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(54) ELECTROCARDIOGRAPH ELECTRODES AND ASSOCIATED ASSEMBLIES

(71) We, HAROLD MILLS, a Citizen of the United States of America, of 1049 Hillcrest Road, Beverly Hills, California, United States of America and HERBERT STEIN, a Citizen of the United States of America, of 238 South McCarty Drive, Beverly Hills, California, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The Electrocardiogram (ECG) has proven over the years to be the single most effective clinical record for the diagnosis of cardiac muscle and cardiac nervous conduction abnormalities. An electrocardiogram is routinely taken not only on patients suspected of having cardiac disease, but also on normal patients to establish base line cardiac data. Thus, millions of ECG tracings are recorded yearly in private physicians' offices and in hospitals. It is imperative that these tracings be reliable and also that they be obtained rapidly to minimize the cost.

Generally, the ECG is usually comprised of twelve distinct records (i.e., tracings) which are obtained from a combination of specific electrical signals obtained from the body of the patient. These signals result from the heart's electrical activity which is conducted throughout the body. The signals, ordinarily in the millivolt range, may be sensed by metal electrodes making electrical contact with the body by way of electrically conductive electrode paste. The signals are transmitted from the electrodes through cables to an electrocardiograph or ECG recorder which includes amplifying circuity, a heat stylus writing mechanism and switching circuitry. The latter circuitry permits combining the signals ordinarily taken from ten different positions on a patient's body to obtain the twelve tracings ordinarily desired.

The twelve tracings, ordinarily adequate to obtain the heart's full spectrum of electrical data, are obtained from electrodes placed on the patient's four extremities and six electrodes carefully positioned on the precordium (i.e. the chest wall of the heart area). The latter six electrodes in the precordial positions are designated as V_1, V_2, V_3, V_4, V_5 and V_6. In certain cases, other positions on the chest may be chosen (e.g. V_3R) so that the specific example using positions V_1 to V_6 is illustrative rather than limiting.

The usual practice is to apply the electrodes to the arms (LA, RA), legs (LL, RL) and procordium (V_1, V_2, V_3, V_4, V_5 and V_6), with the electrodes being of a clamp type, suction cup type or adhesive type. Such electrodes must be applied one-at-a-time and, in the case of the precordial electrodes particularly, require careful placing at specific anatomical locations. Thus, the careful and time-consuming attention of a skilled nurse, technician or doctor is required.

According to the invention there is provided a chest piece for automatically locating the precordial anatomic positions for electrocardiograph electrodes on the chest of a patient comprising:

a strip of stretchable, non-conductive material adapted for positioning on the chest of a patient in preparation for electrocardiographic monitoring with the ends thereof at predetermined locations on the chest of the patient,

said strip having a plurality of apertures in predetermined locations, thereon, each of said apertures identifying a precordial anatomic position for electrocardiographic monitoring of the patient when said strip is positioned in a substantially unstretched condition on the chest of a first patient having a chest of relatively small size; and,

retaining means carried by said strip at

opposite ends thereof for stretching said strip to locate the ends thereof at said predetermined locations on the chest of a patient having a chest of larger size thereby to increase the spacing between each of the apertures and to locate automatically the correct precordial anatomic positions on the chest for electrocardiographic monitoring of the patient having a larger chest.

The invention also comprehends a chest piece including a plurality of electrodes carried by said strip in said plurality of apertures in the strip.

The electrocardiograph electrode assembly may also include a retainer or holder means for engaging the ends of the stretchable strip and for stretching the strip a selectable amount to position and maintain the electrodes in contact with precordial anatomic positions on the chest of the patient.

Advantageously, the holder may be releasably attached to the chest piece, and may take the form of a member positioned behind the back of the patient or weights positioned along the sides of the chest of the patient.

The invention also comprehends a method of automatically determining the anatomic precordial positions for electrocardiograph electrodes on the chest of patients having significantly different chest sizes comprising the steps of providing a chest piece of stretchable material provided with means for identifying at least two predetermined positions thereon corresponding to a like number of predetermined positions on chests of significantly differing sizes, and carrying indicia of a plurality of anatomical precordial positions;

stretching the chest piece to position said identifying means of the chest piece on the corresponding positions on the chest of a patient; and,

determining a plurality of anatomical precordial positions on the chest of the patient by reference to the indicia carried by the chest piece.

Some embodiments of the invention will now be described by way of example.

Figure 1 is a plan view of one embodiment of a chest piece for establishing anatomically acceptable precordial electrode positions for connection to electrocardiograph apparatus;

Figure 2 is an enlarged vertical sectional view taken along the line 2-2 of Figure 1;

Figure 3 is a plan view of one embodiment of a holder for securing the chest piece of Figure 1 to the chest of a patient;

Figure 4 is an enlarged pictorial view of one embodiment of a spring connector for use with the chest piece of Figure 1;

Figure 5 is a pictorial view of the chest piece of Figure 1 secured to the chest of a patient by the holder of Figure 3;

Figure 6 is an enlarged plan view showing the connection of the spring connector of Figure 4 to the chest piece of Figure 1;

Figure 7 is a plan view of a second embodiment of a chest piece;

Figure 8 is an exploded pictorial view of a second embodiment of a holder for use with the chest piece of Figure 7;

Figure 8A is a view of one embodiment of a connector wire for use with the chest piece of Figure 8;

Figure 9 is a pictorial view schematically illustrating the connections of the holder of Figure 8 to a ten terminal electrocardiograph recorder;

Figure 10 is a pictorial view schematically illustrating the connections of the holder of Figure 8 to a five terminal electrocardiograph recorder;

Figure 11 is a pictorial view of one embodiment of an adaptor for use with a five terminal electrocardiograph;

Figure 12 is a schematic circuit diagram of the adaptor

Figure 13 is a plan view of a second embodiment of a chest piece;

Figure 14 is a pictorial view of one embodiment of the electrode of the present invention;

Figure 15 is a cross-sectional view of the electrode of Figure 14 taken along line 15-15;

Figure 16 is a pictorial view in partial section of a second embodiment of the electrode of the present invention;

Figure 17 is a pictorial view of the electrical connector of Figure 16;

