Sept. 11, 1962 E. M. SMITH 3,053,249

CARDIAC MASSAGE APPARATUS

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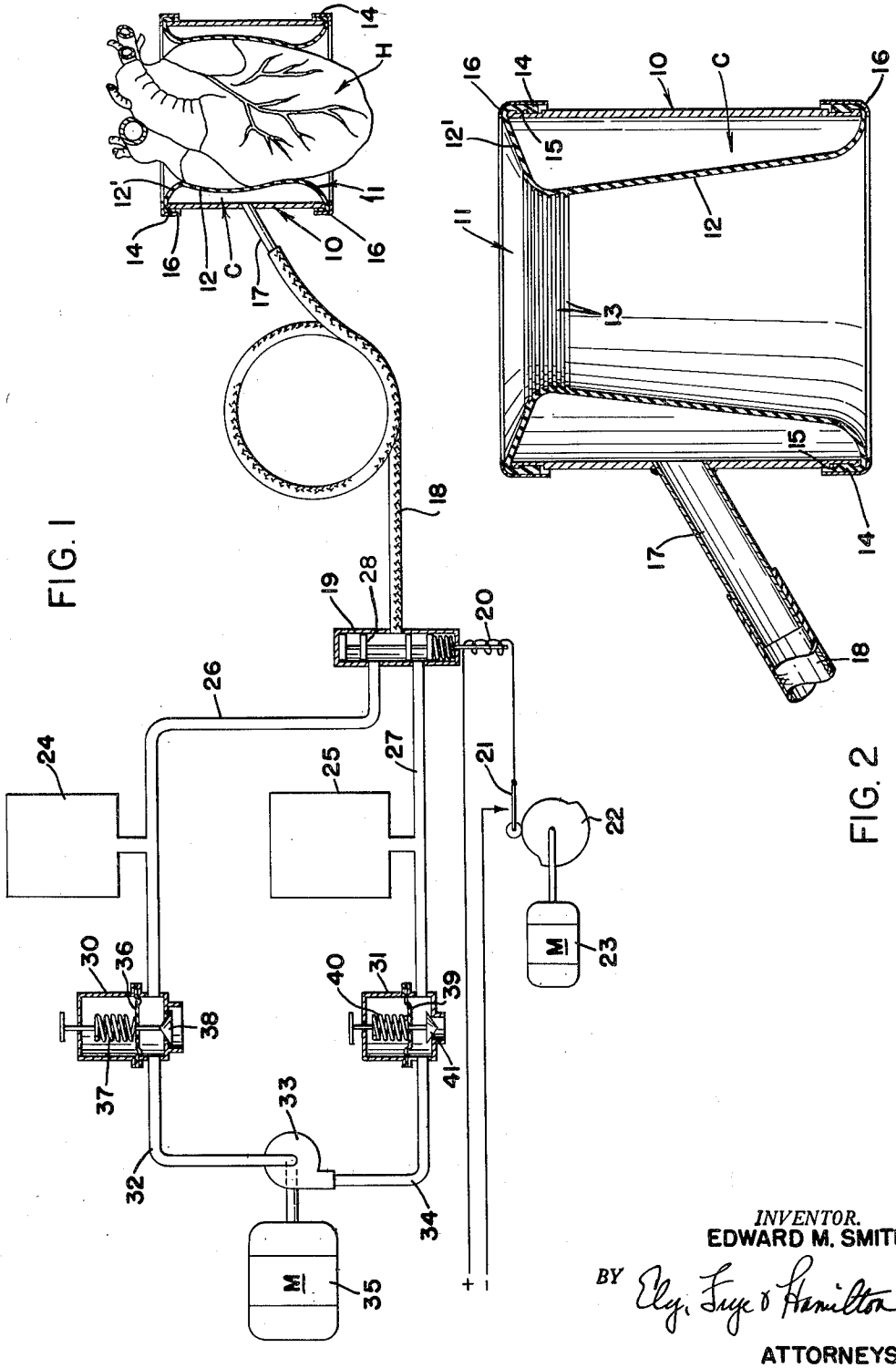

