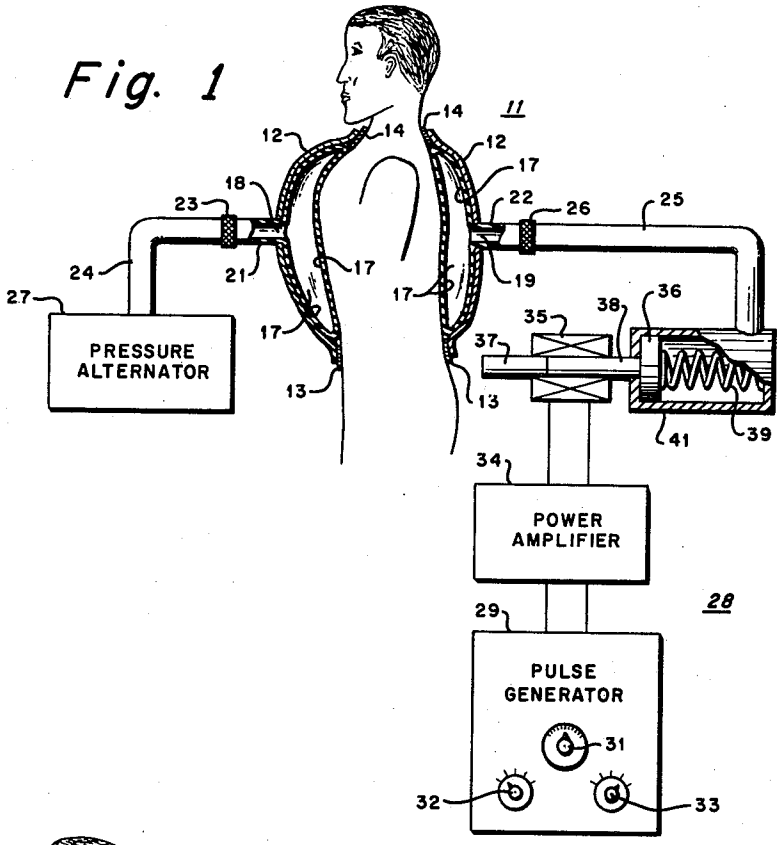
Feb. 26, 1963 R. F. GRAY 3,078,842

RESUSCITATION APPARATUS

Filed June 29, 1959

Fig. 1



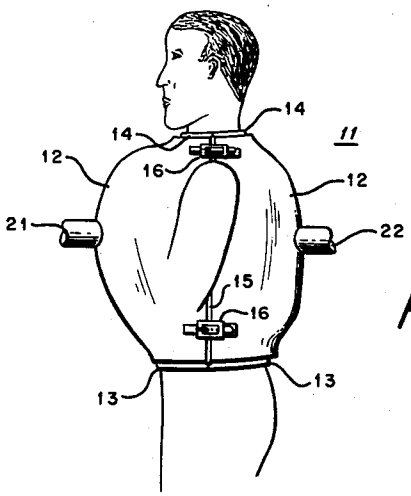


Fig. 2

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RESUSCITATION APPARATUS

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to resuscitation apparatus and more particularly to resuscitation apparatus for promoting respiration and circulation by changing the external air pressure about the chest.

While instrumentalities exist in the prior art for effectively assisting the respiratory function in a human, there are few contemporary devices which satisfactorily supplement or perform the circulatory function in the body without experiencing certain severe limitations. Known cardiac devices presently in use are the artificial heart, which requires for its operation the severing of a large blood vessel, and the defibrillator, a device which applies alternating electric current to the surface of the heart by means of electrodes, for the purpose of stimulating the heart and establishing normal heart rhythm. A necessary consideration attendant the use of these cardiac devices is the need for surgery, whether major or minor.