Figure 18 is a pictorial view of another embodiment of the holder of the present invention;

Figure 19 is a cross-sectional view of the embodiment of Figure 18 taken along line 19-19;

Figure 20 is a cross-sectional view of the embodiment of Figure 18 taken along line 18-18;

Figure 21 is a pictorial view of another embodiment of the holder of the present invention;

Figure 22 is a cross-sectional view of the embodiment of Figure 21 taken along line 21-21;

Figure 23 is an elevation in partial section of a third embodiment of an electrocardiograph electrode assembly;

Figure 24 is a cross-section of the embodiment of Figure 22 taken along line 23-23;

Figure 25 is the cross-section of Figure 23 with a sleeve and pin type connector in place therein;

Figure 26 is the cross-section of Figure 23 showing the operation of a split sleeve and pin type connector;

Figure 27 is a pictorial view of another holder;

Figure 28 is a section taken along line 27-27 of Figure 26;

Figure 29 is a pictorial view of another embodiment of the holder;

Figure 30 is a pictorial view of one embodiment of a weight for use in the embodiment of Figure 28; and

Figure 31 is a pictorial view of an electrocardiograph electrode assembly with a frame member for overlying the chest of a patient.

As illustrated in Figure 1, a chest piece 22 may comprise a strip 24 of expandable or stretchable material such as rubber sheeting. Extending through the strip 24 are six spaced electrodes designed V_1, V_2, V_3, V_4, V_5 and V_6 in accordance with their positions. As best shown in the enlarged sectional view through the electrode V_6 in Figure 2, each electrode may comprise a hollow metal sleeve or rivet member 26 extending through the strip with the outer end (away from the patient's skin) projecting beyond the adjacent surface of the strip at 26' to facilitate the attachment of leads as will be discussed below. At each end of the strip 24, three transversely spaced connector rings 28 are shown extending through the strip 24.

With reference to Figure 3, a holder 30 is preferably formed of rigid wood or plastics material or the like although it might in certain circumstances be of flexible fabric or other material. The holder may include hooks 32 at each end corresponding in number and spacing to the connector rings of the chest piece of Figure 1. The holder 30 extends around the back of the patient so that the hooks 32 thereon may engage the connector rings 28 of the chest piece to hold the latter in place across the chest of the patient as shown in Figure 5.

A significant feature of the construction thus far described is the disposition or location of the electrodes V_1 to V_6 on the chest of the patient. With the strip 24 of the chest piece in an unstretched condition, these electrodes are spaced suitably for engagement with the correct anatomic contact areas for the precordial electrodes usually designated V_1, V_2, V_3, V_4, V_5 and V_6 on a chest of small size such as that of a ten year old child. To facilitate positioning on the patient, the strip of the chest piece may be provided with a vertical line or mark 34 indicating the location for the mid-chest or mid-sternum line and a horizontal mark 36 indicating the location of the mid-nipple line. Thus, the vertical line is midway between the electrodes V_1 and V_2 and the horizontal line is in alignment with these electrodes.

With the basic pattern for the electrodes based on the measurements of a small chest as stated, the electrodes can be made to automatically assume the correct anatomic location on a larger chest by stretching the stretchable strip 24 the appropriate amount in securing it to the patent. This is readily accomplished by employing holders 30 of different sizes, or with multiple hook locations, for securing the chest piece in place on different size chests. Alternatively, elastic strips of different flexibility might be used as a holder.

Figure 4 shows a conductor 38 including a U-shaped spring connector 40 for engaging electrodes 26 at the aforementioned projecting portion 26' as shown in Figure 6. The hollow construction of electrodes 26 permits the introduction of conductive electrode paste from the outside of the passage therethrough to the other end which contacts the skin of the patient so as to provide a low-resistance contact between the electrode and the patient's skin. The other end of the conductor 38 may be provided with a spring wire adaptor 42 or other suitable conventional connector for receiving a metal pin connector at the end of a lead wire of the patient cable of an electrocardiograph recorder. A single conductor 38 may be moved from one electrode V_1 to V_6 to another or conductors may be connected to all the electrodes simultaneously for operation through an adaptor unit such as is hereinafter described in connection with Figures 11 and 12.

Figures 7 and 8 illustrate, respectively, another chest piece and a holder. With reference to Figure 7, the chest piece includes a strip 122 of stretchable material similar to the strip 24 of Figure 1 and is provided with electrodes 126 spaced therein in accordance with the appropriate precordial anatomic positions V_1, V_2, V_3, V_4, V_5 and V_6 for a patient having a small chest. Also, like the chest piece of Figure 1, the chest piece of Figure 7 is stretchable across the chest of a larger patient to automatically adjust the spacing of the electrodes 126 to cause them to engage the corresponding precordial anatomic positions for persons having larger chests. Three connecting rings 128L and 128R are shown secured at the left and right ends, respectively, of the strip 122 for engagement by hooks on corresponding positions on a holder member to be described in connection with Figure 8.

The chest piece 122 includes electrical conductors 130 individually making electrical connection between the six metal electrodes 126 and the end connectors 128L and 128R. In Figure 7, the electrodes at precordial positions V_1, V_2 and V_3 are shown connected by the conductors 130 to the connector rings 128R for the patient's right side, which rings are labelled V_1, V_2 and V_3, respectively. Similarly, the electrodes at positions V_4, V_5 and V_6 are connected, respectively, to the connector rings 128L on

the patient's left side designated V_4, V_5 and V_6. The electrical conductors 130 interconnecting the electrodes and connector rings are preferably embedded in the stretchable or elastic strip 122, although they may be disposed on the surface of the strip opposite the surface which contacts the patient's skin. It is also preferred that the conductors be made flexible, as by employing a slight helical or curved configuration, so that they may accommodate to the changes in spacing of the interconnected electrodes and connector rings when the chest piece is stretched to the different lengths necessary for use in patients having chests of different sizes.

The electrodes 126 may be hollow sleeve members extending through the chest piece strip similarly to the electrodes 26 of Figures 1 and 2, whereby electrically conductive electrode paste can be conveniently introduced into them from the outside after the chest piece is installed to obtain a low-resistance contact with the patient's body. Because of the internal electrical connections to the connector rings, the electrodes 126 do not necessarily require outwardly projecting portions such as are shown at 26' in Figure 2.

