ABSTRACT OF THE DISCLOSURE

An external heart massage and pulmonary ventilation device comprising a base, an arm mounted for adjustable movement vertically thereof, a vertical cylinder carried by the arm, a plunger in the cylinder mounting an external sternum compressor pad, a source of gas under pressure and valved conduits connecting the source to the top and bottom of the cylinder to simultaneously supply air to one end and exhaust air from the other end of the cylinder to thereby reciprocate the plunger, means to adjustably limit the stroke of the plunger and means to deliver air or oxygen intermittently to a patient synchronously with the stroke adjustment.

This invention relates to a heart-lung resuscitator and constitutes a continuation-in-part of my copending application Ser. No. 137,904, filed Sept. 13, 1961 and now Patent No. 3,241,551.

The primary object of the invention is to provide an external heart massage and pulmonary ventilation by means of a relatively light-weight portable machine which is easily operable, even by one person alone, and is therefore especially adapted for use by first aid and paramedical personnel in hospitals, ambulances, in rescue squads, at first aid stations, on shipboard, at rail and air terminals or wherever an large group may gather.

An important object of the invention is to provide a heart-lung resuscitator employing a motor driven reciprocating sternum compressor, a means to regulate the length of its stroke to apply variable pressure on patients differing in size and age so as to minimize damage to the rib cage, a means to deliver air or oxygen to the patient and a means synchronizing the stroke adjustment with the volume of air delivered to prevent sudden increases in intra-pulmonary pressure with resultant rupture of blood and alveoles.

Another object of the invention is to provide a heart-lung resuscitator of the character described wherein compressed gas, such as oxygen, nitrogen, etc., is employed to provide the energy for the motor so that the resuscitator can be employed at any location and needs no source of electrical energy for its operation.

Another object of the invention is to provide a heart-lung resuscitator of the character described wherein, upon initial actuation of the machine, the compressor will always move upward away from the patient to prevent accidental injury.

Another object of the invention is to provide a heart-lung resuscitator of the character described employing a fail-safe means so that if the compressor stroke is incorrectly adjusted or the machine functions incorrectly it will jam rather than the continue to malfunction with possible resultant injury to the patient.

These and other objects of the invention will become more apparent as the following description proceeds in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of the overall machine; FIG. 2 is a schematic view of the control system; FIG. 3 is a fragmentary perspective view, partly diagrammatic, of the means to adjust the length of the compressor stroke; FIG. 4 is a view similar to FIG. 3 illustrating the means to synchronize delivery of air for pulmonary ventilation with the stroke adjustment; FIG. 5 is a detail of FIG. 4, some parts in section, taken from the opposite side thereof; FIG. 6 is a vertical sectional view of the double acting cylinder and compressor piston operable therein the plunger and pad at the bottom thereof being shown in elevation; and FIG. 7 is a fragmentary perspective view of the means to adjust the horizontally extending compressor arm relative to the base.

Specific reference is now made to the drawings in which similar reference characters are used for corresponding elements throughout.

The machine is indicated at 10 and comprises, in general, an elongated base 12 upon which is removably mounted at a predetermined location an arcuate, preferably hard rubber, posterior fixation block or protuberance 14 adapted to engage the back of the patient opposite the sternum for proper transmission of forces to the heart. An upright member 16 is secured at one end of the base and supports a generally horizontal member in the form of a housing 18 upon which is removably secured by appropriate screws 20 a cover 22 having an upright bail or handle 24. A compressor 26 is operatively carried by the horizontal member vertically opposite the fixation block 14, the housing 18 and cover 22 enclosing the various means to operate and adjust the compressor and horizontal arm and the means to deliver air to the patient through a conventional flexible tube 27 which fits onto a nipple on the housing 18 and which is equipped with a face mask 28.

