and second chambers,

a first power transmission mechanism located in said first chamber and rotatably mounted on the housing operable to angularly move said first air displacer between first and second positions,

a second power transmission mechanism located in said second chamber and
5 rotatably mounted on the housing operable to angularly move said second air displacer between first and second positions,

a power transmission assembly operably connected to the first and second power transmission mechanisms to concurrently operate the first and second power transmission mechanisms to angularly move the first and second air displacers in opposite
10 directions toward and away from each other to draw air into the first and second chambers and force air through the air flow control valves into the third chamber and expel air and air pressure pulses out of the third chamber for transport into the air core of the garment, and

a motor for driving the power transmission assembly whereby the first and second power transmission mechanisms angularly move the first and second displacers in
15 opposite directions toward and away from each other.

2. The apparatus of Claim 1 wherein:

the housing includes inside walls,

the first air displacer has an outer peripheral edge,

a first seal mounted on the outer peripheral edge of the first air displacer
20 slidably engageable with the inside walls of the housing,

the second air displacer includes an outer peripheral edge, and

a second seal mounted on the outer peripheral edge of the second air displacer
slidably engageable with the inside walls of the housing.

3. The apparatus of Claim 2 wherein:

25 the outer peripheral edges of the first and second air displacers include outwardly open grooves,

said first and second seals comprise ribs and foam material located in said grooves, said foam material biasing the ribs into engagement with said inside walls of the housing thereby inhibiting air flow between the first and second air displacers and the inside walls of the housing.

4. The apparatus of Claim 1 wherein:

the first power transmission mechanism includes

a first arm mounted on the first air displacer,

a first crankshaft drivably connected to the power transmission assembly,

a first roller mounted on the first crankshaft engageable with the arm,

and a second roller mounted on the first crankshaft and located in engagement

with the first air displacer,

the second power transmission mechanism includes

a second arm mounted on the second air displacer,

a second crankshaft rotatably mounted on the housing and drivably connected

to the power transmission assembly,

a third roller mounted on the second crankshaft and located in engagement

with the second arm, and

a fourth roller mounted on the second crankshaft and located in engagement

with the second air displacer.

5. The apparatus of Claim 4 wherein:

the first arm has opposite ends,

a pivot member pivotally mounting one end of the first arm on the first air displacer for movement toward and away from the first air displacer,

a first member secured to the first air displacer adjacent to the other end of the first arm,

a biasing member located between the first member and the other end of the first arm to bias the first arm into engagement with the first roller,

a second arm having opposite ends,

a pivot member pivotally mounting one end of the second arm on the second

5 air displacer for movement toward and away from the second air displacer,

a second member secured to the second air displacer adjacent the other end of the first arm,

a biasing member located between the second member and the other end of the second arm to bias the second arm into engagement with the third roller.

10 6. The apparatus of Claim 5 wherein:

each biasing member comprises a spring.

7. The apparatus of Claim 1 including:

an air flow restrictor device operable to restrict the flow of air into and out of the first and second chambers to regulate the air pressure generated by the angularly moving first and second air displacers.

15

8. The apparatus of Claim 7 wherein:

the air flow restrictor device includes

a first member operable to regulate the flow of air into the first and second chambers, and

20 a second member to adjust the location of the first member to alter the flow of air into the first and second chambers thereby adjusting the air pressure of the air pulses discharged from the housing to the air core of the garment.

9. The apparatus of Claim 1 wherein:

the first and second displacers each include

25 a one-piece rigid member having

a generally flat body having an outer and an inner end, and a convex outer end section joined to the outer end of the body,

a ridge joined to the inner end of the body, said ridge having opposite ends,

and

5 the first and second pivot members comprising cylindrical pivot members joined to the opposite ends of the ridge and extended outwardly from the opposite ends of the ridge.

10. The apparatus of Claim 9 wherein:

the body, convex outer end and ridge include

10 an outer peripheral groove, and

at least one seal located in said groove.

