Oct. 5, 1965 H. M. JAMES 3,209,469

EXTERNAL CARDIAC MASSAGE TRAINING DEVICE

Filed March 7, 1962

2 Sheets-Sheet 1

FIG-1

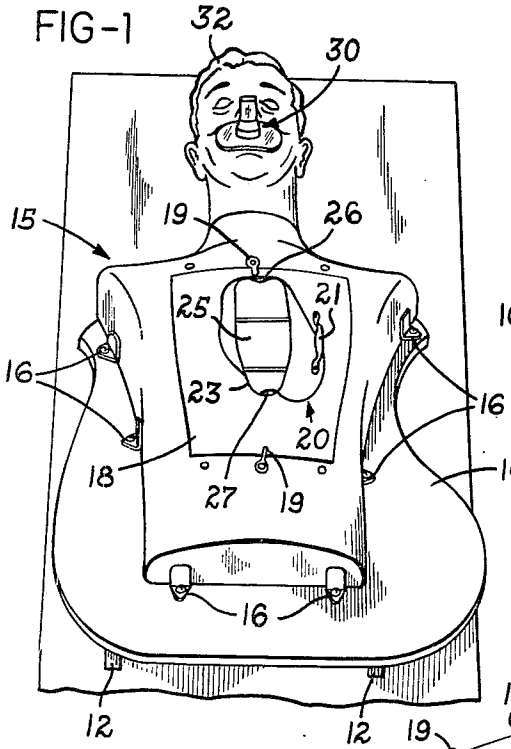


FIG-2

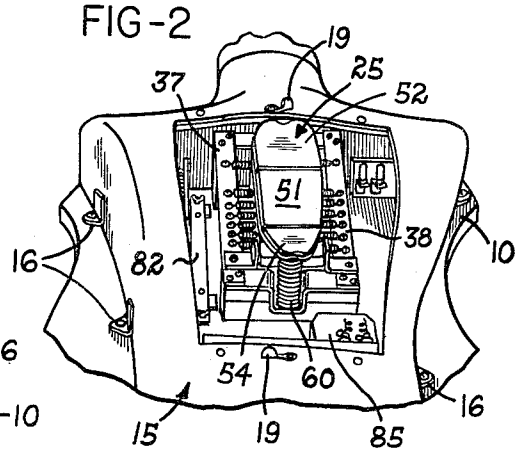


FIG-3

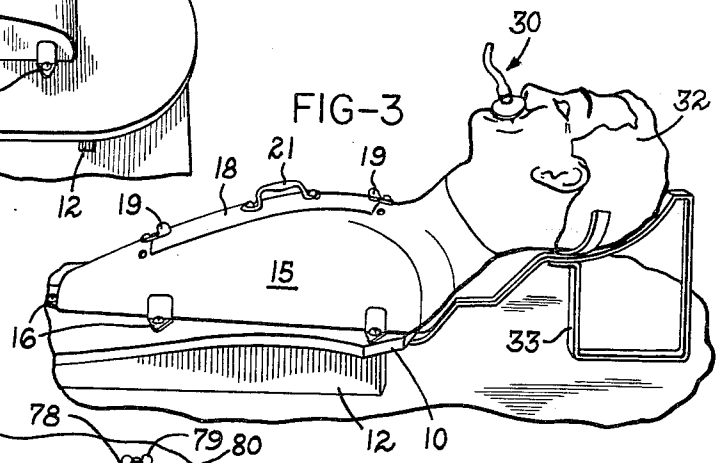
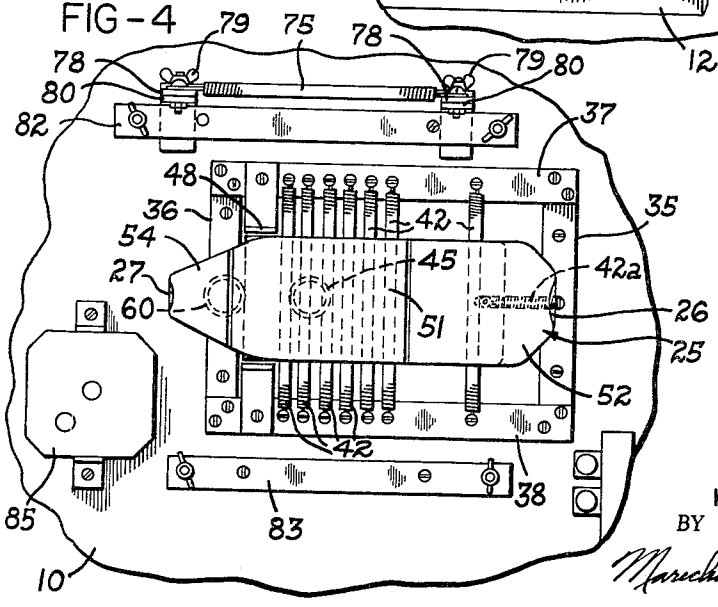


