

Jan. 28, 1969

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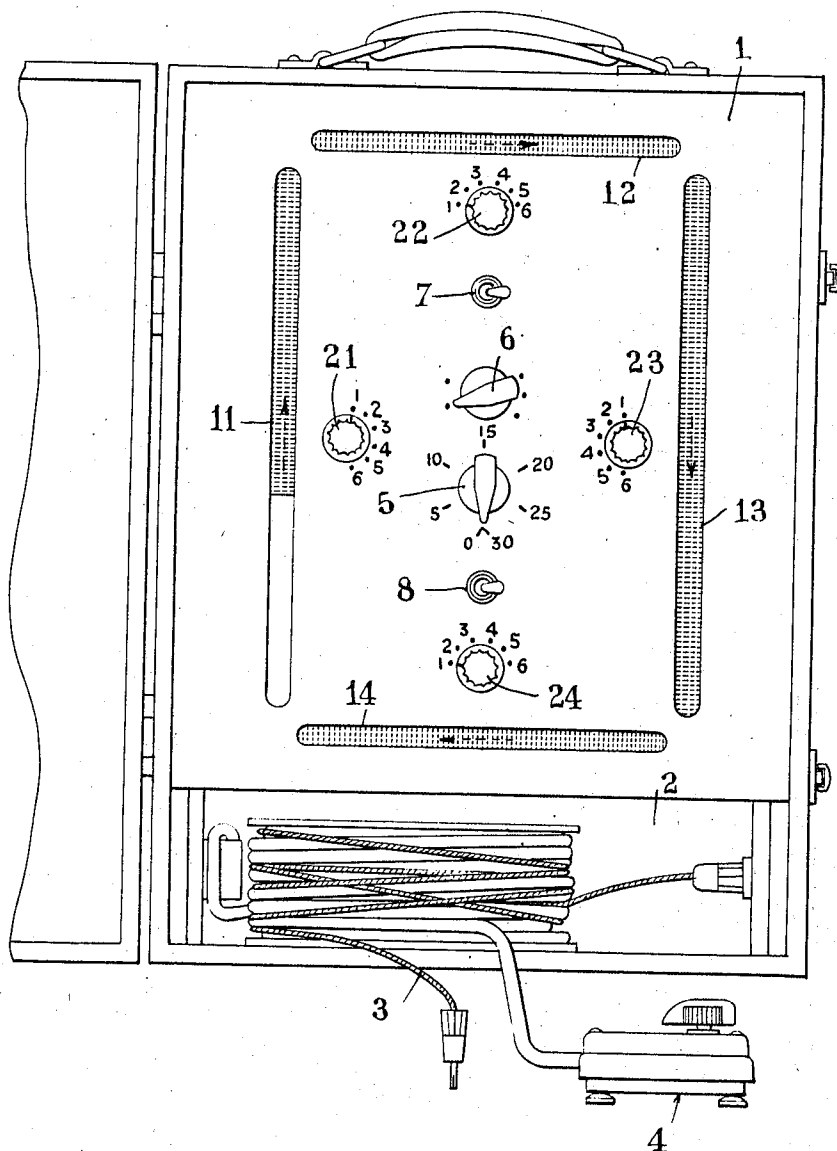
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APPARATUS FOR IMPOSING A RESPIRATORY CYCLE TO A PATIENT

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Fig. 1.