11. The apparatus of Claim 10 wherein:

the seal comprises peripheral ribs and foam material located in said groove,

said foam material biasing the ribs into engagement with the housing.

15 12. The apparatus of Claim 9 wherein:

said ridge includes bosses located adjacent the opposite ends of the ridge,

said pivot members being joined to said bosses.

13. The apparatus of Claim 9 wherein:

20 the body includes at least one hole to allow air to flow through the one-piece rigid member, and

said air flow control valve comprising a check valve mounted on the body associated with the one hole in the body to allow only one-way flow of air through the one-piece rigid member.

25 14. An apparatus for applying pressure and high frequency pressure pulses to the thorax of a person comprising:

a garment having an air core adapted to be located on the thorax of the person for subjecting the thorax of the person to pressure and high frequency pressure pulses,

a housing having an enclosed space, an air inlet passage to allow air to flow into the enclosed space, and an air outlet passage to allow air and air pressure pulses to exit
5 from the enclosed space,

a hose member connected to the garment and housing for transporting air and air pressure pulses from the air outlet passage to the air core of the garment,

an air displacer assembly located in said enclosed space separating the enclosed space into at least one air pumping chamber and an air pulsing chamber,

10 said air displacer assembly having at least one air displacer located between the pumping chamber and pulsing chamber,

at least one pivot member pivotally mounting the air displacer on the housing for angular movement between first and second positions,

an air flow control valve operable to allow air to flow from the pumping
15 chamber into the pulsing chamber and prevent air to flow from the pulsing chamber into the pumping chamber, and

a power drive system operable to angularly move the air displacer between the first and second positions to allow air to flow from the pumping chamber into the pulsing chamber and prevent air to flow from the pulsing chamber into the pumping chamber.

20 15. The apparatus of Claim 14 wherein:

the power drive system includes

a power transmission mechanism rotatably mounted on the housing operable to angularly move the displacer between said first and second positions to draw air into the pumping chamber and force air and air pulses out of the pulsing chamber into the hose
25 member,

a power transmission assembly operatively connected to the power transmission mechanism to operate the power transmission mechanism to draw air into the pumping chamber, force air through the air flow control valve into the pulsing chamber, and expel air and air pressure pulses through the air outlet passage out of the pulsing chamber into the hose member, and

a motor for driving the power transmission assembly whereby the power transmission mechanism angularly moves the displacer between said first and second positions.

16. The apparatus of Claim 14 wherein:

the power drive system includes an anti-backlash device operable without lost motion to angularly move the displacer between the first and second positions.

17. The apparatus of Claim 16 wherein:

the anti-backlash device includes

an arm mounted on the displacer,

a crankshaft,

a first roller mounted on the crankshaft engageable with the arm,

at least one second roller mounted on the crankshaft engageable with the

displacer whereby on rotation of the crankshaft the displacer is angularly moved between said first and second positions.

18. The apparatus of Claim 17 wherein:

the arm has opposite ends,

a pivot member pivotally mounting one end of the arm on the displacer for movement toward and away from the displacer,

a member secured to the displacer adjacent the other end of the arm, and

a biasing member located between the member and the other end of the arm to bias the arm into engagement with the first roller.

19. The apparatus of Claim 18 wherein:
the biasing member is a spring located about the member secured to the
displacer.

20. The apparatus of Claim 14 including
an air flow restrictor device operable to restrict the flow of air into the
pumping chamber to regulate the air pressure generated by the angularly moving displacer.

21. The apparatus of Claim 20 wherein:
the air flow restrictor device includes
a first member operable to regulate the flow of air into the pumping chamber,

and

a second member to adjust the location of the first member to alter the flow of
air into the pumping chamber thereby adjusting the air pressure of the air pulses in the
pulsing chamber.

22. The apparatus of Claim 14 wherein:
the housing includes inside walls,
said displacer has an outer peripheral edge, and
a seal mounted on said outer peripheral edge of the displacer slidably
engageable with the inside walls of the housing.