The housing 18 is an open-top member and as seen in FIG. 7, its rear wall 30 is secured as at 32 to a split block 34 whose clamping jaws 36 slidably engage vertical posts 38 which are secured upon the base in a vertical housing consisting of spaced plates 40, the posts 38 and plates 40 constituting the upright 16. The block 34 carries a handle 42 which extends to the rear and beyond the plates 40. A bolt 44 extends through the split block and has a sprocket 46 at its end which is engaged by an endless chain 48 that extends through the rear wall 30 of the housing 18. The chain is trained over another sprocket 50 which is rotatably mounted on the housing wall 30 by a suitable bracket and is equipped with an operating handle 52. Thus when the handle is rotated in one direction the bolt 44 unscrews and opens the jaws 36 so that the housing, with the aid of the handle 42, can be moved up and down on the posts 38 relative to the base 12 and can be locked in an adjusted position by rotating the handle 52 in an opposite direction to tighten the jaws on the posts. A windup spring 53 is connected between the block 34 and the vertical housing to serve as a counterforce whereby the housing 18 is readily lifted and lowered relative to the base 12. The side walls 40 are equipped with curved brackets 54 for removably retaining cylinders 56 of compressed gas, i.e. oxygen, nitrogen, etc., for a purpose soon to appear.

Mounted on the inside face of the front wall 58 of the housing 18 is a vertically extending double acting pneumatic cylinder 60, see FIG. 6, having caps equipped with upper and lower ports 62 and 64 which communicate with the interior. Extending slidably through the lower cap and into the cylinder is a rod or plunger 66 upon whose lower end is snap mounted the compressor 26 which includes a rubber member 68 contoured to engage the lower one-third of the sternum, the plunger or rod 66 passing through a suitable opening in the bottom wall of the housing 18 above the fixation block 14. The upper end of the rod mounts a piston head 70 of special construction so that
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no lubrication is required thus permitting operation by oxygen when there is no other gas supply available. The piston comprises upper and lower steel disks 72 and 74 and an intermediate Teflon (polytetrafluoroethylene) disk 76 separated by washers 78 and held together by having the reduced threaded end 89 of the rod 66 pass through these members and receive a closure nut 92. The Teflon disk 76 closely approximates the internal diameter of the cylinder and the other disks 72 and 74 have annular grooves 84 which receive suitable packing 86 so that a tight smoothly operable fit of the piston head in the cylinder is obtained without the need for a lubricant which generally degrades in the presence of oxygen.

Secured upon the bottom wall of the housing 16 adjacent its rear wall 30 is a plenum chamber 88, see FIG. 4, which is communicative with an accordion-type bellows 90 equipped with a rigid top plate 92 having upstanding ears 94. A longitudinal lever bar or crank 96 is pivoted between the ears 94 about a horizontal pin 98. The crank has a corner 100 intermediate its ends which carries a linear extending rod 102 which is journaled at its ends between plates 104 and 106, see FIG. 3, which extend longitudinally rearwardly from the cylinder 60. Rearwardly of the corner 100 towards the bellows, the crank mounts a lateral pin 108.

Fixed to the plunger or rod 66 is a block 110 through which a lateral rod 112 passes, one end of the rod extending into an elongated slot 114 adjacent the free end of the crank 96. Thus as the plunger reciprocates, the crank pivots about the rod 102 and thereby actuates the bellows.

Extending through one side wall 116 is a rod 118 carrying an operating handle 120. The rod carries a toothed member 122 and a leaf spring 124 with a detent 126 thereon mounted on the side wall and is urged into the teeth so that the handle can operate as a releasable selector. The rod 118 is connected by means of a universal coupling 128 to a further rod 130 which passes through vertical slots 132 in the wall members 104 and 106, the rod 130 mounting an accurate toothed cam 134 which is located immediately above the pin 108. Thus by rotating the handle 120, the distance between the pin 108 and cam 134 may be varied to ultimately adjust the length of the stroke of the compressor as will be more evident hereinafter.

Mounted on and communicative with the plenum chamber 88 is an L-shaped coupling, the horizontal arm 136 of which going to exhaust and the vertical arm 138 of which enclosing a ventilation directing valve 140. As seen in FIG. 5, the valve body has a port 142 which is communicative with the exhaust arm 136, another port 144 which is communicative with the face mask hose 26, and a third port 146 which is communicative with the plenum chamber 88. The valve 140 is vertically reciprocal in the body and has a stem 150 with head 152 on its free end. The stem on the inside of the body has a pair of spaced piston heads 154 and 156. Normally, a spring 158 urges the stem downwardly so that the upper head 154 closes off port 144 to the mask and the lower head 156 exposes port 142 to exhaust. Thus, valve 140 is a mechanically-operated two-way valve. In the position where air is delivered to the face mask, the reverse occurs as seen in FIG. 5.