The resuscitation apparatus of the instant invention on the other hand, in addition to performing respiration, promotes the establishment of circulation in the vascular system of the body by the external cyclic application of pressure pulses to the chest of a subject. Due to the fact that the respiratory tract has associated with it a certain resistance to airflow, the cyclic application of pressure pulses to the chest will develop an internal pressure within the chest, such that a pressure differential will exist between the chest and other portions of the vascular system. The existence of such a pressure differential in the body promotes circulation, while the subsequent immediate absence or removal of the externally applied pressure is instrumental in relieving the pressure within the chest and lungs so that the elastic tissues in the vascular system return to normal, completing the circulatory flow cycle.

An object of the present invention is the provision of a resuscitator for cyclically applying an external pressure to the region of the chest in order to maintain circulation.

Another object is to provide circulation in the body by utilizing the resistance to airflow in the respiratory tract to develop pressure within the chest.

A further object of the invention is the provision of a resuscitator for supplying rapid cyclically recurring pressure bursts or pulses to the area surrounding the chest.

An additional object of the present invention is the provision of a resuscitator for developing a pressure differential between the region of the chest and other portions of the vascular system of the body so as to promote the circulatory function.

The exact nature of the invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the annexed drawing in which:

FIG. 1 shows a diagrammatic view in partial cross-section of a preferred embodiment of the invention, and

FIG. 2 is a side elevation view of the resuscitation jacket of the apparatus shown in FIG. 1.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIGS. 1 and 2 a resuscitation jacket generally designated by numeral

11. The outer portion or shell 12 of the jacket is constructed in two parts, a front and back section, as illustrated in FIG. 2, from a material such as aluminum, or the like, having rigid characteristics. Resilient sealing such as that obtained by the use of a pliable material such as sponge rubber is provided at the neck and waist by members 14 and 13, respectively, each being permanently secured to the jacket by conventional means, such as an adhesive or bonding agent. Similar sealing provisions, not illustrated, are also provided at the arm pits. In addition, a gasket 15 is supplied, as illustrated in FIG. 2, along the edges adjoining the front and back sections of the jacket. The buckle and strap member 16 insures that sufficient pressure can be made to bear on gasket 15, so as to provide air tight integrity of the closure within the jacket. Within the closure formed by the outer shell of the resuscitation jacket, the subject wears an inflatable sweater-like member 17, made from an elastic material, such as rubber, having tubular members 21 and 22 which protrude through corresponding openings in the front and back sections of the jacket. The tubular member 21 is coupled in a conventional manner to hose or conduit 24 by a coupler 23. In a similar manner, the tubular member 22 is coupled to the hose or conduit 25 by the coupler 26. A sealed fit is also provided between the tubular members 21 and 22 and the shell 12 of the jacket. Pressure alternator 27 is a device for producing an alternating pressure, including a subatmospheric pressure, at the respiratory rate of between 10–20 cycles per minute and functions in a manner similar to that of an iron lung. Thus, pressure alternator 27 functions to produce a pressure which periodically alternates below and above atmospheric pressure. Hose 24 is connected to pressure alternator 27 for supplying the alternating pressure to bladder 17.

The apparatus for periodically generating pressure bursts or pulses is generally designated in FIG. 1 by numeral 28. A pulse generator 29 of conventional type is capable of generating recurring pulses of voltage, the frequency, amplitude, and pulse duration characteristics of which are controlled within predetermined limits by dials 31, 32, and 33, respectively. The output of generator 29 is applied to a power amplifier 34 which converts the pulses of voltages into a form having suitable amplitude and low impedance characteristics for driving solenoid 35. The stem of piston 36 is comprised of a magnetically permeable member 37 joined to the non-magnetic member 38, such brass, the combination forming a magnetic plunger or armature, which is attached to the piston. A compression spring 39 is interposed between the piston 36 and an extremity of pressure chamber 41, as illustrated, providing in this manner the bias necessary for returning the piston 36 to its rest position in the absence of solenoid excitation. Energization of the solenoid 35 effects magnetic attraction of member 37, actuating piston 36 in accordance with the character of the voltage pulses produced by pulse generator 29. A corresponding pressure is developed in pressure chamber 41, the pressure being transmitted to bladder 17 by the hoses 25, 22, through opening 19. It should be understood that the frequency of the pressure pulses is at the circulatory rate of between 60–120 pulses per minute and may be selectively varied by control 31. In addition, it should be understood that the duration of the pressure pulses is a fractional part of the circulatory pulse period.