23. The apparatus of Claim 22 wherein:
the outer peripheral edge of the displacer includes an outwardly open groove,
said seal comprise peripheral ribs and foam material located in the groove,
said peripheral ribs having surfaces biased by the foam material into sliding
contact with the inside walls of the housing.

24. The apparatus of Claim 14 wherein:
the displacer comprises
a one-piece rigid member having

a generally flat body having an outer and an inner end,
 a convex outer end section joined to the outer end of the body,
 a ridge joined to the inner end of the body, said ridge having opposite ends,
 and

5 the at least one pivot member comprises cylindrical pivot members joined to
 the opposite ends of the ridge and extended outwardly from the opposite ends of the ridge.

25. The apparatus of Claim 24 wherein:

the body, convex outer end and ridge include
 an outer peripheral groove, and

10 at least one seal located in said groove.

26. The apparatus of Claim 24 wherein:

the seal comprises peripheral ribs and foam material located in said groove.

27. The apparatus of Claim 24 wherein:

15 said ridge includes bosses located adjacent the opposite ends of the ridge, said
 pivot members being joined to said bosses.

28. The apparatus of Claim 24 wherein:

the body includes at least one hole to allow air to flow through the one-piece
 rigid member, and

20 said air flow control valve comprising a check valve mounted on the body
 associated with the at least one hole in the body to allow only one-way flow of air through the
 one-piece rigid member.

29. An apparatus for generating air pulses comprising:

25 a housing having an interior enclosed space, an air inlet passage for allowing
 air to flow into the enclosed space, and an air outlet passage for allowing air and air pulses to
 exit from the enclosed space,

a first air displacer located in said enclosed space,

at least one first pivot member pivotally mounting the first air displacer on said housing for angular movement in said enclosed space,

a second air displacer located in said enclosed space,

at least one second pivot member pivotally mounting the second air displacer

5 on said housing for angular movement in said enclosed space,

said first and second air displacers separating the enclosed space into first, second and third chambers,

said first and second chambers being in communication with the air inlet passage for allowing air to flow into the first and second chambers,

10 said third chamber being located between said first and second air displacers and in communication with the air outlet passage for allowing air and air pulses to flow out of the third chamber,

an air flow control valve mounted on each first and second air displacer operable to allow air to flow from the first and second chambers into the third chamber and prevent air to flow from the third chamber into the first and second chambers, and

15 a power drive system operable to angularly move the first and second air displacers to draw air into the first and second chambers and force air into the third chamber and out of the third chamber through the air outlet passage.

30. The apparatus for generating air pulses of Claim 29 wherein:

20 the power drive system includes

first and second power transmission mechanisms mounted on the housing operable to concurrently angularly move the first and second air displacers in opposite directions toward and away from each other to draw air into the first and second chambers and force air through the air flow control valves into the third chamber and expel air and air pressure pulses through the air outlet passage out of the third chamber,

25

a power transmission assembly operably connected to the first and second power transmission mechanisms to operate the power transmission mechanisms to angularly move the first and second air displacers, and

a motor for driving the power transmission assembly.

5 31. The apparatus of Claim 29 wherein:

the housing includes inside walls,

the first air displacer has an outer peripheral edge,

a first seal mounted on the outer peripheral edge of the first air displacer
slidably engageable with the inside walls of the housing,

10 the second air displacer includes an outer peripheral edge, and

a second seal mounted on the outer peripheral edge of the second air displacer
slidably engageable with the inside walls of the housing.

32. The apparatus of Claim 29 wherein:

the outer peripheral edges of the first and second air displacers include

15 outwardly open grooves,

said first and second seals comprise ribs and foam material located in said
grooves,

said foam material biasing the ribs into slidably engagement with said inside
walls of the housing thereby inhibiting air flow between the first and second air displacers
20 and the inside walls of the housing.

33. The apparatus of Claim 29 wherein:

the power drive system includes an anti-backlash device operable without lost
motion to angularly move the first and second displacers between the first and second
positions.