Referring to FIG. 4, longitudinal bar 160 is provided adjacent the forward end of the housing 18 which is pivoted to the plate 106 as at 162 about a horizontal pivot intermediate its ends, its rear end being notched as at 164. The front end of the bar is pivotally connected as at 166 to a substantially L-shaped vertical arm 168 whose upper end is pivotally connected as at 170 to a yoke member 172 which is vertically reciprocated by the plate 106 and is guided in its motion by a headed pin 174 which extends between the forks, there being a spring 176 which is termi-

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nally secured between the yoke member 172 and the arm 168 acting to urge the front end of the bar upwardly and the notch 164 downwardly towards the rod 112.

Pivoted centrally to the plate 106 about a horizontal axis as at 175 is an indexing member in the form of a plate 179 having laterally extending pins 180 which are 90° apart. The yoke member 172 has a depending arm 182 with a hook 184 which is adapted to engage each rod 180 and upon continued downward movement of the yoke member cause the indexing plate 179 to rotate in a clockwise direction.

A longitudinal bar 186 with a curving front end 188 is pivoted about a horizontal axis as at 190 to the other side of the indexing plate 179 adjacent one of the pins 180. The rear end of the bar 186 has a longitudinal slot 192. Secured to the rear wall 30 of the housing 18 is a bracket 194 to which is pivoted about a horizontal axis as at 196 an L-shaped link 198, one arm of which secures a longitudinal angle bar 200 with a slot 202 which slidably receives the valve stem 150 of the plunger 66. The width of the slot being less than the diameter of the head 152, the other arm of the bar 198 carries a headed pin 204, the shank of which extends slidable through the slot 192 of bar 186.

Referring now to FIG. 2, the housing 18 mounts a manifold 206 which is operatively connected to one of the compressed air cylinders via line 208 which contains a pressure gauge 210, there being a pressure regulator 212 which is set to open when the pressure at the gas input supply exceeds 75 p.s.i. A pilot-operated,弹簧- biased, normally open, valve 214 is operatively connected as at 215 to the manifold and to a similarly, normally closed, two-way, spring-biased valve 216 via conduit 218.

Valve 216 is also connected to the manifold as at 219 and by line 220 to the lower port 64 of the cylinder 60. A T-connector 222 is interposed in line 220, one arm of which is operatively connected to another pilot-operated, normally open, two-way valve 224, the latter being connected as at 226 to the upper port 62 of the cylinder 60 and via line 228 back to the manifold, there being a throttle valve 230 with an operating handle 232 in line 228 to vary the gas flow to the top of the cylinder 60 and therefore the speed of the downstream of the plunger 66. It should be noted that the valves 216 and 224 are the same as valve 140 except that they are pilot rather than mechanically operated.

Three mechanically-operable, spring-biased, normally closed, valves 234, 236 and 238 are provided; the valve 234 being connected via line 240 to the manifold and via line 242 to valve 214; the valve 236 being connected to line 242; and the valve 238 being connected via line 244 to line 218, there being an on-off push button valve 246 in line 244 which can be locked in the open position by pushing down and rotating the button in a given direction. Valves 234, 236 and 238 are similar to valve 246 except that the latter has no spring bias. The valves herein described are all conventional and may be purchased commercially, as for example, from Humphrey Products Division of General Gas Light Company, Kalamazoo, Mich.

The exhausts from valves 216, 224, 236 and 238 can be connected to a silencer 248 if so desired. A valve 250 may be secured to the plenum chamber 88 for connection to an oxygen cylinder if oxygen enrichment of the pulmonary ventilation is desired.