Figure 8 shows a holder for location at the back of a patient to hold the chest piece in an adjustable position according to the size and conformation of his chest and facilitate making the necessary electrical connection to electrocardiograph recorder equipment.

The holder includes a holder base plate 142, preferably of rigid plastics material including an outwardly projecting longitudinal bar 144 having downwardly and inwardly extending bevelled sides 146. Longitudinal bar members 148R and 148L have bottom slots 150 making a sliding fit over the longitudinal bar 144 and further include transverse upper slots 152 with upwardly converging, bevelled edges 154. Transverse bar members 156R and 156L are provided with corresponding projections 158 fitting into the slots 152 for transverse sliding adjustment therein.

Bar 156R includes three metal hooks 160R, designed V_1, V_2 and V_3, each connected to one of the wires in a five-wire cable 162R. Also two pin jacks RA (right arm) and RL (right leg) are disposed on bar 156R and connected to the other two wires of five-wire cable 162R. In like manner, bar 156L includes three hooks, designated V_4, V_5 and V_6 and two pin jacks LA (left arm) and LL (left leg) connected individually to five wires in five-wire cables 162L. The remote ends of five-wire cables 162R and 162L extend into a terminal or connector block 164 of non-conductive material with the ten wires of the cables terminating in ten binding posts 166.

The construction of the holder is such that the engagement of the slots 150 of bars 148R and 148L with the base plate 142 and the engagement of the slots in the bars 148R and 148L with the projections on the transverse bars 156R and 156L is loose or frictionless to provide free movement or the chest piece pulls the sliding bars of the holder together until they touch the sides of the chest. The adjustable bars will hold their adjusted positions with the chest piece 122 stretched the desired amount and in the desired transverse position through the pull of the chest piece.

In use, bars 148R and 148L are assembled on bar 144 with their slots 150 in longitudinally adjustable engagement with longitudinal bar 144. Also projections 158 on transverse bars 156R and 156L are fitted into transverse slots 152 in bars 148R and 148L, respectively, for slidable transverse adjustment therein. The chest piece is placed over the chest of the patient and the holder under the back of the patient. The connector rings 128R and 128L are engaged with hooks 160R and 160L, respectively. With the aid of the mid-sternum and mid-nipple lines 134 and 136 on the chest piece 122, the blocks 148R and 148L and 156R and 156L are slidably adjusted to so stretch the flexible or stretchable strip of the chest piece as to locate the respective electrodes 126 at the correct percordial anatomic positions corresponding to V_1, V_2, V_3, V_4, V_5 and V_6 for the particular chest size of the patient.

Figure 8A illustrates a connector wire 168 for use in connecting the pin jacks RA, RL, LA and LL to the extremities of the patient. One end of a wire 170 terminates in a miniature plug 171 for engagement with the aforementioned pin jacks while the other end is provided with a standard ECG plug 172 for engagement with extremity electrodes which may be of conventional type.

With the chest piece and holder assembled on the patent as described, and the pin jacks RA, RL, LA and LL connected through wire correctors 168 to extremity electrodes on the right arm, right leg, left arm and left leg, respectively, the binding posts 166 of the connector block 164 for the holder will provide connections to each of the four extremity positions and each of the six usual precordial positions.

Figure 9 shows schematically the electrical connections of the form of the invention shown in Figures 7 and 8 to a ten-terminal electrocardiograph conductor. Thus, the five-wire leads 162R and 162L from the holder 140 are connected to the terminal block 164 and the ten binding posts 166 from the block are connected by a ten conductor cable 174 to the electrocardiograph 176. When the chest piece and holder of Figures 7 and 8 are used with a five-terminal

electrocardiograph recorder, the electrical connections are made as shown in Figure 10.

Figures 11 and 12 show the adaptor as including five output conductors extending to the five terminal, single V channel electrocardiograph recorder. Four of these conductors extend directly through the adaptor to the four extremity conductors FL, LL, RA and RL while the fifth conductor is the V channel conductor which may selectively be connected to each of the precordial leads V_1 to V_6. A manually controlled selector 184 is movable from a zero position 0 through connections to the leads V_1 and V_6.

As illustrated in Figure 13, a chest piece 22 may comprise a strip 24 of expandable or stretchable material such as rubber sheeting. Extending through the strip 24 are six spaced electrodes 226 designated V_1, V_2, V_3, V_4, V_5 and V_6 in accordance with their positions. The electrodes will be described in greater detail in connection with Figures 14 and 15. The electrodes are adapted to receive an electrolyte through apertures 228, which, when the chest piece is disposed on the patient, open outwardly from the chest of the patient. Terminal members 230, which may be rotatably mounted to the electrode, are adapted to receive a cable plug from the electrocardiograph machine.

As shown in Figure 13, the chest piece 22 may include strip end members 232. Advantageously, the strip end members 232 may be detachably coupled to the stretchable strip 24 by means of snap fasteners 234. The strip end members may carry, for example, a buckle catch (not shown) or similar device for releasably engaging the holders or retainers hereinafter described. Since both the strip end members and electrodes are readily detachable from the stretchable strip, some or all of the electrodes, and the strip end members can be replaced, permitting the remaining components to be reused.

With continued reference to Figure 13, the strip 22 may include a number of "stays" 236 similar to collar stays. These stays are useful in reducing the reduction in the width of the strip as it is stretched lengthwise across the chest of a patient. They may be attached by any suitable conventional means such as pressure sensitive adhesive.

Referring now to Figures 14 and 15 where the electrode 226 of Figure 13 is illustrated in greater detail, the electrode may include a hollow tubular member 240 made of electrically conductive material and terminate circular bell-shaped flange portions 242. A pair of circular flanges 244 carried by the tubular member 240 may together form an annular slot 246 configured and dimensioned to engage the edge portions of an aperture in the sheeting material 22 to releasably maintain the electrode 226.

A terminal 248 may be rotatably mounted on the tubular member 240 and may be configured and dimensioned to receive and frictionally engage a banana cable plug 250 connected to an input terminal of a conventional electrocardiograph machine. A thumb screw 252 may be provided to insure an electrical connection with any electrical lead from an electrocardiograph machine.