25 34. The apparatus of Claim 33 wherein:

the anti-backlash device includes

a first arm mounted on the first air displacer,
a first crankshaft rotatably mounted on the housing,
a first roller mounted on the first crankshaft engageable with the arm, and
a second roller mounted on the first crankshaft and located in engagement with

5 the first air displacer,

a second arm mounted on the second air displacer,
a second crankshaft rotatably mounted on the housing,
a third roller mounted on the second crankshaft and located in engagement

with the second arm, and

10 a fourth roller mounted on the second crankshaft and located in engagement
with the second air displacer.

35. The apparatus of Claim 34 wherein:

the first arm has opposite ends,

15 a pivot member pivotally mounting one end of the first arm on the first air
displacer for movement toward and away from the first air displacer,

a first member secured to the first air displacer adjacent to the other end of the
first arm,

a biasing member located between the first member and the other end of the
first arm to bias the first arm into engagement with the first roller,

20 a second arm having opposite ends,

a pivot member pivotally mounting one end of the second arm on the second
air displacer for movement toward and away from the second air displacer,

a second member secured to the second air displacer adjacent the other end of
the first arm,

25 a biasing member located between the second member and the other end of the
second arm to bias the second arm into engagement with the third roller.

36. The apparatus of Claim 35 wherein:

each biasing member comprises a spring.

37. The apparatus of Claim 29 including:

an air flow restrictor device operable to restrict the flow of air into and out of

5 the first and second chambers to regulate the air pressure generated by the angularly moving first and second air displacers.

38. The apparatus of Claim 37 wherein:

the air flow restrictor device includes

a first member operable to regulate the flow of air into the first and second

10 chambers, and

a second member to adjust the location of the first member to alter the flow of

air into the first and second chambers thereby adjusting the air pressure of the air pulses

discharged from the housing to the air core of the garment.

39. The apparatus of Claim 29 wherein:

15 the first and second displacers each include

a one-piece rigid member having

a body having an outer end and an inner end, a convex outer end section

joined to the outer end of the body,

a ridge joined to the inner end of the body, said ridge having opposite ends,

20 and

the first and second pivot members each comprising cylindrical pivot members

joined to the opposite ends of the ridge and extended outwardly from the opposite ends of the ridge.

40. The apparatus of Claim 39 wherein:

25 the body, convex outer end and ridge include

an outer peripheral groove, and

at least one seal located in said groove.

41. The apparatus of Claim 40 wherein:

the seal comprises ribs and foam material located in said groove.

42. The apparatus of Claim 39 wherein:

5 said ridge includes bosses located adjacent the opposite ends of the ridge, said pivot members being joined to said bosses.

43. The apparatus of Claim 39 wherein:

the body includes at least one hole to allow air to flow through the one-piece rigid member, and

10 said air flow control valve comprising a check valve mounted on the body associated with the one hole in the body to allow only one-way flow of air through the one-piece rigid member.

44. An apparatus for generating air pressure pulses comprising:

15 a housing having an enclosed space, and an air inlet passage to allow air to flow into the enclosed space, and an air outlet passage to allow air and air pressure pulses to exit from the enclosed space,

an air displacer assembly located in said enclosed space separating the enclosed space into an air pumping chamber and an air pulsing chamber,

20 said air displacer assembly having at least one air displacer located between the pumping chamber and pulsing chamber,

at least one pivot member pivotally mounting the air displacer on the housing for angular movement between first and second positions,

25 an air flow control valve operable to allow air to flow from the pumping chamber into the pulsing chamber and prevent air to flow from the pulsing chamber into the pumping chamber, and

a power drive system operable to angularly move the air displacer between the first and second positions to allow air to flow from the pumping chamber into the pulsing chamber and out of the pulsing chamber through the air outlet passage.

45. The apparatus of Claim 44 wherein:

5 the air flow control valve is mounted on the displacer.