FIG. 1

FIG. 2

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FIG. 3

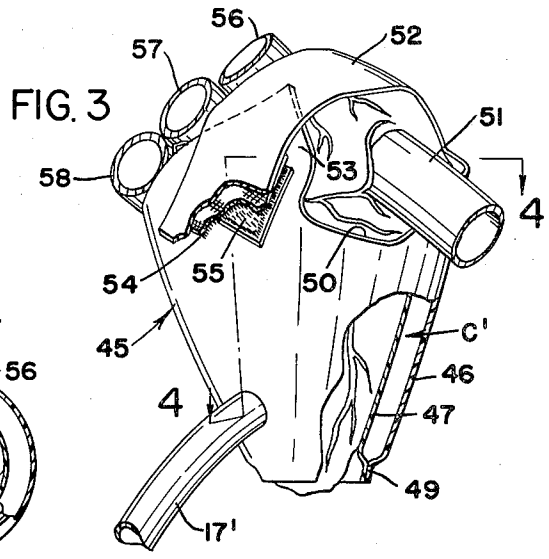


FIG. 4

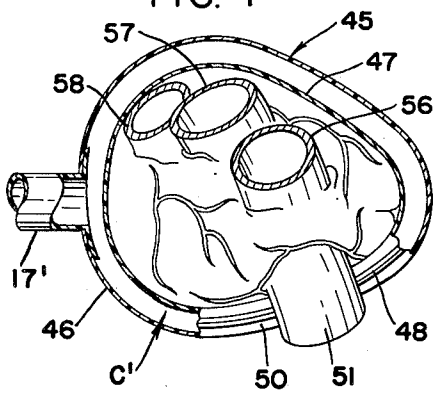
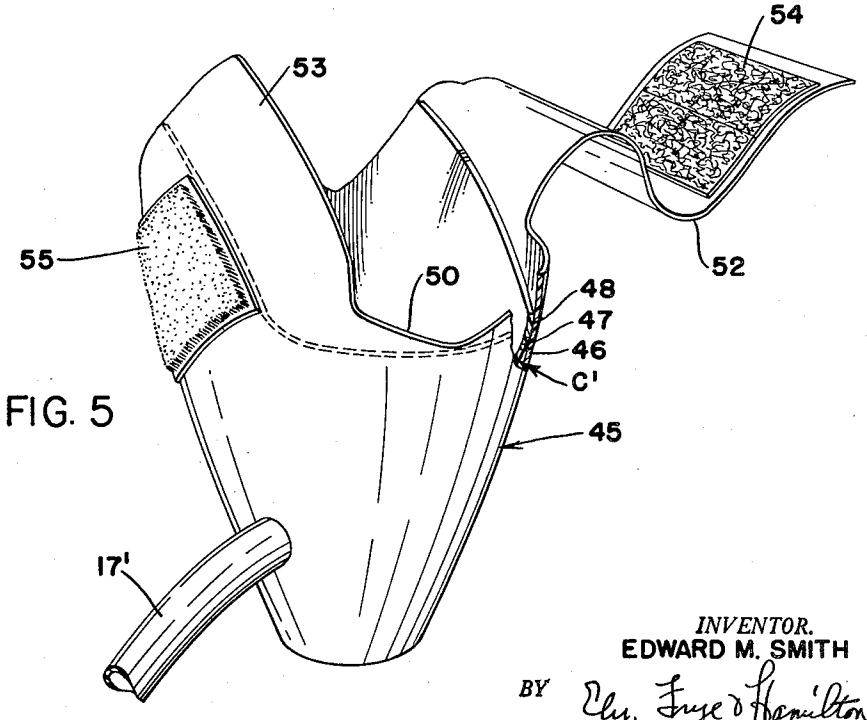


FIG. 5



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3,053,249

CARDIAC MASSAGE APPARATUS

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The invention relates generally to apparatus for mechanically massaging a human heart, and more particularly to improved means for fitting around and conforming to the heart, and adapted to be pulsated in correlation to the natural heart beat of the patient.

The practice of manually massaging a human heart which is beating weakly or has stopped entirely during an operation, or for any reason, is well known. However, this practice has met with limited success, because it is very difficult to apply the correct amount of pressure at the correct rate to maintain a steady flow of blood to and from the heart. Further, where the manual massaging is required to be maintained for a substantial period of time, the operator becomes very tired and fails to maintain proper pressure and uniform rate.

Certain prior cardiac massage apparatus has comprised a flat pouch to be wrapped around the heart having opposed flexible membranes which are mechanically pulsated, but the positioning and fastening of the pouch is a time consuming and difficult operation when performed within the chest cavity of the patient.