In operation, the bell or cup shaped portion 242 may be held against the chest of a patient by the stretch of the sheet 22 across the chest of the patient. An electrolyte paste may then be inserted through the top of the tubular member 240 to contact the chest of the patient. The terminal 248 may, if rotatable, be positioned to any convenient orientation and may include a spring biased alligator clip or other suitable electrical connecting means in lieu of the aperture and thumb screw illustrated.

An alternate to the electrode 226 of Figures 14 and 15 is illustrated in Figures 16 and 17 where the electrode is maintained in place in an aperature in the sheet 22 by a single flange 252 and the bell or cup shaped terminator 254 of the tubular member 56.

As shown in Figure 17, the connector 64 may be a flat metal sheet rolled at one end to form a split sleeve for insertion into the tubular member 256 to be there retained by the spring action of the sleeve. The other end of the connnector 264 may be formed into two split sleeves 266 and 268 of different diameters to facilitate the insertion of banana plugs of different sizes.

A holder for a chest piece such as that described in connection with Figure 13 is illustrated in Figure 18. With reference to Figure 18, the chest piece 269 may include strip end members 270, formed with buckle catches 272 for insertion into their respective buckle members 274 to thereby engage the ends of the chest piece 269 with the holder 268. The holder 68 may include a first belt 76 threaded in a first direction through a base member 78, and a second belt 80 threaded in the opposite direction through the base member 78.

Advantageously, the buckle members 274 and belts 280 and 282 may be attached to the base member 278 in the manner depicted in Figure 19, where one end 284 of the belt may be anchored to the base member 278. The belt may then be disposed about a roller 286 within the buckle member 274 and be threaded through an elongated channel 288 in the base member. In order to tighten the chest piece 269, the end 282 of the belt may be pulled to draw the buckle member 274 toward the anchored belt end 284 to be maintained in position vis-a-vis the belt by frictional engagement between the buckle member, the belt, and the roller 286.

Referring now to Figures 21 and 22, the holder 300 may include a first belt 302 threaded through a channel in base member 304. One end of the belt 302 may be provided with a snap coupling 306 adapted for releasably engaging the strip end piece 308 of the chest piece 310. A second strip end piece 312 of the chest piece 310 may be formed with a buckle catch 314. The buckle catch may be releasably engaged by the buckle member 316 carried by a second belt 318. The second belt may engage a roller 320 which redirects the second belt 318 so that a portion thereof is nearly parallel to a portion of the first belt 302. The ends of the first and second belts may be joined to facilitate stretching of the chest piece across the chest of the patient.

In operation, the holder 300 may be disposed behind the patient prior to electrocardiograph monitoring. The strip end member 308 may be engaged to the snap fastener 306 of the belt 302. The chest piece 310 may be placed about the chest of the patient and loosely secured in position by buckling the buckle catch 314 with the buckle member 316. The electrodes may be positioned and maintained in contact with the precordial anatomic positions on the chest by pulling on the joined ends of the belts 302 and 318 in the direction of the arrow 324. A quick release seat belt type locking mechanism 326 may be provided to permit movement of the belts 302 and 318 only in the approximate direction of the arrow 324. However, the belts may be quickly released.

A third embodiment of an electrode is illustrated in Figure 23 where the body of the electrode is provided with a single generally circular flange 150 radially outwardly extending from a tubular upper portion 152. A cup shaped lower portion 154 cooperates with the flange 150 to prevent the slippage of the electrode from the stretchable strip 22.

The body of the electrode may be of non-conducting material which is desirably resilient to a minor degree. The upper portion is also provided with one or more lateral bores 156 having a portion common with the axial bore 158 as is illustrated more clearly in Figures 24-26.

As shown in Figure 23 and Figure 25, a sleeve 160 of electrically conductive material may be inserted into the bore 158 of the non-conductive body of the electrode, the sleeve 160 extending from a point along the uppermost lateral bore to a point just above the bottom of the cup shaped portion of the electrode.

As is illustrated in Figure 25, a lead of an ECG machine may terminate in an electrically conductive pin 162 adapted for insertion into the lateral bore 156 to be removably held in pressural engagement with the sleeve 160 by the physical configuration of the bores 156 and 158 and/or the resiliency of the material of the electrode body.

A fourth embodiment of an electrode is illustrated in Figures 27 and 28, where the body 170 is desirably molded out of a plastic material into a generally tubular configuration. As shown in the figures, an electrically conductive thin-walled tube 172 extends substantially the length of the body 170 and may terminate in a bell shaped portion in contact with the skin. The lower end of the body is generally in the shape of a truncated cone to form a cavity 174 for electrolyte introduced into the upper end of the tube 172.

The sides of the body 170 are desirably formed to provide notches 176 and 178 at different heights from the bottom of the body. When the present invention is utilized on women with large breasts, greater extension of the electrodes beneath the belt it required for good electrical contact in the V_2 and V_6 positions. Notch 178 is desirably used in such circumstances.

As also shown in the drawings, two lateral apertures 180 and 182 are provided into which the tube 172 extends. These apertures 180 and 182 are desirably of different sizes to accommodate bayonet or banana plugs of differing sizes. The body 170 of the electrode is desirably split into the apertures 180 and 182 to provide a resilient spring action in holding the plug from the electrocardiograph machine into pressural engagement and thus good electrical contact with the tube 172.

It is important to note that the tube 172 may extend upwardly from the top of the body 170 so that a suction cup (not shown) of a conventional type may be attached for use in creating a suctional attachment of the electrode to the patient.

Figure 29 is a pictorial view of an electrocardiograph electrode assembly including means for applying a downward force to ends of an elastic chest piece such as that described in connection with Figure 13. The chest piece 130 of Figure 29 may be stretched to place the electrodes in contact with the proper precordial anatomic positions on the chest of a reclining patient by placing the chest piece 130 on the chest of the patient and disposing weights 132 on either side of the patient to exert a downward force on ends 134 of the chest piece.