46. The apparatus of Claim 44 wherein:

the power drive system includes

a power transmission mechanism rotatably mounted on the housing operable to angularly move the displacer between said first and second positions to draw air into the pumping chamber and force air and air pulses out of the pulsing chamber,

10 a power transmission assembly operatively connected to the power transmission mechanism to operate the power transmission mechanism to draw air into the pumping chamber, force air through the air flow control valve into the pulsing chamber, and expel air and air pressure pulses through the air outlet passage out of the pulsing chamber,
15 and

a motor for driving the power transmission assembly whereby the power transmission mechanism angularly moves the displacer between said first and second positions.

47. The apparatus of Claim 44 wherein:

20 the housing includes inside walls,
said displacer has an outer peripheral edge, and
a seal mounted on said outer peripheral edge of the displacer slidably engageable with the inside walls of the housing.

48. The apparatus of Claim 47 wherein:

25 the outer peripheral edge of the displacer includes an outwardly open groove,
said seal comprise ribs and foam material located in the groove.

said foam material biasing the ribs into sliding contact with the inside walls of the housing.

49. The apparatus of Claim 44 wherein:

the power drive system includes an anti-backlash device operable without lost
5 motion to angularly move the at least one displacer between first and second positions.

50. The apparatus of Claim 49 wherein:

the anti-backlash device includes
an arm mounted on the displacer,
a crankshaft rotatably mounted on the housing,
10 a first roller mounted on the crankshaft engageable with the arm,
at least one second roller mounted on the crankshaft engageable with the
displacer whereby on rotation of the crankshaft the displacer is angularly moved between said
first and second positions.

51. The apparatus of Claim 50 wherein:

15 the arm has opposite ends,
a pivot member pivotally mounting one end of the arm on the displacer for
movement toward and away from the displacer,
a member secured to the displacer adjacent the other end of the arm, and a
a biasing member located between the member and the other end of the arm to
20 bias the arm into engagement with the first roller.

52. The apparatus of Claim 51 wherein:

the biasing member is a spring located about the member secured to the
displacer.

53. The apparatus of Claim 44 including

25 an air flow restrictor device operable to restrict the flow of air into the
pumping chamber to regulate the air pressure generated by the angularly moving displacer.

54. The apparatus of Claim 53 wherein:

the air flow restrictor device includes

a first member operable to regulate the flow of air into the pumping chamber,

and

5 a second member to adjust the location of the first member to alter the flow of
air into the pumping chamber thereby adjusting the air pressure of the air pluses in the
pulsing chamber.

55. The apparatus of Claim 44 wherein:

the displacer comprises

10 a one-piece rigid member having

a generally flat body having an outer end and an inner end,

a convex outer end section joined to the outer end of the body,

a ridge joined the inner end of the body, said ridge having opposite ends, and

the first and second pivot members comprising cylindrical pivot members

15 joined to the opposite ends of the ridge and extended outwardly from the opposite ends of the
ridge.

56. The apparatus of Claim 55 wherein:

the body, convex outer end and ridge include

an outer peripheral groove, and

20 at least one seal located in said groove.

57. The apparatus of Claim 56 wherein:

the seal comprises ribs and foam material located in said groove.

58. The apparatus of Claim 44 wherein:

said ridge member includes bosses located adjacent the opposite ends of the

25 ridge member,

said pivot members being joined to said bosses.

59. The apparatus of Claim 44 wherein:

the body includes at least one hole to allow air to flow through the one-piece rigid member, and

said air flow control valve comprising a check valve mounted on the body

5 associated with the one hole in the body to allow only one-way flow of air through the one-piece rigid member.

60. An air displacer for an apparatus for generating air pressure pulses comprising:

a one-piece rigid member having

10 a body having an outer end and an inner end,

a convex outer end section joined to the outer end of the body, a ridge joined to the inner end of the body, said ridge having opposite ends, and

cylindrical pivot members joined to the opposite ends of the ridge and extended outwardly from the opposite ends of the ridge.

15 61. The air displacer of Claim 60 wherein:

the body, convex outer end and ridge include

an outer peripheral groove, and

at least one seal located in said groove.