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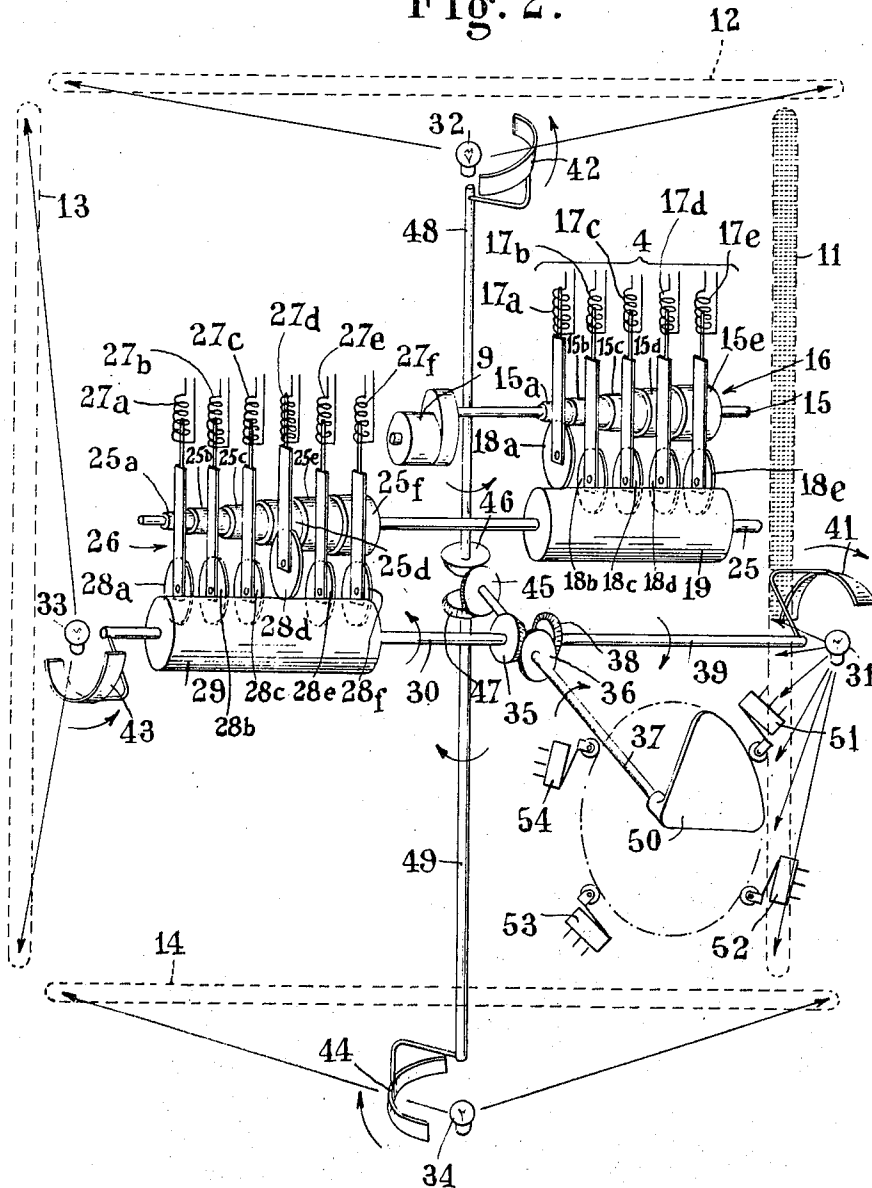
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Fig. 2.



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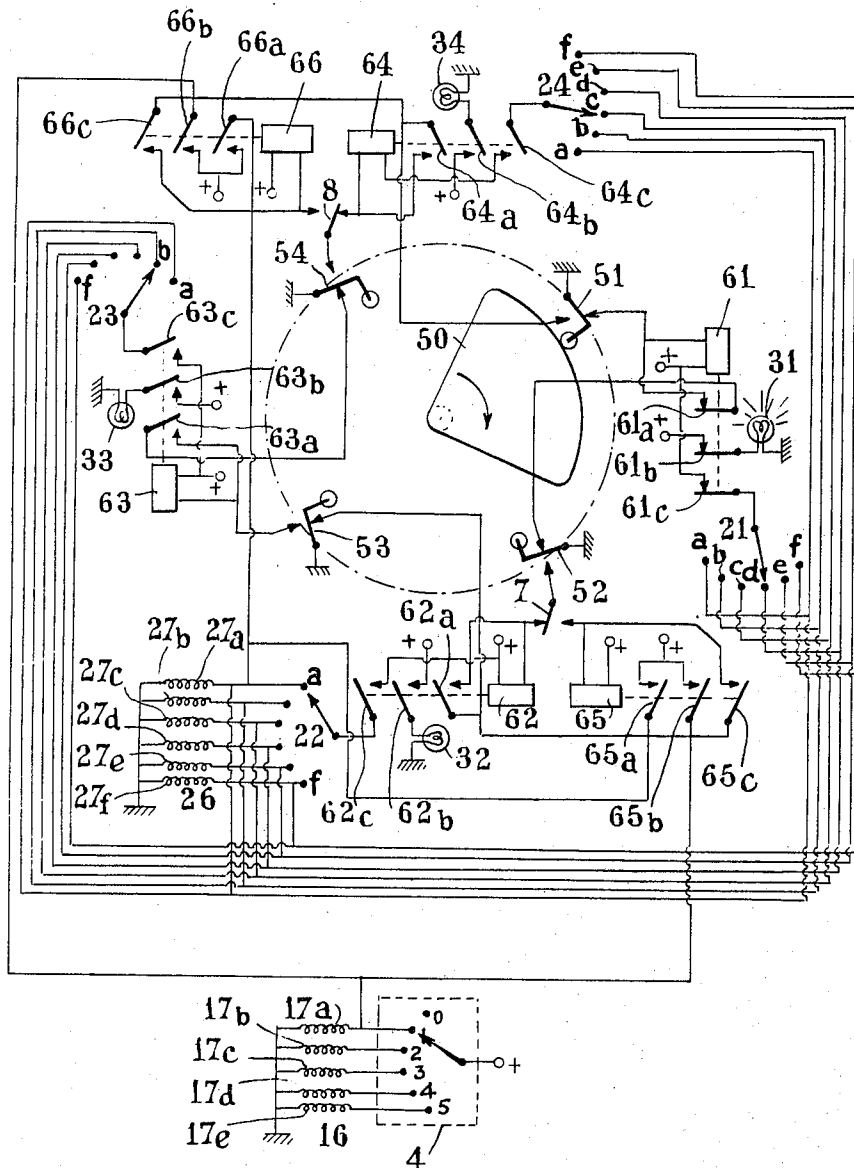
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Fig. 3.