The weights may take any desired form but it has been found advantageous for comfort and safety to use a "bean bag" weight such as illustrated in Figure 30. With reference to Figure 30, the weight may include a fabric bag 136 of particulate material such as dried beans or the like connected by any suitable conventional

means such as the illustrated fastener 138 to a rigid retainer 140 to which the free ends of the chest piece might be buckled.

The embodiment of Figure 29 is particularly desirable where movement of the patient to place some retaining means behind his chest may result in injury or discomfort. Another embodiment not requiring movement of the patient is illustrated in Figure 31 where the buckle 139 includes arcuate members 142 for bridging the chest of the patient. A surface 144 may be provided on either side of the chest of the patient for receiving weights sufficient to stretch the chest piece 146. The chest piece 146 may be releasably engaged to the retainer 139 by snap fasteners 148.

The electrodes of the present invention may be configured with notches on two of four sides and be smooth on the other two sides to facilitate retaining of the electrodes in a canted position by an aperture in the belt. This may be particularly desirable for the V_1, V_2 and V_6 positions on certain type chests.

In lieu of a liquid or paste electrolyte, gel pads may be used. These may be held to the electrodes by suction prior to placing the belt on the chest after which a new suction may be drawn through the gel pad to the chest.

From the foregoing description, it will be apparent that the present invention provides a number of features which increase the ease and speed with which electrocardiograms can be made and at the same time decrease the chance of errors and reduce the cost. The stretchable chest piece provides a means for rapidly and repeatedly locating the precordial electrodes at the correct anatomic position on a patient's chest. The described embodiments are to be considered in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT WE CLAIM IS:-

1. A chest piece for automatically locating the precordial anatomic positions for electrocardiograph electrodes on the chest of a patient comprising:

a strip of stretchable, non-conductive material adapted for positioning on the chest of a patient in preparation for electrocardiographic monitoring with the ends thereof at predetermined locations on the chest of the patient,

said strip having a plurality of apertures in predetermined locations thereon, each of said apertures identifying a precordial anatomic position for electrocardiographic monitoring of the patient when said strip is positioned in a substantially unstretched condition on the chest of a first patient having a chest of relatively small size; and,

retaining means carried by said strip at opposite ends thereof for stretching said strip to locate the ends thereof at said predetermined locations on the chest of a patient having a chest of larger size thereby to increase the spacing between each of the apertures and to locate automatically the correct precordial anatomic positions on the chest for electrocardiographic monitoring of the patient having a larger chest.

2. A chest piece according to Claim 1, wherein said retaining means includes a pair of weights removably attached to each of the ends of said strip of stretchable material.

3. A chest piece according to Claim 2, wherein said weights include particulate material contained within a flexible container.

4. A chest piece according to any one of Claims 1 to 3, including means carried by said strip for resisting the width reduction of said strip as said strip is longitudinally stretched.

5. A chest piece according to Claim 4, wherein said strip is between two inches and five inches in width, and wherein said width reduction means includes a plurality of stays spaced along the length of said strip and secured thereto, each of said stays being disposed laterally across the width of said strip and having a length substantially coextensive with the width thereof.

6. A chest piece according to any one of Claims 1 to 5, including a plurality of electrodes carried by said strip in said plurality of apertures in the strip.

7. A chest piece according to Claim 6, wherein each of said electrodes is removably carried by said strip, each of said electrodes comprising an electrically conductive member having a hollow cavity extending through said strip whereby an electrolyte may be inserted through the cavity into contact with the chest of the patient.

8. A chest piece according to Claim 6, wherein each of said electrodes comprises a hollow member of an electrically conductive material which is flared at one end to engage the skin of the patient and is open at the other end so that an electrolyte can be inserted into the hollow of said member to establish a low resistance electrical connection between the skin of the patient and said member, connector means electrically connected to the other end of said member for establishing an electrical connection with a lead of an ECG machine without interference with the insertion of an electrolyte into the hollow of said member when connected to a lead of an ECG machine, and means carried by said hollow member for removably retaining said electrode in an aperture

in said sheet of stretchable material.

9. A chest piece according to Claim 6, wherein each of said electrodes comprises a non-metallic member having an upper generally tubular portion and a lower generally cup-shaped portion adapted to engage the skin of a patient thereby to form a cavity bounded in part by the skin of the patient for containing an electrolyte, said upper portion having a first bore extending from the upper surface of said member downwardly into said cavity and a second bore generally normal to said first bore with a portion thereof being common to said first bore, and an electrically conductive generally tubular member disposed in said first bore including a portion of said second bore common to said first bore, said member extending downwardly into said cavity whereby electrolyte introduced into said cavity through said conductive member provides a low impedance electrical connection between said conductive member and the skin of the patient, said second bore being dimensioned to removably receive a lead from an ECG machine and to retain the lead in contact with said conductive member thereby to provide a low impedance electrical connection between said conductive member and the lead from the ECG machine.

10. A chest piece according to Claim 9, wherein the upper portion of said non-metallic member includes a third bore generally normal to said first bore with a portion thereof common to said first bore, said electrically conductive member is also disposed in a portion of said third bore common to said first bore, said third bore is dimensioned to receive a lead from an ECG machine and for retaining the lead in contact with said conductive member thereby to provide a low impedance electrical connection between said conductive member and lead, and said second and third bores differ in diameter whereby leads of different diameters may be electrically connected to said electrode.

11. A chest piece according to Claim 1, wherein said retaining means comprises a rigid base member adapted for positioning behind the back of the patient, a first belt carried by said base member for releasably engaging said strip adjacent one end, and a second belt carried by said base member for releasably engaging said strip adjacent the other end, at least one of said belts being threaded through said base member so that the belt passes behind the patient.

12. A chest piece according to Claim 1, wherein said retaining means includes frame means adapted to overly the chest of the patient thereby obviating the necessity for moving the patient to place apparatus behind the back of the patient.