FIG-4



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EXTERNAL CARDIAC MASSAGE TRAINING DEVICE

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2 Sheets-Sheet 2

FIG-5

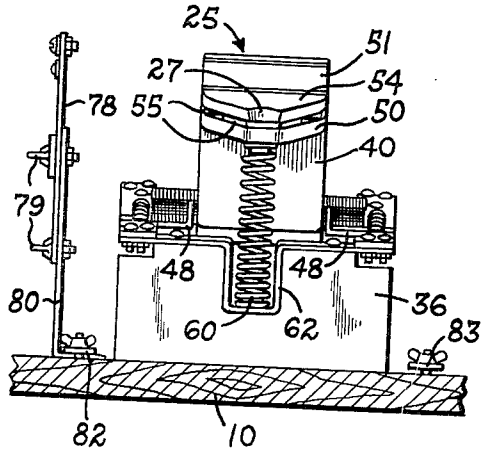


FIG-6

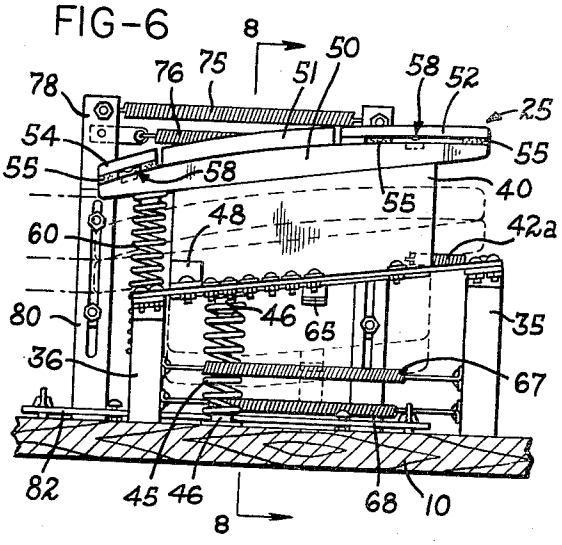


FIG-7

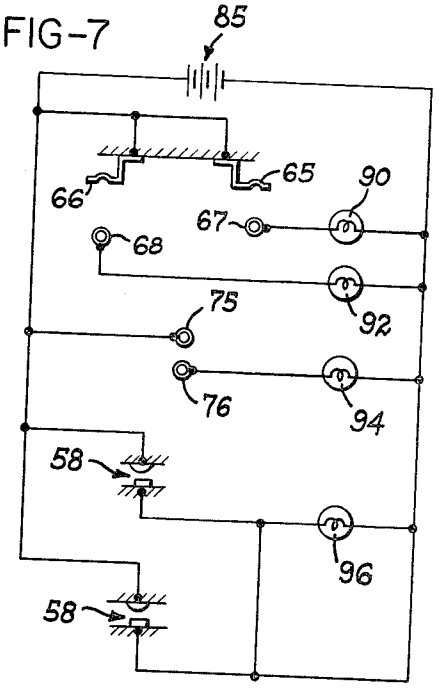
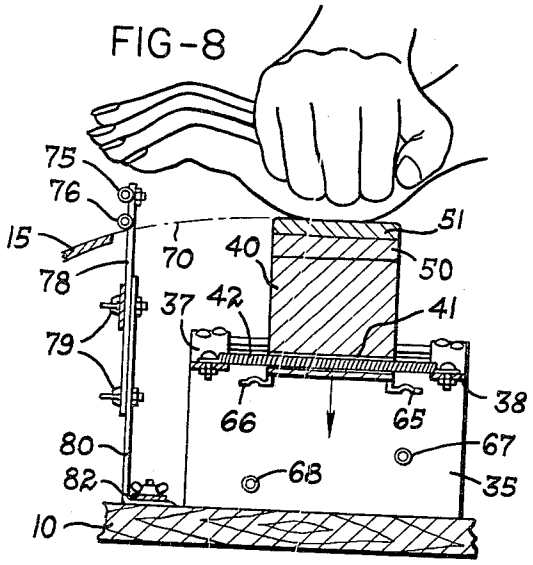