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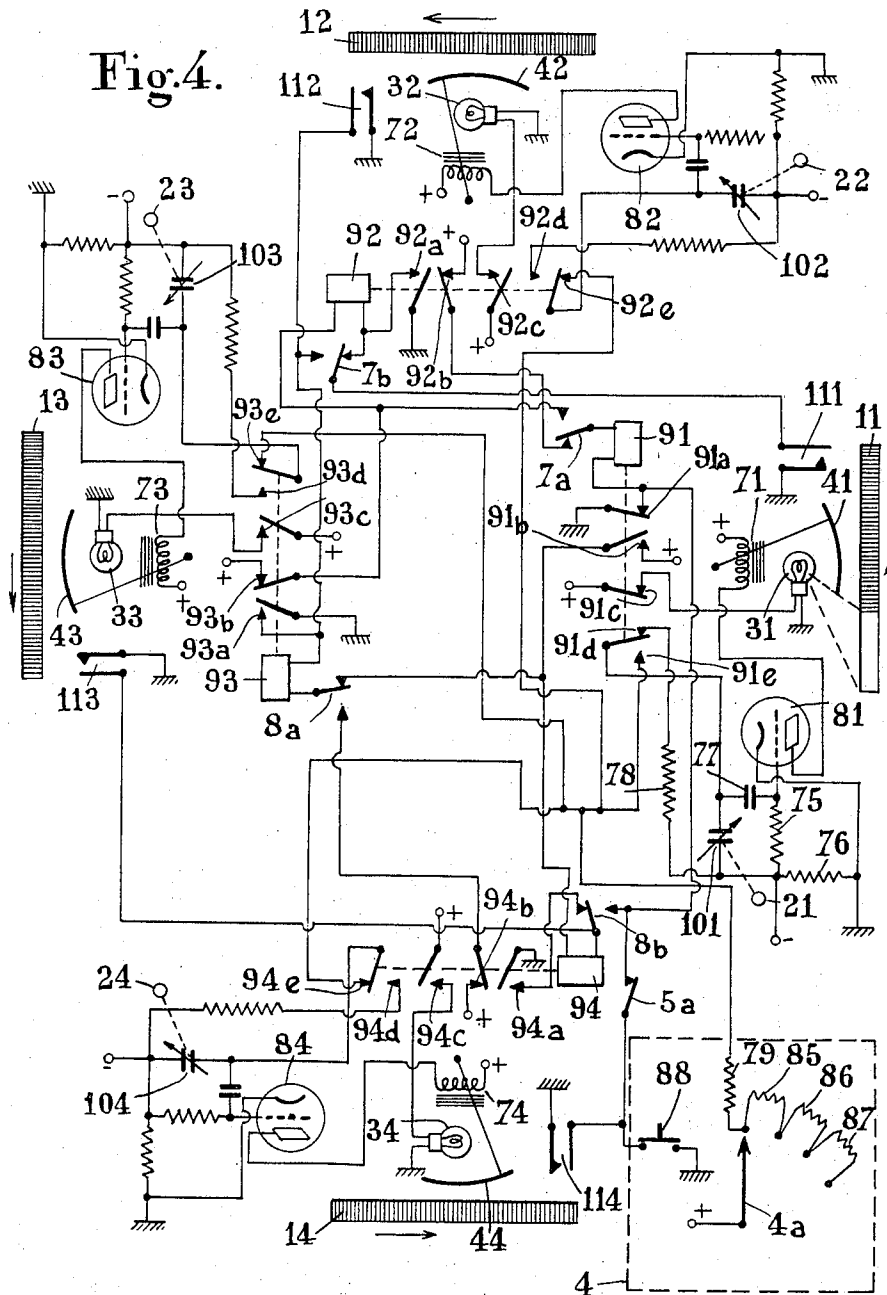
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APPARATUS FOR IMPOSING A RESPIRATORY CYCLE TO A PATIENT

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6 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for imposing to a patient a respiratory cycle comprising the successive phases: inspiration, apnoea and expiration, consisting essentially of a board on which four tracks associated respectively with the four phases of the cycle are provided. Movable luminous images are formed on said tracks so as to form a substantially closed continuous trace and an adjustable time selector is associated with each track for controlling the time necessary for the movable luminous image to travel along the corresponding track or, in other words, the relative duration of the corresponding phase of the respiratory cycle.

The present invention relates to an apparatus for imposing a respiratory cycle to a patient.

Certain modern therapeutics require the application of a suitable breathing rhythm (for example in painless delivery, treatment of certain diseases, relaxation, etc.) which is difficult to obtain from a patient by the practitioner or his assistant and without which no valuable result can be obtained.