13. A chest piece according to Claim 6, wherein said retaining means includes means individually electrically connecting the electrodes at left and right precordial positions to connection elements at the left and right ends of said strip, respectively, said means comprising a back member for engagement with the back of a patient, a pair of contact members each adjustable longitudinally and transversely over at least one end portion of said back member, a plurality of electrically conductive, connector elements disposed in spaced relationship on each of said contact members transverse of said strip for engaging corresponding connector elements on said strip to retain said strip mechanically in a stretched condition upon the chest of the patient and to make electrical contact with the electrodes connected to the conductive connector elements of said strip, contact elements on each of said contact members for electrical connection to the extremities of a patient on that side of the patient, a multi-conductor cable connected to each of said contact members including conductors connected individually to the connector elements and the contact elements of that contact member, a connecting block including a plurality of contact posts individually connected to the conductors in said multi-conductor cables and an adaptor switch box having input terminals connected individually to said contact posts of said connecting block with output terminals connected, respectively, to the input leads and a precordial lead, and with switch means in said box for selectively connecting precordial leads sequentially to said precordial lead.

14. A chest piece according to Claim 6, wherein said retaining means comprises an elongated member adapted to be positioned laterally across the back of a patient in engagement therewith, positioning means carried by said back engaging member adjacent each end thereof, said means being adjustably positionable with respect to said member in a lateral direction across the back of the patient and in a direction longitudinally of the patient, and mechanical connector means carried by said positioning means for engaging said strip when disposed across the chest of the patient, the lateral positioning of said positioning means being responsive to the elasticity of said strip.

15. A chest piece according to Claim 14, wherein said positioning means includes first means and second means relatively movable in a direction longitudinally of the patient, said first means being slidably carried by said elongated member for relative movement with respect thereto in a direction laterally of the patient, said second means being slidably carried by said first

means for relative movement with respect thereto in a direction longitudinally of the patient.

16. A chest piece according to any one of Claims 1 to 15, wherein the strip has means for identifying at least two predetermined positions thereon corresponding to a like numbered position on the chest of any patient.

17. A method of automatically determining the anatomic precordial positions for electrocardiograph electrodes on the chest of patients having significantly different chest sizes comprising the steps of providing a chest piece of stretchable material provided with means for identifying at least two pre-determined positions thereon corresponding to a like number of predetermined positions on chests of significantly differing sizes, and carrying indicia of a plurality of anatomical precordial positions, stretching the chest piece to position said identifying means of the chest piece of the corresponding positions on the chest of a patient, and determining a plurality of anatomical precordial positions on the chest of the patient by reference to the indicia carried by the chest piece.

18. A method according to Claim 17, wherein the indicia carried by the chest piece includes a plurality of metallic electrodes adapted to contact the chest of the patient when the chest piece is in place on the chest of the patient, each of the plurality of electrodes defining a passageway through the chest piece, and including the further step of depositing an electrolyte into the passageway defined by the electrodes whereby the electrodes are automatically positioned on the chest of the patient in anatomic precordial positions and a low impedance electrical connection established between each of the electrodes and the chest of the patient.

19. A method of applying ECG electrodes to the chest of a patient comprising the steps of:

(a) providing a strip of stretchable nonconductive material having a plurality of apertures arranged in a predetermined pattern with the proportional spacing of the apertures corresponding to the proportional spacing of precordial positions for ECG monitoring;

(b) inserting a hollow electrode into each of the apertures;

(c) attaching a weight to both ends of the strip;

(d) stretching the strip across the chest of a prone patient with a predetermined point of the strip in a predetermined anatomical position on the chest of the patient;

(e) positioning the weights alongside the chest of the patient to retain the strip in its stretched position;

(f) connecting a lead from an ECG machine to each of the electrodes; and

(g) applying an electrolyte to the hollow of each electrode in place on the chest of the patient thereby to establish a low impedance connection from the chest of the patient to the ECG machine.

20. A chest piece for automatically locating the position of electrocardiograph electrodes on the chest of a patient, substantially as herein described with reference to the accompanying drawings.

21. A method of applying electrocardiograph electrodes to the chest of a patient, substantially as herein described with reference to the accompanying drawings.

PAGE, WHITE & FARRER,
27 Chancery Lane,
London WC2A 1NT.
Agents for the Applicants

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1593594 COMPLETE SPECIFICATION
6 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG.1

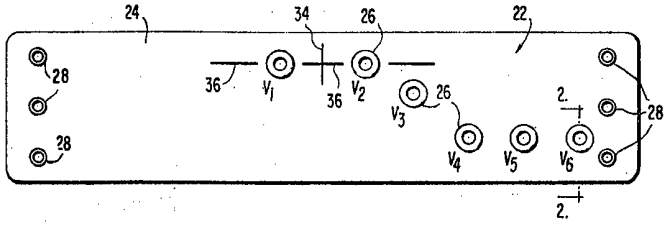


FIG.2

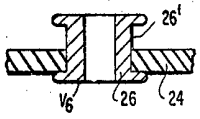


FIG.3

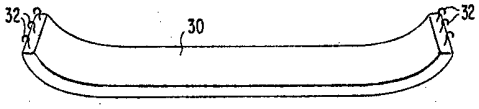


FIG.4

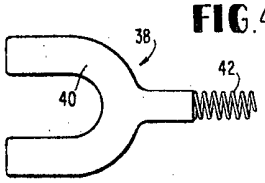


FIG.5

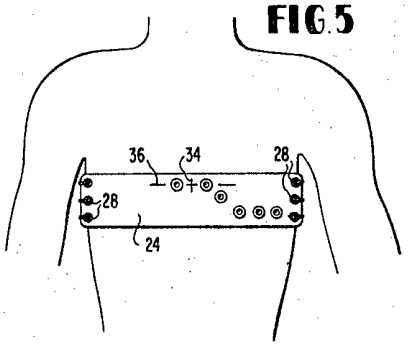
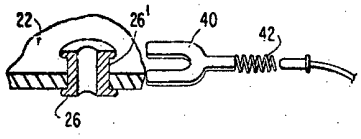


FIG.6



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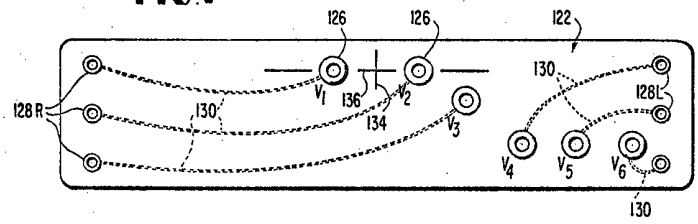