FIG-8



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3,209,469

EXTERNAL CARDIAC MASSAGE TRAINING DEVICE

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Filed Mar. 7, 1962, Ser. No. 178,185
7 Claims. (Cl. 35—17)

This invention relates to a training device particularly adapted for training persons to execute properly external cardiac massage upon victims of cardiac arrest.

It has been known for some time that victims of cardiac arrest, attributable to any number of causes, can often be helped by cardiac massage to such an extent that the heart is caused to begin beating again by itself. The most popular system up to this time has been to open the chest through surgery and to reach into the chest cavity and palpitate and massage the heart with the fingers. Obviously, this system is only to be employed where all other means of reviving the patient, or reviving the heart beat, have been unsuccessful, since the quick surgery required is dangerous, and may be particularly so if the patient is in non-sterile surroundings. As a result of these difficulties a system has been developed which is known as external cardiac massage.

The external massage system operates because of certain physical construction of the human body. With a person, in the present case the cardiac arrest victim, placed in the supine position, i.e., lying upon his back, the heart is limited posteriorly by the vertebral column and anteriorly by the sternum or breast bone, the bone at which the ribs join along the front of the chest. The pericardium or sac which surrounds the heart restricts lateral motion of the heart. Therefore, with the victim in the supine position, when pressure is applied on the sternum the heart is pushed against the spine, forcing blood into the arteries as the pericardium is distorted outwardly by such downward pressure. Relaxation of this presure allows the heart to fill with venous blood. Because the thoracic cage in unconscious cardiac arrest victims is flexible, the sternum can be depressed by a distance of one and one-half to two inches (about three to five centimeters) without endangering the ribs.

Accordingly, the external cardiac massage system requires that the victim be placed in the supine position, and force applied against his sternum, in a regular or rhythmic fashion, and thus to force blood into the arteries and maintain an artificial circulation of the blood particularly to the lungs and to the brain. This action, coupled with ventilation of the respiratory system, as by mouth-to-mouth or mouth-to-nose artificial respiration, will maintain adequate flow of blood and thus an adequate supply of oxygen to the brain. It has been determined that if a victim of cardiac arrest is allowed to remain without restoration of heart beat, either self-sustained or by such massage, permanent damage to the brain will result within approximately four minutes.

Accordingly, the external cardiac massage system assures that the function of the heart in circulating or pumping blood from the venous system into the arteries is maintained, and this action coupled with artificial respiration will maintain the required supply of oxygen containing blood to the brain to circumvent such permanent brain damage.

The external cardiac massage system is of course much more acceptable than the open chest massage system heretofore known. Obviously, it is no longer necessary always to make an incision in the chest, and the danger of infection is essentially eliminated. Moreover, laymen can be readily trained in the technique, and thus lives can be saved in instances where no medically trained person is at hand.