An apparatus is already known wherein a sequence of light impulses travelling four tracks arranged in succession so as to form a substantially closed continuous trace, said four tracks being associated to the various phases of the respiratory cycle. The patient regulates his respiration as a function of the cycle represented by the movable luminous images.

However, this apparatus was objectionable in that the relative duration of each phase (inspiration, exhalation, or apnoea between these two phases) of the respiratory cycle is predetermined when constructing the apparatus and therefore it is no more possible to adjust at will the relative time period of the various phases of the respiratory cycle.

The present invention aims at avoiding this drawback by providing an apparatus designed for universal use wherein any desired combinations of cycle phase durations can be preset with a high degree of precision.

To this end, this apparatus for imposing to a patient a respiratory cycle comprising the successive phases: inspiration, apnoea and expiration, consists essentially of a board on which four tracks associated respectively with the four phases of the cycle are provided, said four tracks being arranged in succession so as to form a substantially closed continuous trace, movable luminous images being formed on said tracks, and is characterized in that an adjustable time selector is associated with each track for controlling the time necessary for the movable luminous image to travel along the corresponding track or, in other words, the relative duration of the corresponding phase of the respiratory cycle.

By properly adjusting the time selectors associated with the various elementary tracks, a predetermined respiratory cycle may be imposed to a patient, whereby the time periods imparted to the various phases of the cycle may be selected as a function of the specific therapeutics to be administered.

The respiratory apparatus according to this invention

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may also comprise a remote control device whereby the total duration of the selected respiratory cycle may be multiplied at will so that this cycle may be spread to a considerable extent from a distance.

In order to afford a clearer understanding of this invention and of the manner in which the same may be carried out in practice, a typical form of embodiment of the apparatus constituting the subject-matter thereof will now be described with reference to the diagrammatic drawing attached hereto and wherein:

FIGURE 1 is an elevational view of the respiratory apparatus according to this invention.

FIGURE 2 is a perspective view showing the device for driving the movable screen elements;

FIGURE 3 is a wiring diagram of the apparatus;

FIGURE 4 is a wiring diagram concerning an alternate form of embodiment of this apparatus.

The respiratory apparatus according to this invention comprises essentially, as shown in FIGURE 1, a front board 1 of opaque material and a compartment 2 underlying said board and containing a supply wire 3 and a remote control device 4. Mounted on the board 1 is a knob 5 controlling a timer for operating the apparatus during a preset time period and automatically stopping same at the end of the selected time period. Another knob 6 is mounted on the board 1 and controls a light attenuator for adjusting the luminous intensity of the movable images as a function of the ambient illumination.

Four windows or slots 11, 12, 13 and 14 are formed in the board 1, namely two vertical windows 11 and 13, and two horizontal windows 12 and 14, the assembly forming a rectangle. Of course, this arrangement should not be construed as limiting the invention since each window may have a different shape, provided that the four windows are arranged in succession so as to form together a substantially closed continuous trace. Behind these windows, translucent plates are disposed and receive projected luminous images travelling along the windows in the direction shown by the arrows in FIGURE 1.

Window 11 is associated with the breathing-in, phase of the respiratory cycle, window 13 with the expiration phase, and windows 12 and 14 associated with apnoea phases taking place between the inspiration and expiration phases. Besides, a switch is associated with each window 11 to 14, that is, with each phase of the respiratory cycle; they are switches 21, 22, 23 and 24 of which the control knobs are visible on board 1. As will be explained presently, the function of these switches is to permit of selecting the relative duration of each elementary phase of the respiratory cycle.

Finally, this board carries a pair of switches 7 and 8 for suppressing at will the corresponding apnoea phase.

Now reference will be made to FIGURE 2 to describe the projection, onto windows 11 to 14, of luminous images to be used by the patient for regulating his respiratory rhythm.

The device comprises a synchronous motor 9 having a horizontal output shaft 15 revolving at a constant speed, for example one-quarter of a revolution per second. This shaft 15 constitutes the primary shaft of an electromagnet-operated change-speed device designated by the reference numeral 16 and comprising a cone-pulley with five cylindrical steps 15a, 15b, 15c, 15d and 15e. The change-speed device 16 further comprises five electromagnets 17a, 17b, 17c, 17d and 17e connected to the remote control device 4. This remote control device is adapted to control the energization of one of the electromagnets 17a to 17e for selecting the desired gear ratio in the change-speed device 16. Each electromagnet 17a to 17e controls in turn the movement of one of corresponding intermediate rollers 18a, 18b, 18c, 18d and 18e for transmitting with

the desired gear ratio the rotary motion of shaft 15 to a common cylinder 19 rigid with the horizontal output shaft 25 of the change-speed device. In FIGURE 2, electromagnet 17a is energized so that its intermediate roll 18a transmits the rotary motion from step 15a of the cone-pulley to cylinder 19.