62. The air displacer of Claim 61 wherein:

20 the seal comprises ribs and foam material located in said groove.

63. The air displacer of Claim 60 wherein:

said ridge includes bosses located adjacent the opposite ends of the ridge, said pivot members being joined to said bosses.

64. The air displacer of Claim 60 wherein:

25

the member includes at least one hole to allow air to flow through the member,
and

a check valve mounted on the body associated with the one hole in the body to
allow only one-way flow of air through the member.

5 65. A method of applying pressure pulsing forces to the thorax of a person with a
garment having an air core connected with a hose to an apparatus for generating air pressure
pulses having first and second air displacers pivotally mounted on a housing for angular
movements between first and second positions to separate an air pulsing chamber from first
and second air pumping chambers and an air flow control valve for controlling the flow of air
10 from the pumping chambers into the air pulsing chamber characterized by:

 locating the garment around the thorax of a person,

 angularly moving the first and second air displacers toward and away from
each other relative to the air pulsing chamber and the first and second pumping chambers to
cause air to flow into the first and second pumping chambers, through the air flow control
15 valves and into the air pulsing chamber,

 regulating the flow of air into the first and second pumping chambers during
angular movements of the first and second air displacers to regulate the pressure of the air in
the first and second pumping chambers and the air pulsing chamber, and

 regulating the angular movements of the first and second air displacers to
20 adjust the frequency of the air pressure pulses in the air pulsing chamber and air core of the
garment thereby regulating the frequency of the pressure pulses applied to the thorax of the
person.

 66. The method of Claim 65 including:

 adjusting the rate of the flow of air into the first and second pumping
25 chambers to change the pressure of the air in the first and second air pumping chambers and
air pulsing chamber.

67. The method of Claim 65 wherein:

the regulation of the angular movements of the first and second air displacers is achieved by changing the speed of the angular movements of the first and second air displacers.

5 68. The method of Claim 65 including:

adjusting the rate of the flow of air into the first and second pumping chambers to change the pressure of the air in the first and second pumping chambers and air pulsing chamber, and

changing the speed of the angular movements of the first and second air
10 displacers to regulate the angular movements of the first and second air displacers.

69. A method of applying pressure pulsing forces to the thorax of a person with a garment having an air core connected with a hose to an apparatus for generating air pressure pulses having at least one air displacer pivotally mounted on a housing for angular movement between first and second positions to separate an air pulsing chamber from an air pumping
15 chamber and an air flow control valve for controlling the flow of air from the pumping chamber into the air pulsing chamber characterized by:

locating the garment around the thorax of a person,
angularly moving the air displacer relative to the air pumping chamber and air pulsing chamber to cause air to flow into the pumping chamber and through the air flow
20 control valve and into the pulsing chamber,

regulating the flow of air into the pumping chamber during angular movement of the air displacer between the first and second positions to regulate the pressure of the air in the pumping chamber and air pulsing chamber, and

regulating the angular movement of the air displacer to adjust the frequency of
25 the pressure pulses applied to the thorax of the person.

70. The method of Claim 69 including:

adjusting the rate of the flow of air into the pumping chamber to change the pressure of the air in the air pumping chamber and air pulsing chamber.

71. The method of Claim 69 including:

changing the speed of the angular movement of the air displacer to regulate
5 the angular movement of the air displacer to adjust the frequency of the pressure pulses applied to the thorax of the person.

72. The method of Claim 69 including:

adjusting the rate of the flow of air into the pumping chamber to change the pressure of the air in the air pumping chamber and air pulsing chamber, and
10 changing the speed of the angular movement of the air displacer to regulate the angular movement of the air displacer to adjust the frequency of the pressure pulse applied to the thorax of the person.