In performing the external massage, the person doing the massage places the heel of one hand, in some cases with the heel of the other hand on top of it, on the lower sternum, approximately one third of the way upward from the xiphoid, which is at the lower end of the sternum or breast bone, and firm pressure is applied vertically through the heel of the lowermost hand about once per second. At the end of each pressure stroke, the hands are completely relaxed to permit full chest expansion. The massaging person positions his body, particularly his upper torso and shoulders, such that the body weight can assist in applying pressure. Proper technique will result in forcing the sternum one and one-half to two inches (or three to five centimeters) toward the spine. If two persons are available, another can maintain mouth-to-mouth or mouth-to-nose artificial respiration or ventilation while the first person proceeds with the cardiac massage. Respiration is effected about once every three to four seconds, and if only one person is available it is possible for him to interrupt the cardiac massage every twelve to fifteen seconds so to achieve three to five breaths of artificial respiration and thus ventilate the lungs to assure that oxygen is supplied to the lungs and to the blood being circulated by the cardiac massage.

The external massage system, once learned, can be used by properly trained persons who do not have a general medical background. For example, members of rescue squads, fire departments or police departments, or the like, can be trained to perform the external cardiac massage effectively. However, in such training it is necessary that the trainee be permitted to practice the technique, and to learn proper placement of the hands. For example, if the fingers, particularly of the lower hand contacting the sternum, are permitted to press against the ribs of the victim, the force of the massage is exerted partially onto the ribs, and it is quite possible that one or more ribs may be fractured. Furthermore, the same pressure obviously is not required for children as for adults, nor for infants as for children. Therefore, the trainee must learn to analyze the victim and his physical makeup, and to apply the proper pressure accordingly. As an example, the massage can be effected on children using one hand only, with the heel of the hand placed on the sternum. On infants, it is necessary only to use the first two fingers of one hand to press upon the sternum, and the rate at which pressure is applied is generally increased for children and infants such for example that approximately ninety strokes per minute may be used for a child and in the neighborhood of one hundred twenty strokes per minute (in other words two per second instead of one) for infants.

If the trainee were to practice on humans simulating cardiac arrest victims, it would of course be undesirable to practice on children or infants. Even when practicing on adults, the force exerted on the sternum is considerable. When the person being massaged is not unconscious, the thoracic cage is not as flexible as with an actual unconscious victim, and the person simulating the victim would thus be subjected to considerable uncomfortable and in fact painful treatment. Realizing that this would be a time of training, it is quite possible that the trainee, not having mastered the technique but merely learning it, could likely injure the person simulating the victim, perhaps seriously if one or more ribs were broken and caused internal puncture wounds of one type or another.

Accordingly, the present invention provides a device which is effectively used to train persons in the proper technique of applying external cardiac massage to victims of cardiac arrest.

Another object of the invention is to provide such a

device including a part simulating the sternum, wherein such part can be deflected by application of pressure by the trainee, and wherein proper and excessive deflections of the plate, corresponding to proper and excessive depressions of the sternum, will be indicated to the trainee thus to familiarize him with the feel of properly applied massage pressure.

Another object of the invention is to provide such a training device including a means for warning the trainee that his fingers are improperly placed and could result in injury to a real victim.

Another object of the invention is to provide such a device wherein the resistance to motion of the sternum simulating plate can be changed to give the trainee the feel of different resistances as would be encountered in massaging children or infants.

Another object of the invention is to provide a training device which with its distinctive signals indicating adequate sternal pressure, the rhythm of the trainee practicing the massage technique, excessive sternal pressure, excessive finger pressure against the ribs or the adjacent chest wall, with or without the combined pulmonary resuscitation feature, provides a device which can be duplicated and connected in parallel to a monitor panel or the like permitting training of several persons at one time with a trainer-observer being able to view such a monitor panel and accurately control the training of the several persons practicing on the individual units.

Other objects and advantages of this invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

FIG. 1 is a perspective view of a training device according to the invention;

FIG. 2 is a view similar to FIG. 1, on a slightly larger scale, with the cover on the chest of the mannequin removed;

FIG. 3 is a side view on a larger scale of the device as shown in FIG. 1;

FIG. 4 is a plan view on an enlarged scale showing only the details of the device simulating the sternum and the apparatus associated therewith;

FIG. 5 is an end view of the apparatus shown in FIG. 4, with the battery and its mounting omitted;

FIG. 6 is a side view of the apparatus shown in FIG. 4, showing also in dotted lines moved positions of the sternum simulating device;

FIG. 7 is a schematic electrical diagram; and

FIG. 8 is a sectional view taken on line **8—8** of FIG. 6, and including an illustration of the hands of a trainee properly placed upon the device in preparation for execution of the massage technique as it would be applied to an adult.