According to the specific one of electromagnets 17a to 17e which is energized, a predetermined gear ratio is obtained between the velocities of rotation of shafts 15 and 25. The remote control device 4 thus permits of varying at will the total duration of the respiratory cycle as will be explained presently.

Shaft 25 also constitutes the primary shaft of another electromagnetic change-speed device designated by the reference numeral 26. This change-speed device 26 is similar to the above-described device 16 except that it comprises six electromagnets 27a, 27b, 27c, 27d, 27e and 27f controlling the movements of corresponding intermediate rollers 28a, 28b, 28c, 28d, 28e and 28f disposed between the cylindrical steps 25a to 25f of another cone-pulley rigid with shaft 25 and a driven cylinder 29 rigid with a horizontal output shaft 30.

As will be explained presently, during each phase of the respiratory cycle only one of said electromagnets 27a to 27f is energized and determines the time during which the luminous image moves along the corresponding track. In FIGURE 2, it is assumed that electromagnet 27d is energized, thus providing the corresponding gear ratio between the primary shaft 25 of change-speed device 26 and the output shaft 30 thereof.

Behind the windows 11, 12, 13 and 14 are disposed light bulbs 31, 32, 33 and 34 and curved screens 41, 42, 43 and 44 (having preferably the shape of quarters of a cylinder of revolution) revolving about said bulbs and passing during their revolution between these bulbs and the windows associated therewith.

These curved screens 41 to 44 are driven from the horizontal output shaft 30 of change-speed device 36. The screen 43 is directly rigid with this shaft 30. The latter drives through the medium of bevel gears 35 and 36 a horizontal intermediate shaft 37 extending at right angles to said shaft 30, bevel gear 36 meshing with another bevel gear 38 rigid with a shaft 39 aligned with shaft 30 and having secured thereto the curved screen 41 revolving in a direction opposite to that of screens 43 and shifted angularly by 180° in relation thereto.

The intermediate shaft 37 is solid with a bevel gear 45 meshing with a pair of bevel gears 46 and 47 solid respectively with vertical shafts 48 and 49 on which the other screens 42 and 44 are secured, these last-named screens being shifted angularly by 180° from each other and revolving in opposite directions.

The intermediate shaft 37 also carries a cam 50 controlling microswitches 51, 52, 53 and 54 spaced 90 degrees from one another along the path of cam 50.

Now reference will be made to FIGURE 3 to describe the wiring diagram of the apparatus according to this invention. The various switches 51 and 54 actuated by said cam 50 are adapted, when moved to their circuit-closing position by said cam 50, to energize corresponding relays 61, 62, 63 and 64, respectively, associated with tracks 11, 12, 13 and 14 respectively. These relays comprise front holding contacts 61a, 62a, 63a and 64a connected respectively to the back side of the contacts 52, 53, 54 and 51, other front contacts 61b, 62b, 63b, and 64b controlling respectively the lighting of bulbs 31 to 34, and front contacts 61c, 62c, 63c, and 64c connected respectively to the sliding contacts of time selector switches 21 to 24. Each switch (comprising six positions in the example illustrated) is connected through its six studs a, b, c, d, e and f to the six windings of electromagnets 27a to 27f respectively of change-speed device 26.

In their inoperative position, switches 7 and 8 are respectively connected in series with said relays 62 and 64. On the other hand, in the operative position they are

respectively connected to relays 65 and 66. Both front contacts 65a and 66a of relays 65 and 66 are respectively connected to the winding of electromagnet 27a of change-speed device 26, and front contacts 65b and 66b of relays 65 and 66 are jointly connected to the winding of electromagnet 17a of the other change-speed device 16.

Now the operation of the apparatus according to this invention will be described with reference to FIGURES 1 to 3. Assuming that the various movable component elements of the apparatus are in the positions shown in these figures, it will be seen that electromagnet 17a of change-speed device 16 connected to said remote control device 4 is energized since the control knob of device 4 is in position 1. On the other hand, cam 50 holds contact 51 in its front position, whereby relay 61 is energized and closes its contacts 61a, 61b and 61c. Lamp 31 is thus switched on and illuminates the vertical window 11 corresponding to the inspiration phase of the respiratory cycle. Besides, as a consequence of the closing of contact 61c, the rotary switch 21 (in position d) causes the energization of electromagnet 27d of change-speed device 26. Under these conditions, during the inspiration phase the curved screen 41 is rotatably driven about the corresponding bulb 31 by the motor 9 at a speed v1 equal to that of shaft 15 but multiplied by the product of the gear ratios of change-speed devices 16 and 26, as a consequence of the energization of electromagnets 17a and 27d. Thus, the lower end of the shadow cast by the screen 41 onto the window 11 will rise as the screen 41 rotates about the lamp 31 in the direction shown by the arrow. As a consequence, the length of the portion of window or slot 11 which is illuminated by this lamp 31 increases gradually and the patient observing this window will inspire during the time period in which the window 11 is gradually illuminated. Of course, this inspiration time is subordinate to the velocity of rotation of screen 41, that is, to the setting of switch 21.