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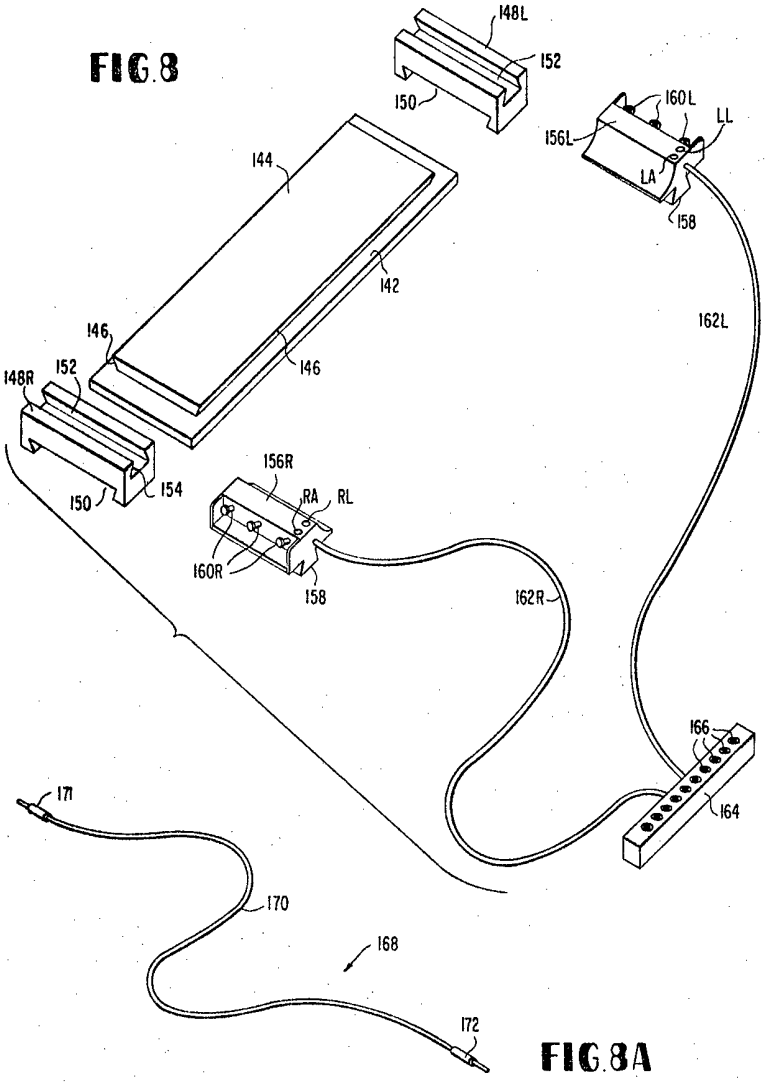
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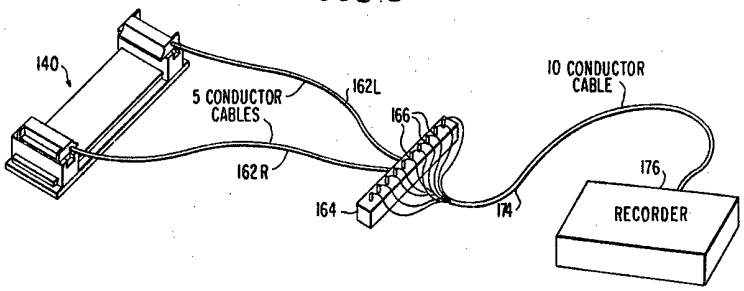
FIG.8A

FIG.9



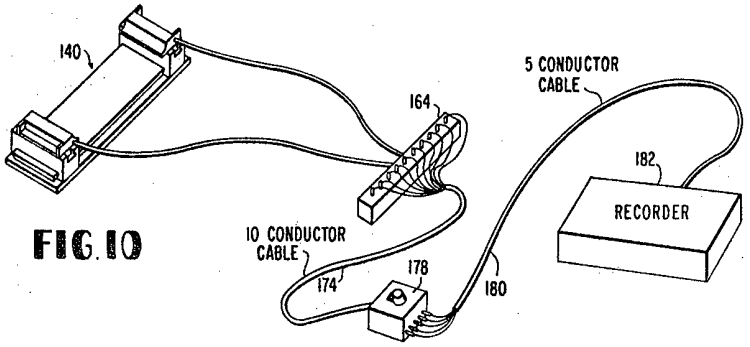


FIG.10

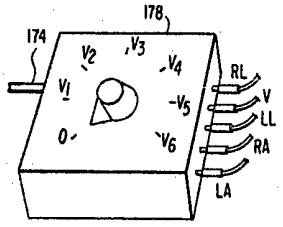


FIG.11

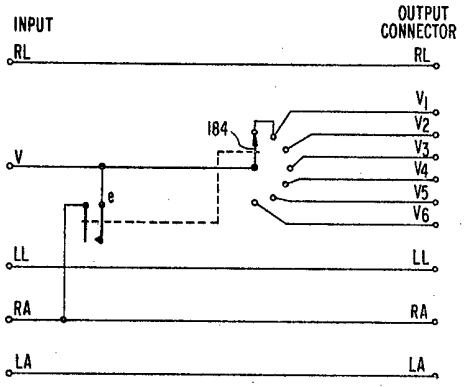


FIG.12

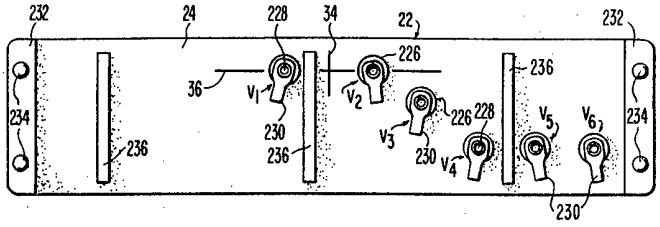


FIG. 13

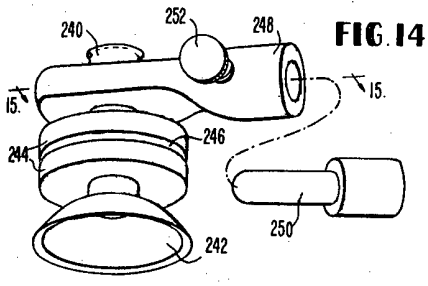
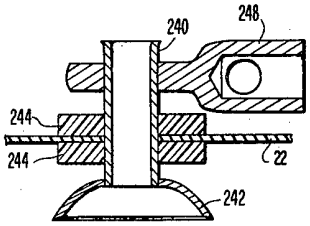