Referring to the drawings, which illustrate a preferred embodiment of the invention, and particularly with reference to FIGS. 1, 2 and 3, the device includes a base **10** which is provided with suitable supporting rails or feet **12** adapted to rest upon the floor or upon a similar surface. A mannequin **15** of the human chest, including the shoulders, neck, and the area of the upper abdominal cavity adjacent the bottom of the thoracic cage, is mounted upon the base **10** in a rigid position, for example being fastened thereto by a number of clips **16**. The mannequin is hollow, and the central chest area is provided with a removable cover **18**, held in place by a pair of pivoting clips **19**, and centrally located on the mannequin. Preferably there is some indicia on the cover, indicated generally by the reference numeral **20**, to indicate the general location of the heart within the chest. For example, in one form of the device this area is painted red within the outline in FIG. 1. A handle **21** preferably is fixed to the cover **18** to facilitate its movement, since the cover ordinarily is removed during use of the device.

The center of the cover is provided with an elongated aperture **23** which extends centrally and longitudinally of the cover, as best seen in FIG. 1, and a plate **25** or the like of the same general configuration as the opening **23**, is mounted within the opening **23** and provides a means simulating the sternum or breast bone of the victim. Preferably, this plate is provided with a locating notch or flat **26** at its upper edge to simulate the location of the upper or sternal notch, at the top of the breast bone, and at its lower end there is a similar notch **27** located to simulate the xiphoid, the lower terminus of the sternum. The trainee can feel these notches and thereby become acquainted with the manner in which he can locate the sternum on a cardiac arrest victim.

As mentioned in the introduction to this specification, the external cardiac massage is generally accompanied by artificial respiration or ventilation of the lungs, and the device may include provision for training in this respect also. For example, it may be desirable to train two persons as a team, one giving the cardiac massage and the other giving mouth-to-mouth artificial respiration through the use of a conventional appliance **30** which fits within the mouth of the victim, and includes a known tongue depressor (not shown) which assures a clear opening through the tubular body into the throat of the victim. Accordingly, the mannequin may be provided with a head **32** to which such an appliance can be attached, and a suitable support **33** for the head is shown in FIG. 3. It should be understood, however, that the primary purpose of the present device is to train persons to execute properly the external cardiac massage, and that the head and appurtenant parts are not a necessary feature of the invention.

Within the mannequin **15**, and mounted upon the base **10**, there is a supporting frame provided by upper and lower mounting blocks or the like indicated respectively at **35** and **36**. The corners of these blocks are joined by side rails **37** and **38**, and the sternum simulating device or plate is formed by a relatively thick body **40** having a number of transverse passages **41** (FIG. 8) through which resilient supporting members such as springs **42** extend, being anchored at their opposite ends to the rails **37** and **38**. Beneath the block **40** there is a larger spring **45** (or its equivalent) which is engaged over suitable guides or short posts **46**, FIG. 6, and which provides a permanent predetermined resistance to depression of the block **40**, in conjunction with the supporting spring members **42**. It should be noted, particularly with reference to FIGS. 4 and 6, that one of the support springs, designated **42*a***, is fastened at one end to the upper mounting end member **35**, and at its other end to the block **40**, and thus provides a restraining and locating force directed transversely to the other springs **42**.

Adjacent the lower end of the block **40**, referring in this sense to FIG. 2 and using the term lower as it would apply to the lower regions of the chest, there are a pair of guiding members in the form of angles **48** which extend vertically alongside the block, in slightly spaced relation thereto, limiting the motion of the block in this area particularly to essentially up and down or vertical motion, indicated by the arrow in FIG. 8.