As the cam 50 moves contact 52 to its front position it de-energizes the relay 61 and then screen 41 is in such a position that it illuminates completely the window 11; in other words, the lower limit of the shadow zone has attained the upper end of window 11. The opening of contact 61b switches off lamp 31 and the opening of contact 61c de-energizes electromagnet 27d. At the same time the screen 42 is interposed between bulb 32 and window 12.

Simultaneously therewith, the closing of contact 52 causes the energization of relay 62 (switch 7 being assumed to be in its inoperative position) and therefore, due to the closing of contact 62b of this relay, lamp 32 is switched on. Simultaneously, the closing of contact 62c of this relay causes one of the electromagnets 27a to 27f to be energized, according to the preset position of rotary switch 22. Actually, in this example electromagnet 27a is energized since the sliding contact of this rotary switch engages contact stud a. From this moment on another gear ratio is applied through the change-speed device 26 and thus screen 42, as well as the other screens 41, 43 and 44, revolve at a speed v2, corresponding to the gear ratios obtaining through the change-speed devices 16 and 26. Screen 42, during the beginning of the apnoea phase, is so positioned that its shadow covers the complete length of window 12 and the latter is subsequently gradually illuminated in the direction from its right-hand and in FIGURE 2 (left-hand end in FIGURE 1). Thus, the patient holds his breath during the time period in which the horizontal window 12 is gradually illuminated.

The other phases of the cycle take place in the same manner. When cam 50 moves contact 53 to its operative position, the lamp 32 is put out, lamp 33 is lighted and electromagnet 27b is energized (due to the setting of switch 23 in position b). Window 13 is thus completely illuminated and then its illuminated length is gradually reduced from top to bottom by the rotation of screen 43,

the patient exhaling the previously inspired air until the window 13 is no more illuminated.

When cam 50 moves contact 54 to its operative position, lamp 33 is switched off, lamp 34 is switched on and electromagnet 27c is energized (as a consequence of the setting of switch 24 in position c). Thus, window 14 is illuminated completely and then reduced in length from its left-hand to its right-hand end in FIGURE 2 (from right to left in FIGURE 1), the patient holding his breath until this gradual dimming of window 14 is completed.

Another cycle is resumed when cam 50 actuates contact 51.

Switches 7 and 8 permit of selectively eliminating the apnoea phases corresponding respectively to the illumination of windows 12 and 14. Thus, for example, if switch 7 is moved to its ON position, contact 52 is closed by cam 50 it energizes relay 65 instead of relay 62. The closing of front contacts 65a and 65b produces the energization of electromagnets 27a and 17a, respectively, so as to drive the output shaft 30 at the highest possible rotational speed. In this case, cam 50 actuates the next contact 53 very rapidly to switch immediately to the exhalation or expiration phase.

The front contact 65c of relay 65, which is connected to the back contact or movable arm of contact 53, holds this relay 65 in its energized condition during the rotation of cam 50 from contact 52 to contact 53. During this short time period lamp 32 is not lighted since relay 62 remains de-energized.

By way of example, assuming that the motor output shaft performs one revolution in 4 seconds and if the maximum gear ratios provided by the change-speed devices 16 and 26 (that is, when electromagnets 17a and 27a are energized) are both 1:1, the rotational speed of screens 41 to 44 and of cam 50 is $\frac{1}{4}$ of a revolution per second. Therefore, the duration of each phase of the respiratory cycle is one second and the total duration of the cycle is four seconds. If switches 21 to 24, in their various positions, permit of adjusting the duration of each phase of the respiratory cycle at values of 1, 2, 3, 4, 5 or 6 seconds, and if the remote control device 4 permits of multiplying the various selected time periods by 1, 2, 3, 4 or 5 for each track, the duration of each phase can be increased by 1 to 30 seconds at will, the total duration of each cycle being therefore variable from 4 to 120 seconds.

With the exemplary arrangement described hereinabove, variable combinations of inspiration, apnoea and expiration times may be obtained, and one or both apnoea phases may be eliminated at will to produce two- or three-phase respiratory cycles.

Now reference will be made to FIGURE 4 showing an alternate form of embodiment of the electrical circuitry of the apparatus. In this modified form of embodiment the movements of screens 41 to 44 associated with windows 11 to 14 respectively are controlled by separate electromagnetic motors designated by the reference numerals 71, 72, 73 and 74, respectively. These motors are advantageously of the variable-gap type and comprise a movable armature rigid with the corresponding screen; this armature is adapted either to revolve through a certain angle at a constant speed when the winding of the corresponding motor is energized, or to resume its inoperative or initial position by spring means (not shown) when it is de-energized.

Flaps 41 to 44 actuate open contacts 111, 112, 113 and 114 at the end of their movements.