In operation, the base 12 is slid under the patient so that the fixation block 14 rests against the opposite the sternum and the patient's sternum is directly beneath the compressor pad 68. The handle 52 is turned to loosen the clamping jaws 36 and with the aid of the handles 24 and 42, the member mounting the sternum compressor is moved vertically to the desired position and there fixed by tightening the handle 52. The throttle valve 230 is then adjusted by turning the handle 232 so that the rate of the plunger can be regulated up to one hundred and twenty strokes per minute. By turning the handle 120 the length of the stroke...
of the plunger 66 can be regulated from one-half to two inches depending on the size and age of the patient. The face mask is placed over the mouth of the patient and the button on the on-off valve 246 is depressed, turned and locked in the on position whereby the sternum is rhythmically compressed and a predetermined volume of air (or oxygen enriched air) is automatically delivered to the face mask on every fourth stroke.

The pneumatic and mechanical operations are as follows. Gas from the manifold 206 flows through valve 214 and directly to valve 216 via line 218 opening valve 216. Gas from the manifold then flows through line 220 to the bottom of the cylinder 60 raising the piston head 70 and plunger while the gas actuates the pilot of valve 224 to close off line 228 and permit venting of air from the top of the cylinder to exhaust. Thus it will be seen that the first stroke of the plunger is always upward away from the patient thereby minimizing any possible damage to the patient which might occur if the initial stroke were downward. At the top of the stroke the bracket 252 on the crank 96 has engaged the stems 254 and 256 of the valves 234 and 238 to keep them open whereas the stem 258 of valve 236 is completely down keeping that valve closed.

The on-off valve 246 is turned to the on position and gas passes from line 218 through line 244 into valve 238 and out to exhaust. This causes the pilot of valve 216 to close the valve and allow gas from the bottom of the cylinder 60 to vent through the exhaust of valve 216. This also actuates valve 224 so that it is closed to exhaust but open to the manifold whereby gas enters the top of the cylinder to cause the plunger 66 to descend. The instant the plunger descends, crank 96 rocks around rod 102 lowering bracket 252 and the valves 234 and 238 close. Gas is thereby trapped in the line 242 from the valve 234 to valve 214 keeping valve 214 closed during the complete pre-adjusted descent of the plunger otherwise the plunger would reverse immediately.

Depending upon the pre-adjusted position of the cam 134, at a particular point in the descent of the plunger, the pin 108 raises the cam 134 until it engages the stem 258 and opens valve 236 and exhaust gas from line 242. This in turn opens valve 214 allowing gas to flow into and actuate the pilot of valve 216 and start the cycle over again.

It will be seen that the bellows 90 contracts on the upstroke to expel air into the plenum chamber 88 and then, to the face mask and expands on the downstroke to take in air from the plenum chamber. Since the distance between the lower surface of the cam 134 and the pin 108 is adjusted and this determines both the length of the stroke and the degree of expansion of the bellows, the amount of air delivered through the face mask for pulmonary ventilation is synchronous with the length of the stroke. Thus for an adult, a stroke of two inches is desirable and a delivery of approximately 1050 cc. of air or oxygen. For an infant, a stroke of one-half inch is desirable and a delivery of approximately 150 cc. of air or oxygen.

Air or oxygen is delivered via the face mask to the patient on every fourth stroke as the respiration rate is generally one-fourth that of the pulse rate. This is accomplished mechanically as follows. Assume the bar 156 is at the 3 o'clock position of the indexing plate 179. The pin 204 is in the extreme forward end of the slot 192 and the angle bar 200 has pushed up on the head 152 raising the stem 150 until the lower head 156 closed off the exhaust port 142 and opened the face mask port 144 so that air or oxygen-enriched air from the plenum chamber 88 was expelled to the face mask. As the plunger 66 moves up, the rod 112 causes the bar 160 to pivot about pin 166 thereby pulling yoke member 172 down. By the action of spring 176, the hook 184 bears down on the pin 180 causing the plate 179 to rotate in a clockwise direction so that the attachment of the bar 186 to the plate 179 reaches the 6 o'clock position. In so doing, the hook 184 has cleared the pin 180 and its upper cam surface engages the next pin to come along and clears it so that the yoke member 172 returns to its original position with the hook engaging the said next pin 180. At the same time the stem 150 has dropped so that the lower head 156 has opened the exhaust port 142 and the upper head 154 has closed the face mask port 144 but the pin 204 has still retained its position at the front end of the slot 192.