73. An apparatus for applying pressure and high frequency pressure pulses to the thorax of a person comprising:

15 a garment having an air core adapted to be located on the thorax of the person for subjecting the thorax of the person to pressure and high frequency pressure pulses, a housing having an interior enclosed space, an air inlet passage for allowing air to flow into the enclosed space, and an air outlet passage for allowing air and air pressure pulses to exit from the enclosed space,

20 a hose member connected to the garment and housing for transporting air and air pressure pulses from the air outlet passage to the air core of the garment, a first air displacer located in said enclosed space,

at least one first pivot member pivotally mounting the first air displacer on said housing for angular movement in said enclosed space,

25 a second air displacer located in said enclosed space,

at least one second pivot member pivotally mounting the second air displacer on said housing for angular movement in said enclosed space,

said first and second air displacers separating the enclosed space into first, second and third chambers,

5 said first and second chambers being open to the air inlet passage for allowing air to flow into the first and second chambers,

said third chamber being located between said first and second air displacers and open to the air outlet passage for allowing air and air pressure pulses to flow out of the third chamber to the hose member connected to the garment and housing,

10 at least one air flow control valve operable to allow air to flow from the first and second chambers into the third chamber and prevent air to flow from the third chamber into the first and second chambers, and

a power drive system operable to angularly move the first and second air displacers to draw air into the first and second chambers and force air through the air flow control valves into the third chamber and out of the third chamber into the hose member.

74. The apparatus of Claim 73 wherein:

the power drive system includes

a first power transmission mechanism located in said first chamber and rotatably mounted on the housing operable to angularly move said first air displacer between
20 first and second positions,

a second power transmission mechanism located in said second chamber and rotatably mounted on the housing operable to angularly move said second air displacer between first and second positions,

a power transmission assembly operably connected to the first and second
25 power transmission mechanisms to concurrently operate the first and second power transmission mechanisms to angularly move the first and second air displacers in opposite

directions toward and away from each other to draw air into the first and second chambers and force air through the air flow control valves into the third chamber and expel air and air pressure pulses out of the third chamber for transport into the air core of the garment, and

a motor for driving the power transmission assembly whereby the first and
5 second power transmission mechanisms angularly move the first and second displacers in opposite directions toward and away from each other.

75. The apparatus of Claim 73 wherein:

the power drive system includes an anti-backlash device operable without lost
10 motion to angularly move the first and second displacers between the first and second positions.

76. The apparatus of Claim 75 wherein:

the anti-backlash device includes
a first arm mounted on the first air displacer,
a first crankshaft rotatably mounted on the housing,
15 a first roller mounted on the first crankshaft engageable with the arm, and a second roller mounted on the first crankshaft and located in engagement with the first air displacer,
a second arm mounted on the second air displacer,
a second crankshaft rotatably mounted on the housing,
20 a third roller mounted on the second crankshaft and located in engagement with the second arm, and
a fourth roller mounted on the second crankshaft and located in engagement with the second air displacer.

77. The apparatus of Claim 76 wherein:

25 the first arm has opposite ends,

a pivot member pivotally mounting one end of the first arm on the first air displacer for movement toward and away from the first air displacer,

a first member secured to the first air displacer adjacent to the other end of the first arm,

5 a biasing member located between the first member and the other end of the first arm to bias the first arm into engagement with the first roller,

a second arm having opposite ends,

a pivot member pivotally mounting one end of the second arm on the second air displacer for movement toward and away from the second air displacer,

10 a second member secured to the second air displacer adjacent the other end of the first arm,

a biasing member located between the second member and the other end of the second arm to bias the second arm into engagement with the third roller.

78. The apparatus of Claim 77 wherein:

15 each biasing member comprises a spring.

79. The apparatus of Claim 73 including:

an air flow restrictor device operable to restrict the flow of air into and out of the first and second chambers to regulate the air pressure generated by the angularly moving first and second air displacers.

20 80. The apparatus of Claim 79 wherein:

the air flow restrictor device includes

a first member operable to regulate the flow of air into the first and second chambers, and

a second member to adjust the location of the first member to alter the flow of
25 air into the first and second chambers thereby adjusting the air pressure of the air pulses discharged from the housing to the air core of the garment.