The actual sternum simulating plate is preferably constructed on the block **40**, and includes a main plate member **50** which is secured to the upper surface of block **40**, and has a raised portion **51** which is a rigid part of the plate **50**. The portion **51** is located generally over the lower third and upward across the center of the plate **50**. Plate members **52** and **54** are secured to the plate member **50** through resilient members **55**, such as small blocks of rubber or the like, which normally hold the plate members **52** and **54** slightly above the main plate member **50** and with their upper surfaces coextensive with the surface of the central member **51**. Between the main plate **50** and each of the plate members **52** and **54** there are electrical contact members **58** normally main-

tained spaced apart by the action of the resilient blocks **55**. If the trainee places his hand upon either of the plate members **52** or **54**, this will tend to close the contacts **58** providing a signal indicating that the trainee has not placed his hand properly upon the sternum simulating device.

It has been established that because the thoracic cage in unconscious persons is flexible, the sternum can be depressed one and one-half to two inches without endangering the ribs. It is therefore desirable to train those who are learning the technique of external cardiac massage in the "feel" of the depression of the chest, particularly the sternum, this amount. Accordingly, the force required to depress the spring **45** is predetermined, and in addition the further spring **60** is mounted between a support bracket **62** and the lower end of the main plate member **50**, particularly beneath the plate member **54**. This spring **60** is removable, and different springs having different known rates may be substituted in this position. Therefore, it is possible to provide different predetermined resistances to depression of the sternum simulating device. In some instances, for example when it is desired to simulate the relatively slight resistance which would be offered by the chest structure of an infant, no spring at all may be required in this position, with the spring **45** being sufficient for the desired purpose.

In order to give the trainee a feeling for the proper rhythmic application of the desired force, the present invention provides a signaling system whereby the trainee is informed when he is depressing the sternum simulating member a sufficient amount, and a further signal is also provided to indicate when excessive force is being applied, such as would endanger the chest structure of an actual patient. For this purpose, a pair of contacts **65** and **66** are fastened to the lower side of the block **40**. Beneath the contact **65** there is a contact preferably in the form of the spring **67**, spaced below the normal elevated position of the contact **65** by a distance of about three centimeters. Motion of the sternum simulating block construction to bring the contact **65** into engagement with the spring contact **67** will represent the minimum desired depression of the sternum in an actual patient.

Beneath the contact **66** there is a spring contact **68**, spaced below the normal elevated position of the contact **66** by a distance of about five centimeters. This distance represents the maximum desired depression of the sternum in a patient, beyond which the force exerted may be dangerous to the rib structure, in particular.

Both the contact members **65**, **67** and **66**, **68** are connected to actuate separate and distinctive signals or indicators, visible (or audible) to the trainee so that he will know when he is depressing the sternum simulating device the proper amount, and not an excessive amount. Details of these signaling or indicating devices are described hereinafter.

Referring particularly to FIG. 8, the correct position of the hands is illustrated upon the main upper plate member **51**. The heel of one hand, shown here as left hand, is placed upon the sternum, and the fingers of that hand are maintained in an elevated position. The hand placement shown is that desired for massage of an adult, and thus the other or right hand is placed with its heel over the back of the left hand, and force is exerted upon the sternum (in the patient) with both hands. In massaging a child, it would be desirable to use only one hand, in the position shown for the lower hand in FIG. 8. In applying massage to an infant, only the first two fingers of one hand would be placed upon the plate **51**.

Particularly when applying the massage to adults or children, it is necessary to develop the proper technique whereby the force is directed onto the sternum, and is not applied to adjacent areas of the rib cage. Thus, as previously mentioned, the fingers of the lowermost hand must be maintained in an elevated position with respect to the chest. For purposes of illustration, a portion of the mannequin **15** is shown in FIG. 8 in the area surrounding the sternum simulating device, and at an elevation which defines the exterior of the chest structure as it would appear in an actual victim. The dot-dash line **70** represents the extension of the chest (or the cover **18**) toward the sternum simulating device, but in actual use of the preferred form of the apparatus, this area is left open, the cover being removed.

A warning apparatus is provided to indicate incorrect placement of the fingers while practicing the message technique on the training apparatus. This apparatus is in the form of spaced contact springs **75** and **76**, which are mounted on a frame **78**, electrically insulated from one another. These springs form contacts at the elevation corresponding to the chest surface (i.e., the location of spring **76**) and if the fingers are lowered by the trainee to the point where the upper spring **75** is carried into contact with the lower spring **76** during depression of the sternum simulating device, a circuit will be closed to actuate a further signal or indicating device. Thus, the trainee learns to maintain his fingers properly away from the chest surface, to avoid closing these contacts.