The energization of the separate electromagnetic motors 71 to 74 is controlled by separate switches consisting, in the form of embodiment illustrated in the drawing, of triodes 81, 82, 83 and 84. These triodes 80 to 84 become conductive under the control of corresponding relays 91, 92, 93 and 94. The time period during which each triode 81 to 84 is conducting and causes the energization of each separate motor 71 to 74 is determined for each phase of

the respiratory cycle by a variable time-constant circuit. In the drawing it will be seen that the triode 81 is associated with a variable condenser 101 of which the value may be varied at will by means of a knob 21 selecting the relative duration of the first phase, that is, the inspiration phase of the respiratory cycle. Similarly, variable condensers 102, 103 and 104 are respectively associated with the other triodes 82, 83 and 84, and adapted to be adjusted by means of knobs 22, 23 and 24 controlling the duration of the other three phases of the respiratory cycle.

As the electrical means associated with the various phases of the respiratory cycle are the same, only one of them will be described in detail, that is, the one associated with the first phase of the cycle and controlling therefore the movement of screen 41. It will be seen that the winding of electromagnetic motor 71 is inserted in the anode circuit of triode 81 having its cathode grounded and its grid also connected to the ground through resistors 75 and 76. One of the armatures of the variable condenser 101 is connected to the junction point of resistors 75 and 76 and to a source of negative bias, its other armature being connected through a capacitor 77 to the grid of triode 81. The junction point between said variable condenser 101 and resistors 75 and 76 is also connected through a resistor 78 to a front contact 91d of relay 91. The movable arm of this front contact is connected to the junction point between said variable condenser 101 and capacitor 77. The back contact 91e of relay 91 is connected to a series-connected resistor 79 of the remote control device 4. On the other hand, this resistor 79 is connected in series with three complementary resistors 85, 86 and 87 and a sliding contact 4a, connected to the positive terminal, is adapted to engage by turns the different contact studs corresponding each to one of said resistors 79, 85, 86 and 87. The remote control device 4 further comprises a starting contact 88 connected on the one hand to the ground and on the other hand to the winding of relay 91 through a contact 5a of a timer.

The contact 91a of relay 91 is a front contact holding this relay 91 in its energized condition. Contact 91b of relay 91 is a back contact connected on the one hand to the positive terminal and on the other hand directly to the winding of relay 94 and, through the medium of a switch 8a, to the winding of relay 93. Contact 91c is a front contact inserted between the positive terminal and the lamp 31 illuminating the window 11. The other relays 92, 93 and 94 also comprise similar contacts a, b, c, d and e connected in the same manner.

This arrangement operates as follows:

At the beginning the operator firstly closes the push-button contact 88 to energize relay 91 through the following circuit: positive terminal, closed contact 92b, switch 7a, relay 91, contacts 5a and 88, ground. Contacts 91a, 91b, 91c, 91d and 91e are shown in the positions obtaining when relay 91 is energized, that is, during the first phase of the respiratory cycle. Before starting the apparatus the variable condenser 101 was charged to a suitable voltage through the following circuit: positive terminal, sliding contact 4a, resistor 79 and possibly one or several resistors 85, 86 and 87 (according to the position of sliding contact 4a), back contact 91e, condenser 101 (of which the capacity is adjusted by means of knob 21), and negative terminal.

When relay 91 is energized, the closing of front contact 91d causes the variable condenser 101 to be discharged through resistor 78. Then the triode 81 becomes conductive and the winding of the electromagnetic motor 71 is energized, thus attracting its armature at a corresponding speed and causing the movement of flap 41 at a constant speed. Since on the other hand the lamp is lighted as a consequence of the closing of contact 91c, a luminous image gradually appears in window 11. The rate of movement of flap 41 or, in other words, the duration of the first phase or inspiration phase of the respiratory cycle, is

determined by the setting of condenser 101 by means of knob 21. On the other hand, the time constant of all the elementary circuits may be varied by adjusting the position of the sliding contact 4a of the remote control device in order to multiply by a same factor all the elementary time periods of each phase.

At the end of the upward stroke of flap 41, the latter closes its limit switch 111 connected through a switch 7b to relay 92. The energization of this relay 92 will close its front contact 92d and render the triode 82 conductive, so that the electromagnetic motor 72 will be energized. Thus, screen 42 begins its travel at a constant speed determined by properly adjusting the variable condenser 102 by means of knob 22. Simultaneously, the opening of back contact 92b de-energizes relay 91 and therefore restores the back contact 91d. The re-charging of variable condenser 101 will then begin as the triode 81 becomes non-conductive. The motor 71 is de-energized and screen 41 urged to its inoperative or initial position by its return spring. During this time period the lamp 31 is de-energized due to the closing of contact 91c.

The above-described cycle of operations is repeated and at the end of the second phase the closing of limit switch 112 energizes relay 93 and motor 73 during a time period determined by the adjustment of the variable condenser 103 by means of control knob 23.