FIG. 14

FIG. 15



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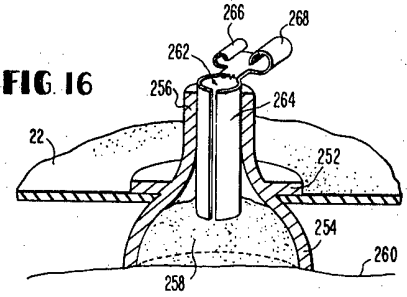


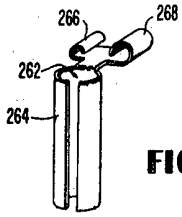


FIG. 17

FIG. 18

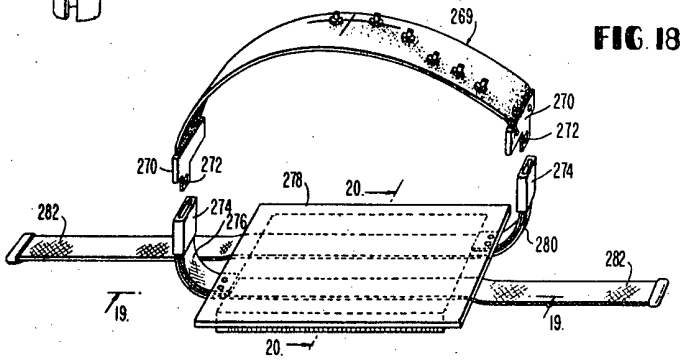


FIG. 19

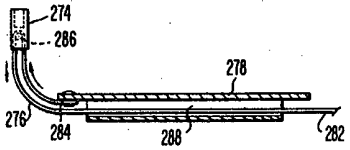
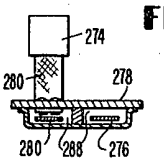


FIG. 20



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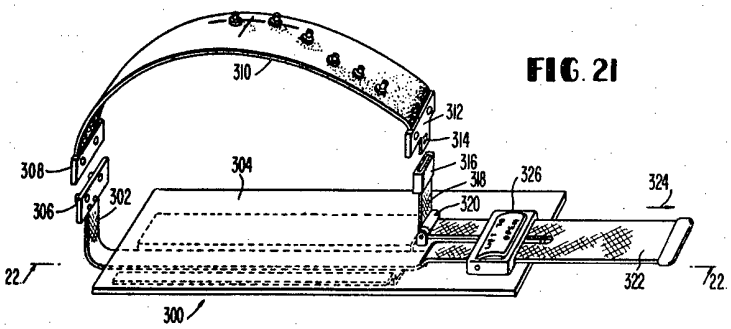


FIG. 22

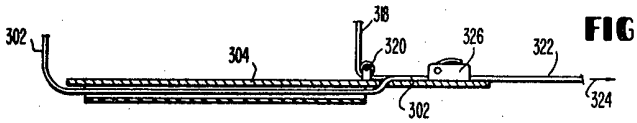


FIG. 23

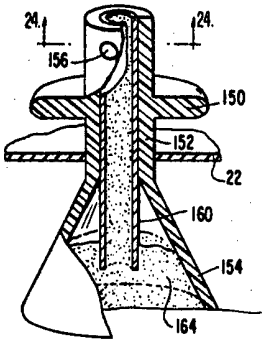
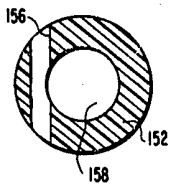


FIG. 24



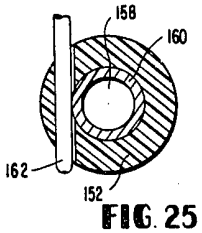


FIG. 25

FIG. 26

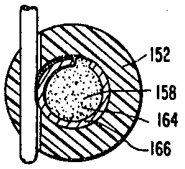


FIG. 27

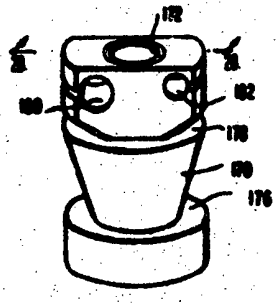
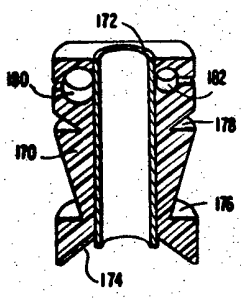
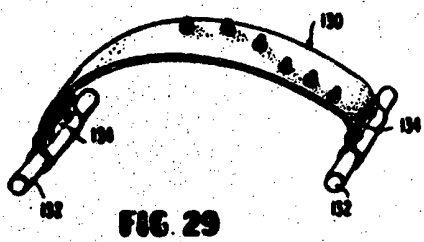


FIG. 28





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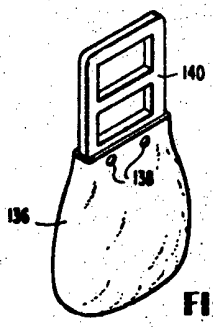

FIG. 30

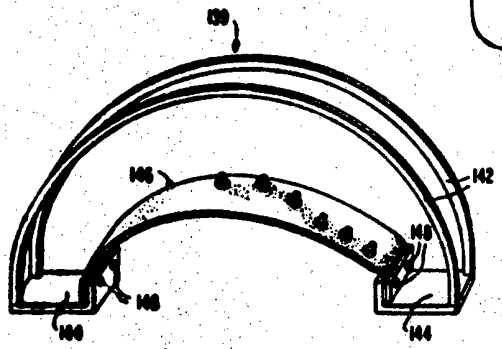

FIG. 31