Preferably an adjustment is provided in the framework mounting the contact springs **75** and **76**. This may be in the form of suitable bolt and wing-nut fasteners **79** which mount the framework **78** on mounting angles **80**. Thus the proper elevation of the spring contacts **75** and **76**, particularly the latter, can be attained. Furthermore, the base leg of the mounting angles **80** is received under a socket forming plate **82**, at one side of the sternum simulating device, and an identical socket forming plate **83** (FIG. 4) is provided at the other side. Thus, the entire spring contact arrangement, including the mountings therefor, can be placed on either side of the sternum simulating device in order to provide the desired signaling or indicating function on either side of the sternum according to the manner in which the trainee operates. Some persons will prefer to kneel to the right side of the victim while others will prefer to kneel on the left side, and it makes no difference which position is attained, so long as the hands are properly placed and used upon the sternum. Thus, the signaling contacts **75** and **76** can be moved to the opposite side of the device from that shown in the drawings, for training in either position.

FIG. 7 is a schematic diagram of a suitable electrical circuit for the signaling devices. Preferably these devices are in the form of differently colored lights, as will be described, and these lights are actuated or energized by the various switch contacts previously described, according to the necessary signal. In order to provide maximum portability, the preferred embodiment employs a simple battery circuit, using for example a conventional lantern battery **85**, mounted on the base of the apparatus and shown schematically in FIG. 7. Obviously, any other suitable source of electrical power can be utilized. As shown in FIG. 7, the contacts **65** and **67** control the energization of a signal lamp or bulb **90**. when the trainee is executing the massage technique on the training device, this lamp will light once for each downward or pressure stroke of the massage. The lighting of this lamp on each stroke also provides a guide to the trainee as he counts to learn proper timing, it being desirable to depress the sternum once each second, approximately, as previously explained. In a preferred form of the apparatus the lamp **90** is a white signal light. The contacts **66** and **68** control energization of a warning lamp **92**, preferably a red or otherwise vivid signal. When the trainee is depressing the sternum simulating device an excessive amount, this signal will operate to provide the warning to him that he is executing the massage too vigorously or with too great a downward force such as would be dangerous to a patient.

The contacts **75** and **76** are connected in circuit with the warning lamp **94**. This lamp also should be some rather vivid color, for example an orange or a different

shade of red, preferably distinct from the lamp **92** but still of a warning nature. Thus when the fingers of the trainee's hands are placed too low or too close to the chest, this signal will light. The contacts **58** are connected in parallel and either will energize a further warning lamp **96**. This lamp or bulb, when lit, indicates to the trainee that he has not placed his hand properly on the sternum simulating device, either contacting the lower plate member **54** or the upper plate member **52**, and thus not having the correct placement of his hand to apply the force of the massage in the proper area of the sternum on an actual victim.

Obviously, other equivalent signaling or indicating devices, either visual or audible or both, can be employed within the scope of the invention. However, the arrangements shown have proven completely satisfactory in actual use, and are thus illustrated as being a preferred embodiment of the invention. It should also be understood that the particular construction of the sternum simulating means is, while in many cases preferred, not essential to the invention. Many equivalent constructions will suggest themselves to those skilled in the art. The constructions illustrated and described herein are however of a type which have actually proven satisfactory.

The location of the various signal lamps is discretionary, and hence has not been illustrated in any detail beyond the circuit diagram. If the device is provided as a single portable unit the various indicating devices, such as the lamps or bulbs, can be mounted on the mannequin where they are readily visible to the trainee and to the trainer who is instructing. It is also within the perview of the invention to provide multiple training devices having connections to such indicating lamps on a remote monitor panel or board, with a set of indicator lamps for each training device. With such an arrangement the trainer can observe and instruct several trainees at the same time.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A device for training persons to execute properly external cardiac massage on victims of cardiac arrest, comprising a base, a mannequin of the human chest mounted on said base in simulated supine position, movable means positioned on said mannequin corresponding to the location of the sternum, and forming a visible indication of such location on the chest, means mounting said movable means for motion in said mannequin simulating the depression of the sternum required for cardiac massage, and means resisting depression of said movable means with a force predetermined to approximate the resistance to flexing of a human thoracic cage.