At the end of the third phase, the flap 43 closes the limit switch 113 and energizes relay 94 and motor 74 during a time period depending on the adjustment of the variable condenser 104; at the end of the fourth phase, the limit switch 114 is closed and re-energizes relay 91, whereby the cycle is resumed.

It will be seen that the durations of the various elementary phases may be determined by adjusting the corresponding variable condensers 101 to 104. On the other hand, these elementary time periods may in turn be multiplied by 1, 2 or 3 according to the number of resistors 85, 86 and 87 connected in series by the sliding contact 4a.

The second and/or fourth phase of this cycle may be eliminated, in order to provide a three-phase or two-phase cycle respectively, by actuating switches 7a and 7b by means of knob 7, and switches 8a and 8b by means of knob 8. Switch 7b is connected in the circuit with a view, when the limit switch 111 is closed, to control the energization of relay 92 (to accomplish the 2nd phase) or relay 93 (to accomplish the 3rd phase); switch 8b is connected in a similar manner.

Of course, the forms of embodiment of this invention which are described hereinabove with reference to the attached drawing are given by way of example only and many modifications may be brought thereto without departing from the spirit and scope of the invention. Thus, the various screens 41 to 44 may be driven in a different manner, for example from a common shaft through counter pinions by being set in proper angular relationship, in the adequate sequence.

On the other hand, instead of gradually increasing the illuminated zone of each window, a single light spot could be caused to travel along each window. In this case, screens 41 to 44 would comprise a slot having the corresponding angular position so as to project a single light beam onto the window associated therewith.

If each screen were driven from a separate electromagnetic motor, one portion of this screen may constitute the movable armature of an electromagnet which is gradually attracted when this electromagnet is energized in order gradually to vary the luminous image on the relevant track.

What I claim is:

1. An apparatus for imposing to a patient a respiratory cycle comprising successive inspiration, apnoea, expiration and apnoea phases, said apparatus comprising a board, four tracks associated respectively to the four phases of said cycle and formed on said board, said four tracks be-

ing arranged in succession so as to form a substantially closed continuous trace, a lamp mounted behind each track, a rotary screen movable between each lamp and each track, means for sequentially energizing the lamps for illuminating said tracks, motor means associated to each screen for rotatably driving said screen, speed changing means for separately controlling said motor means, and four adjustable time selector knobs, respectively associated to the four tracks, mounted on said board and respectively controlling said speed changing means so that the time necessary for the luminous image projected on a track by a lamp and a movable screen associated to said track to run from end to end of the track, that is the relative duration of the corresponding phase of the respiratory cycle may be independently adjusted by means of said time selector knobs:

2. An apparatus as set forth in claim 1, comprising an electromotor, a first electromagnetic change-speed device having an input shaft driven from the electromotor and an output shaft, a remote control device connected to said first electromagnetic change-speed device, another electromagnetic change-speed device having an input shaft rotatably driven from said output shaft of the first electromagnetic change-speed device, said other electromagnetic change-speed device being connected to all the time selectors associated with the various tracks, a cam rotatably driven from said output shaft of said other electromagnetic change-speed device which is also adapted to drive the movable screens associated with the various tracks, and four microswitches associated respectively with said four tracks and disposed at spaced intervals about said cam so as to be actuated thereby when said cam is moved to predetermined angular positions.

3. An apparatus as set forth in claim 2, wherein each time selector consists of a switch comprising a movable contact and a plurality of contact studs engageably by turns by said movable contact, and comprising, for each track, a relay connected to a corresponding microswitch, said relay comprising a first contact for controlling the energization of the lamp illuminating the relevant track, and a second contact connected to the movable contact of the time selector of the track concerned of which the various contact studs are connected respectively and separately to said other electromagnetic change-speed device.

4. An apparatus as set forth in claim 1, wherein each track corresponding to an apnoea phase has associated therewith a switch, a first relay connected to said switch in the inoperative position thereof, said first relay controlling the movement of said luminous image along the relevant track at a speed corresponding to the preadjustment of the time selector associated therewith, and a second relay connected to said switch when the latter is in its operative position, said second relay preventing the energization of the lamp illuminating said track and causing the fast switching to the next track.

5. An apparatus as set forth in claim 1, comprising, for each track, a separate electromagnetic motor adapted to drive said screen, an energizing circuit of said electromagnetic motor, an electronic switch inserted in the energizing circuit of said electromagnetic motor to control its energization, a circuit having an adjustable time constant which is connected to said electronic switch, said circuit comprising a variable condenser of which the capacity is adjustable by means of the time selector knob associated with the track, and a relay so connected in its inoperative position as to charge said condenser and, in its operative position, to permit the discharge of said condenser during the time period in which said switch is closed and said motor is energized.

6. An apparatus as set forth in claim 5, wherein a remote control device is provided which comprises an adjustable resistor connected to the various variable time constant circuits in order to permit the modification, according to a same ratio, of all the time constants of the

various circuits and therefore all the durations of the elementary phases of said respiratory cycle.

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