Referring next to the operation of the resuscitator, pressure actuator 27 supplies to bladder 17 a pressure which cyclically varies within controllable limits above and below atmospheric pressure. The bladder expanding in response to the application of an increase of pressure is instrumental during the exhalation portion of the initial respiratory cycle in expelling the residual air trapped

within the closure, between the bladder and the subject and between the bladder and the shell **12** of the jacket. This air effluxes at the neck, waist, and armpits of the subject, the effluxing action transpiring only for the initial respiratory cycle, and thereafter the sealing of the closure within the jacket is effectively maintained. During the inhalation phase, the pressure within bladder **17** is subatmospheric so that the bladder is in a collapsed state, causing a vacuum to be developed within the jacket. As a consequence of this vacum, the chest expands with inhalation of air to the lungs of the subject being directly promoted thereby. During the next intermediate exhalation phase, the buildup of pressure in the system causes the bladder to inflate, the fully pressurized bladder acting in this instance to contract the chest, thereby promoting exhalation of the air from the lungs of the subject.

The circulatory apparatus of the resuscitator of the instant invention supplies in superposition with the cyclic pressure from alternator **27** the pressure bursts or pulses of the character previously set forth. The stem of piston **36** is actuated in direct response to the electrical current pulses supplied to solenoid **35** from the power amplifier **34**. The expansion of bladder **17** is performed for all practical purposes in a substantially instantaneous manner, coterminously with the actuation of piston **36** to effect compression of the air within the closed spaces of the resuscitation system. Upon cessation of current pulses, the stem or plunger retracts by the action of spring **39**, biasing piston **36** to the quiescent position illustrated in FIG. 1. The magnitude and duration of the pressure bursts are adjusted by the amplitude and pulse width controls **32** and **33**, respectively, such that a most effective pressure differential is developed in the vascular system, between the chest and the portions of the body not so subjected to externally applied pressure. Thus, if pressure is applied to the chest rapidly at the circulatory rate, pressure will build up within the chest. This internal pressure constitutes a pressure differential existing between the chest and portions of the body exposed to ambient atmospheric air pressure. The pressure within the chest will then act to force blood from the chest into the other regions of the vascular system of the body not subjected to pressure other than atmospheric pressure, stretching the tissues in these other regions. When the pressure on the chest is relieved, as by cessation of current pulses through solenoid **35**, the elastic tissues of these other regions will return to normal, and in so doing, force blood back into the chest, completing the cycle of blood flow.

Hence, in the manner delineated above, the resuscitator of the instant invention effects resuscitation of a subject by rapidly varying the air pressure in the region about the chest. By controlled application of pressure bursts to the region of the chest, commensurate pressure differentials are developed in the vascular system between the chest and portions of the body not so subjected to the pressure bursts, thus providing resuscitation.

It should be noted that while in the preferred embodiment thus disclosed, the use of air is preferred as a medium, the instant invention is not restricted as such, and may use water, or other fluid media for translating the pressure bursts into corresponding body displacements. Moreover, while a degree of correlation is desirable between the applied pressure bursts and the subject's heart pulsations, once the pulsations are definitively ascertained, such apparatus may be of the form disclosed in patent application Serial No. 816,650 of Reuben Flanagan Gray for Apparatus for Controlling the Volume of Air and the Distribution of Blood in the Body filed May 28, 1959.

It should be understood that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. Resuscitation apparatus comprising an inelastic jacket shaped to form a space between its interior and the exterior of the thorax of a subject when worn by the subject, sealing means attached to said jacket for confining said space, openings in said jacket, and means coupled to said openings for supplying at a respiratory rate an alternating pressure to said space and in superposition with said alternating pressure an additional pressure cyclically recurring at a circulatory rate.