2. A device for training persons to execute properly external cardiac massage on victims of cardiac arrest, comprising a base, a mannequin of the human chest mounted on said base in simulated supine position, movable means positioned on said manequin corresponding to the location of the sternum, said movable means including a main portion corresponding to the correct placement of the hand of a trainee, first and second members movably mounted on said main portion corresponding to incorrect placement of the hand, first and second sets of switch contacts mounted on said first and second members and adapted to be actuated upon incorrect placement of the hand on said movable means, signal means operatively associated with said first and second sets of contacts for indicating the incorrect placement of the hand in response to actuation of either of said contacts, means mounting said movable means for motion in said mannequin simulating the depression of the sternum required for cardiac massage, means resisting depression of said movable means with a force predetermined to approximate the resistance to flexing of a human thoracic cage, and means operatively connected to said movable means indicating the acceptable limits of movements of the sternum attendant to proper cardiac massage.

3. Apparatus for instructing and training persons in the application of external cardiac massage, comprising a plate constructed to simulate the sternum and forming a visible indication of the position of the sternum with respect to the chest structure, means mounting said plate providing for restrained movement thereof by the hand of a trainee in a manner corresponding to depression of the human sternum with the body in supine position, means resisting such motion of said plate with a predetermined force corresponding to resistance encountered in depressing the sternum, and signal means connected to indicate proper depression of said plate by the trainee.

4. Apparatus for instructing and training persons in the application of external cardiac massage, comprising a device constructed to simulate the sternum and forming a visible indication of the position of the sternum with respect to the chest structure, means mounting said device providing for restrained motion thereof in a manner corresponding to depression of the human sternum with the body in supine position, means resisting such motion of said device with a predetermined force corresponding to resistance encountered in depressing the sternum, a first signal device connected to indicate motion of said device corresponding to sufficient depression of the sternum for effective heart massage, and a second signal device connected to indicate motion of said device corresponding to excessive depression of the sternum which could result in damage to the thoracic cage or organs contained therein.

5. Apparatus for instructing and training persons in the application of external cardiac massage, comprising a mannequin of the human chest including a device constructed to simulate the sternum, means mounting said sternum simulating device providing for restrained motion thereof in a manner corresponding to depression of the human sternum with the body in supine position, means resisting such depression of said sternum simulating device with a force predetermined in amount to the resistance encountered due to limiting flexibility of the thoracic cage, and signal means operatively associated with said sternum simulating device for indicating application of force at an improper location on the sternum.

6. Apparatus for instructing and training persons in the application of external cardiac massage, comprising a mannequin of the human chest including a device constructed to simulate the sternum, means mounting said sternum simulating device providing for restrained motion thereof in a manner corresponding to depression of the human sternum with the body in supine position, means resisting such depression of said sternum simulating device with a force predetermined in amount to the resistance encountered due to limited flexibility of the thoracic cage, and signal means including a switch contact operatively mounted on said mannequin alongside said sternum simulating device and at essentially the level of the chest for teaching the trainee to hold his fingers in properly elevated position above the ribs while exerting a sufficient depressing force with the heel of his hand on said sternum simulating device.

7. A device for training persons to execute properly external cardiac massage on victims of cardiac arrest, comprising a base, a mannequin of the human chest mounted on said base in simulated supine position, movable means positioned in said mannequin in a location corresponding to the sternum, mountings for said movable means confining movement thereof in said mannequin to motion simulating the depression and raising of the sternum required for external cardiac massage, adjustable means resisting depression of said movable means with a force predetermined to approximate the resistance to

flexing of different human thoracic cage structures, electrical contacts arranged for selective operation by said movable means for indicating the limits of movement of said movable means corresponding to sufficient but not excessive motion of the sternum required for effective cardiac massage.

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