It is an object of the present invention to provide a novel and improved cardiac massage apparatus which is quickly and easily applied to the heart of a patient, and pulsated indefinitely at the proper pressure and rate.

Another object is to provide an improved heart massaging device which is simple and inexpensive to make, and adapted readily to be pulsated when applied to the human heart.

A further object is to provide an improved heart massaging device which can be easily applied to and removed from a human heart without danger of injury thereto.

These and other objects are accomplished by the improvements comprising the present invention, preferred embodiments of which are shown and described herein as exemplifying the best known mode of carrying out the invention. Variations and modifications of the forms disclosed herein are comprehended within the scope of the appended claims.

In one embodiment of the present invention the envelope comprises a rigid sleeve having a resilient liner forming a pocket therein, and another embodiment comprises a flexible envelope having a pocket formed around its inner periphery, the pockets in each embodiment conforming to and gently gripping the heart, and connected to means for applying a pulsating fluid pressure between the sleeve and liner in correlation to the natural heart beat of the patient.

Referring to the drawings:

FIG. 1 is a schematic view showing the improved apparatus as embodying the rigid sleeve applied to a human heart for mechanically massaging or pulsating the heart.

FIG. 2 is an enlarged sectional view of the improved rigid sleeve applicator which fits around and grips the heart.

FIG. 3 is a perspective view, partly broken away, of the flexible envelope embodiment applied to a schematically depicted human heart.

FIG. 4 is a plan sectional view substantially on line 4—4 of FIG. 3.

FIG. 5 is an enlarged perspective view of the envelope of FIG. 3 detached from the heart.

Referring first to FIG. 2, the envelope in this embodiment comprises a rigid sleeve 10 having an axial length somewhat less than that of a human heart, and a diameter substantially greater than the greatest lateral dimension of the heart. A tubular diaphragm or liner 11 is positioned within the sleeve 10, and may be secured thereto by turning the ends of the diaphragm back over the ends of the sleeve and clamping the turned over ends thereon.

The diaphragm is preferably constructed of resilient material such as rubber, and has relatively thin, soft, flexible walls which are easily distorted so as to be readily conformable to the contour of the heart. As shown, the side wall 12 of the diaphragm is upwardly convergent or somewhat conical to provide a narrowed upper portion, which, when applied over the larger upper section of the heart, as shown in FIG. 1, tends to hold the heart H in place during the massaging action. A series of circumferential ribs or ridges 13 is provided at the top of the narrowed portion, and the side wall diverges sharply therefrom, as shown at 12', to engage over the upper end of the rigid sleeve 10. The ribs 13 aid materially in resiliently gripping the outer surface of a heart to hold it in place within the sleeve 10 during the massaging action, without injuring the heart.

The top and bottom ends of the diaphragm 11 are preferably formed to have inturned ribs 14 which fit into circular grooves 15 in the outer surface of the sleeve 10, and metal clamping rings 16 are forced over the turned back ends of the diaphragm to hold the ribs 14 in the grooves 15. The clamped ends of the diaphragm provide fluid-tight seals for the annular chamber C formed between the sleeve and the diaphragm, and a tube 17 extends through and is secured to said sleeve for supplying and exhausting fluid pressure to and from said chamber.

As shown in FIG. 1, tube 17 is connected by flexible tubing 18 to a three-way valve 19 which is actuated by the solenoid 20 controlled by the rotary switch 21. The rotary switch 21 is actuated by a cam 22 driven by a variable speed motor 23, so that the rate of pulsation can be adjusted to approximate the natural pulse of the patient, or as the attending surgeon desires.

The operation of valve 19 selectively connects the tubing 18 to a vacuum reservoir 24 or to a pressure reservoir 25 by means of conduits 26 and 27, respectively. As shown, the valve 19 is connecting tubing 18 to the vacuum reservoir 24 through conduit 26, to exhaust fluid pressure from around diaphragm 12, and the conduit 27 is closed off. When the high part of cam 22 closes switch 21, the solenoid will move the valve piston 28 down, closing off conduit 26 and opening conduit 27 to the pressure reservoir 25, to supply a pressure pulse between the diaphragm 12 and sleeve 10.

The vacuum in reservoir 24 is maintained at the desired value by means of a vacuum control valve 30, and the pressure in reservoir 25 is maintained at a desired value by pressure control valve 31. The vacuum line 32 is connected to the intake of an air pump 33, and the pressure line 34 is connected to the exhaust of said pump. The pump is driven by an electric motor 35.