2. Resuscitation apparatus comprising an inelastic jacket shaped to form a space between its interior and the exterior of the thorax of a subject when worn by the subject, sealing means attached to said jacket for confining said space, an elastic bladder member within said space adapted to be worn by the subject including a pair of tubular openings in said bladder extending through the jacket, means coupled to one of said openings for supplying an alternating pressure at a respiratry rate to said bladder, and means coupled to the other of said openings for superimposing cyclical pressure bursts to the bladder recurring at a circulatory rate.

3. Resuscitation apparatus comprising an inelastic jacket shaped to form a space between its interior and the exterior of the thorax of a subject when worn by the subject, said jacket being constructed into at least two sections, each section having an edge in juxtaposition with the other edge, means secured to the jacket for joining the sections of the jacket together, sealing means fixedly attached to said jacket including a resilient gasket interposed between the edges for confining said space, an elastic bladder member within said space adapted to be worn by the subject including openings in said bladder, and means coupled to said openings for supplying at a respiratory rate an alternating pressure to said bladder and in superposition with said alternating pressure an additional pressure cyclically recurring at a circulatory rate.

4. Resuscitation apparatus comprising an inelastic jacket shaped to form a space between its interior and the exterior of the thorax of a subject when worn by the subject, said jacket being constructed into at least two sections, each section having an edge in juxtaposition with the other edge, means secured to the jacket for joining the sections of the jacket together, sealing means fixedly attached to said jacket and contiguous with the subject including a resilient gasket interposed between the edges for confining said space, an elastic bladder member within said space adapted to be worn by the subject including a pair of tubular openings extending through said jacket, means coupled to one of said openings for supplying an alternating pressure at a respiratory rate to said bladder, and means coupled to the other of said openings for superimposing cyclical pressure bursts to the bladder recurring at a circulatory rate.

5. Resuscitation apparatus comprising an inelastic jacket shaped to form a space between its interior and the exterior of a subject when worn by the subject, sealing means attached to said jacket and contiguous with said subject for confining said space, an elastic bladder member within said space adapted to be worn by the subject including a pair of tubular openings in said bladder extending through the jacket, means coupled to one of said openings for supplying an alternating pressure at a respiratory rate to said bladder, and means coupled to the other of said openings for cyclically supplying pressure bursts to the bladder recurring at a circulatory rate, said last mentioned means comprising pulse generating means for producing a train of periodically recurring voltage pulses, amplifier means electrically connected to said pulse generating means and responsive to convert said voltage pulses into an output driving voltage of low impedance, means including a solenoid actuated pressure chamber electrically connected to said amplifier means to produce pressure bursts cyclically recurring in response to said output driving voltage, and means connected between the

bladder and the pressure chamber for supplying said pressure bursts to the bladder.

6. Resuscitation apparatus comprising an inelastic jacket shaped to form a space between its interior and the exterior of a subject when worn by the subject, said jacket being constructed into at least two sections, each section having an edge in juxtaposition with the other edge, means secured to the jacket for joining the sections of the jacket together, sealing means fixedly attached to said jacket and contiguous with the subject including a resilient gasket interposed between the edges for confining said space, an elastic bladder member within said space adapted to be worn by the subject including a pair of tubular openings extending through said jacket, means coupled to one of said openings for supplying an alternating pressure at a respiratory rate to said bladder, pulse generating means for producing a train of periodically recurring voltage pulses, amplifier means electrically connected and responsive to convert said voltage pulses into an output driving voltage of low impedance, means including a solenoid actuated presure chamber electricaly connected to said amplifier means to produce pressure bursts cyclically

recurring in response to said output driving voltage, and means connecting the bladder and the pressure chamber for supplying said pressure bursts to the bladder.

7. A method of resuscitating a subject, comprising the steps of: imparting a cyclical pressure externally to the thorax of the subject at the respiratory rate of the subject, and simultaneously imparting a cyclical pressure externally to the thorax of the subject at the criculatory rate of the subject; whereby respiration and systemic circulation of the subject are simultaneously augmented.

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