On the next upstroke of the plunger the bellows contracts sending air out into the atmosphere via exhaust port 144 and the hook 184 again causes the indexing plate to rotate clockwise so that the connection of the bar 186 to the plate assumes the 9 o'clock position. In so doing the bar 186 moves so that the pin 204 occupies the extreme rear end of the slot 192 but the valve stem 150 remains in its lowered unchanged position. In the next rotation from the 9 o'clock to the 12 o'clock position, the bar 186 shifts so that the pin 204 occupies the extreme forward end of the slot 192 without changing the position of the valve stem, so that on the upstroke of the plunger air is again expelled to the atmosphere. On the next rotation from the 12 o'clock to the original 3 o'clock position, the pin 204 retains its position in the extreme forward end of the slot 192 but acts to raise the angle bar 200 and turn the valve stem so that the exhaust port 142 is closed and the face mask port 144 is opened. Thus for three of the positions of the indexing plate 179, air is expelled to the atmosphere and for the fourth position it is expelled into the face mask.

While a preferred embodiment of the invention has been shown and described herein, skilled artisans may make variations without departing from the spirit of the invention and the scope of the appended claims.

1. An external heart massage and pulmonary ventilation device comprising a base, a horizontally extending member, means mounting said member above said base for adjustment vertically towards and away from said base, a sternum compressor carried by said member, means to reciprocate said sternum compressor vertically, adjustable means limiting the downward stroke of said sternum compressor and means operatively connected to said stroke adjusting means to deliver air or oxygen intermittently to a patient synchronously with said stroke adjustment, said compressor includes a plunger having a piston head at one end and a pad at its other adapted to engage the sternum and said means to reciprocate said compressor includes a cylinder in which said piston head and plunger are slideable, a source of gas under pressure and valve conduits operatively connected to the top and bottom of said cylinder so that gas is supplied to the bottom of the cylinder beneath said piston head while it is simultaneously exhausted from the top of the cylinder above said piston head to raise said compressor and at the top of the stroke the operation is reversed to lower said compressor and the cycle is repeated.

2. The combination of claim 1 wherein said gas is oxygen and said piston head includes a rigid disk extending to the inner wall of said cylinder made of a material which is not attacked by oxygen.

3. The combination of claim 1 and a throttle valve in the conduit operatively connected to the top of said cylinder to adjust the speed of reciprocation of said compressor.

4. The combination of claim 1 wherein said stroke adjusting means includes a bar pivoted intermediate its ends and operatively connected at one of its ends to said plunger, a rod extending laterally above said bar and mounted for limited vertical movement, a cam having a generally arcuate surface carried by said rod, a pin extending laterally from said bar beneath said arcuate surface, said rod being rotatable to vary the
distance between said arcuate surface and said pin and a normally closed valve in one of said conduits having a vertically reciprocable stem above said cam so that at a pre-adjusted downstroke position of said plunger said pin will engage said cam which will in turn depress said stem and open said valve to cause gas to be supplied to the bottom of said cylinder and to be exhausted from the top to cause said piston to reverse and move in an upstroke.

5. The combination of claim 4 wherein said means to deliver air or oxygen to the patient includes a plenum chamber, a tube carrying a face mask connected to said chamber and a bellows communicative with said chamber, said bar being pivotally attached to said bellows at its end opposite said plunger whereby said bellows contracts on the upstroke of said plunger and expands on the downstroke.

6. The combination of claim 5 wherein said means to deliver air or oxygen to the patient further includes a two-way valve including a body communicating with said plenum chamber and ports to atmospheric exhaust and to said face mask tube and including a stem extending outside of said body, and linkage including an indexing member operatively connected between said stem and said plunger whereby for three successive contractions of said bellows said exhaust port remains open and said face mask tube port remains closed and on the fourth contraction of said bellows said face mask tube port opens and said exhaust port closes so that pulmonary ventilation is provided for every fourth stroke of said plunger.

References Cited
UNITED STATES PATENTS
3,209,748 10/1965 Thomas 128—53
3,254,645 6/1966 Rand et al. 128—52
3,277,887 10/1966 Thomas 128—53
3,291,124 12/1966 Jennings et al 128—53

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