When the vacuum in line 32 and reservoir 24 drops below a predetermined minimum, the pressure differential acting on diaphragm 36 of valve 30 will overcome tension spring 37 and open valve element 38 to atmosphere. Similarly, when the pressure in line 34 and reservoir 25 exceeds a predetermined maximum, the pressure differential acting on diaphragm 39 of valve 31 will overcome compression spring 40 and open valve element 41 to atmosphere.

In the embodiment shown in FIGS. 3, 4 and 5, the flexible envelope indicated as a whole at 45 is substantially funnel-shaped, and has an outer flexible wall 46 of a suitable plastic material such as a vinyl resin and an inner liner or diaphragm 47 preferably of the same or

similar material. The inner liner is bonded along its top and bottom edges to the outer wall, as shown at **48** and **49**, respectively, to form a closed pocket C' extending around the inner periphery of the envelope. The bonding may be done by heat sealing or cementing, or in any suitable manner.

A tube **17'** extends through and is secured to the outer wall **46**, and is adapted to be connected to the flexible tubing **18** for supplying and exhausting fluid pressure to and from said pocket C' in the same way as described in connection with the pocket C in the embodiment of FIGS. 1 and 2.

The outer wall **46** is formed along its upper edge with a recess **50** to allow passage therethrough of the inferior vena cava of the heart represented at **51** in FIG. 3. On either side of the recess the wall **46** extends upwardly and one side is formed into a flap **52** which is adapted to be turned back over the upper portion of the heart and overlap the extended portion **53** on the other side of the recess. Suitable complementary attaching means are provided on the extended portion **53** and the underside of flap **52**. As shown, the attaching means may comprise a synthetic wool material **54** on the flap and a synthetic material **55** having microscopic hook elements which attach to the wool when the portions **54** and **55** are pressed together.

When the flap **52** is attached to extended portion **53**, as indicated in FIG. 3, the envelope is securely held around the heart without pinching any of the tubular arterial or venal connections, the flap passing over the heart above the inferior vena cava **51**, and below the superior vena cava **56**, the aorta **57** and the pulmonary artery **58**. When pulsating pressure is introduced through tube **17'**, the pocket C' expands and contracts to apply the pulsating pressure peripherally around the exterior of the heart.

In use, once the chest wall of the patient is opened to permit access to the heart, the surgeon can quickly apply the sleeve **10** by forcing it upwardly over the lower end of the heart to the position shown in FIG. 1, or apply the flexible envelope and secure it in place by attaching the flap **52** to extended portion **53**. In both embodiments, the flexible inner liner conforms itself to the outer contour of the heart. The tube **17** or **17'** is connected to tubing **18** and the motor **23** operated to control reversing valve **19** through the action of switch **21** and solenoid **20**. By changing the speed of variable speed motor **23**, the pulse rate may be varied to correlate it to the pulse rate of the patient. By changing the settings of the control valves **30** and **31**, the pulsation pressure may be varied as desired.

It will be apparent that a novel cardiac massage apparatus has been provided by the present invention, which apparatus is inexpensive to make and easy to apply to the heart, and that the pressure and rate of pulsation of the device is accurately controllable.

What is claimed is:

1. In cardiac massage apparatus, an envelope of a size fitting about the human heart comprising a flexible substantially funnel-shaped outer wall for surrounding said human heart, a single flexible inner liner attached to said outer wall and forming therewith a peripheral closed pocket for conforming substantially to the peripheral exterior of said heart, a tube connected to said pocket through said outer wall for supplying pulsating pressure thereto, a flap extending from the upper edge of said outer wall for being turned back over the heart and attached to the outer wall on the opposite side, the upper edge of said outer wall having a recess for extending below the inferior vena cava of said heart, and means for attaching said flap to said outer wall.

2. In cardiac massage apparatus, an envelope of a size fitting about the human heart comprising a flexible substantially funnel-shaped outer wall for surrounding said human heart, a single flexible inner liner attached to said outer wall and forming therewith a peripheral closed pocket for conforming substantially to the peripheral exterior of said heart, a tube connected to said pocket through said outer wall for supplying pulsating pressure thereto, an attaching portion extending upwardly from one side of the outer wall and a flap extending upwardly from the opposite side, complementary attaching means on the attaching portion and the underside of said flap, and a recess in the upper edge of said outer wall between said attaching portion and said flap to allow passage through said wall of the inferior vena cava of said heart.

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