June 17, 1969 A. A. BIRCH, JR 3,450,133

ELECTROCARDIOGRAPH ELECTRODE SYSTEM

Filed March 2, 1967 Sheet 1 of 2

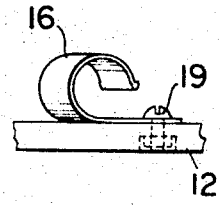

Fig. 3

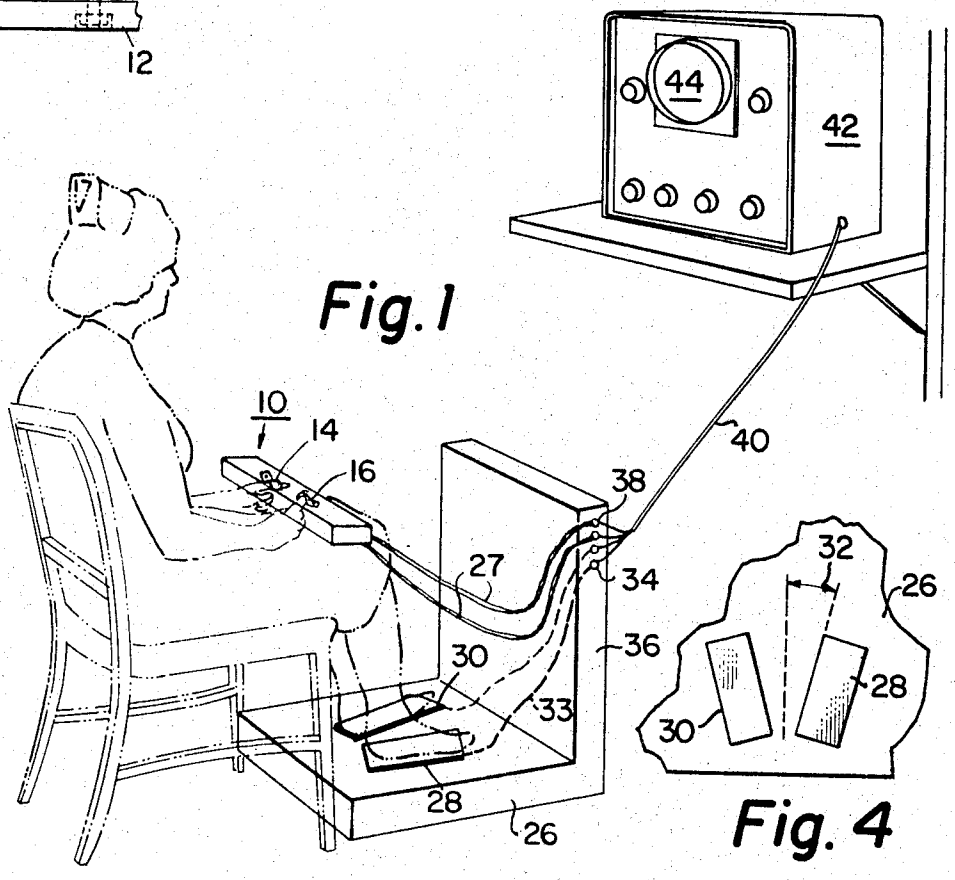

Fig. 1

Fig. 4

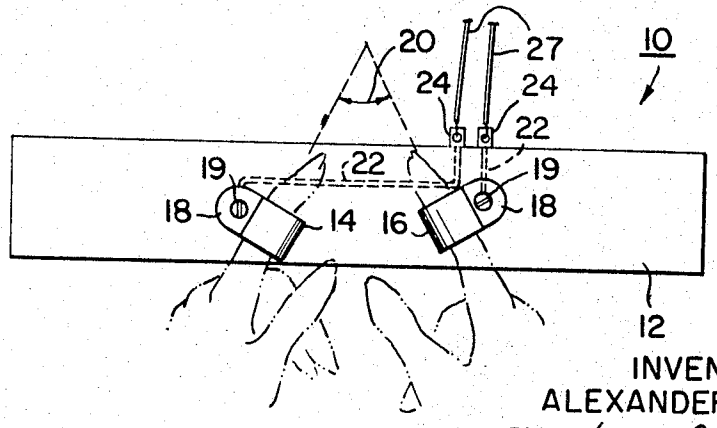

Fig. 2

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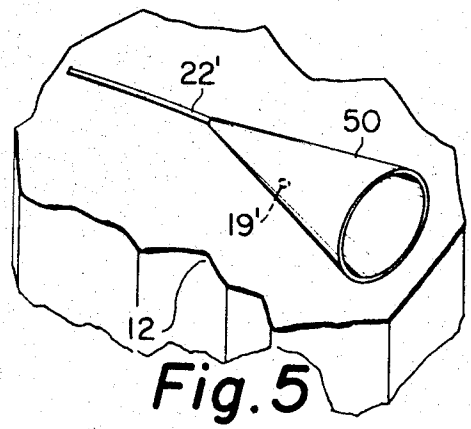
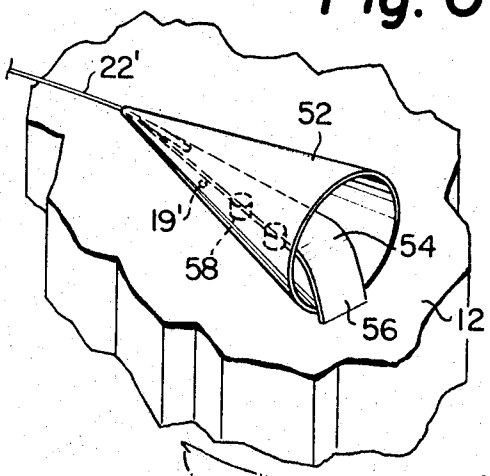


Fig. 5

Fig. 6



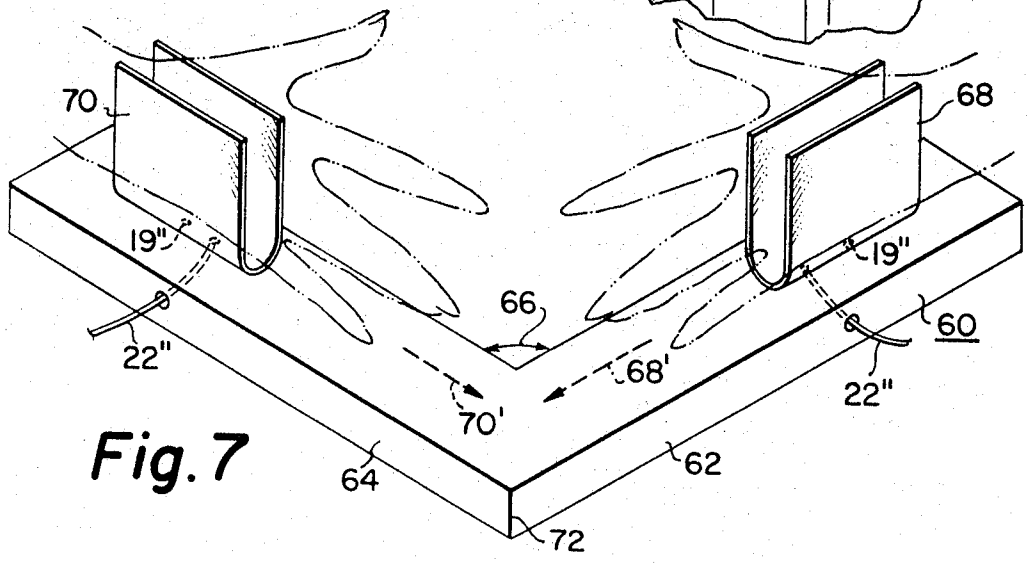


Fig. 7

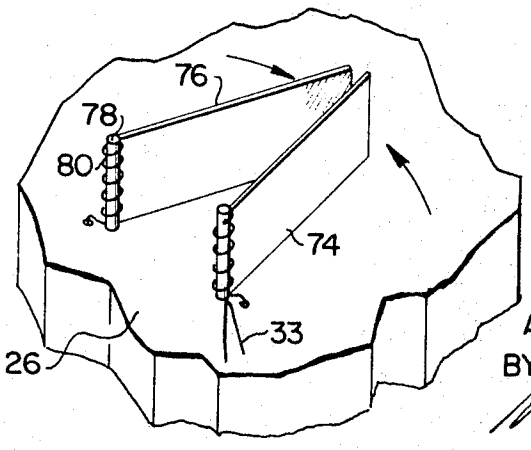


Fig. 8

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3,450,133

ELECTROCARDIOGRAPH ELECTRODE SYSTEM

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Int. Cl. A61b 5/04
U.S. Cl. 128—2.06 9 Claims

ABSTRACT OF THE DISCLOSURE

An electrocardiograph system uses a lap bar having a pair of finger or hand electrodes that have receptable openings with converging axes to contact portions of a patient's hands when resting in a neutral position. A floor board carries a pair of electrodes such as plates that contact the feet.

This invention relates to electrocardiography, and particularly to an electrocardiograph system employing electrodes that enable the rapid taking of electrocardiograms.

It is an object of this invention to provide a new and improved electrocardiograph system for the rapid, simple, and reliable obtaining of electrocardiogram rhythm strips.

Another object is to provide a new and improved electrocardiograph system using electrodes that do not have to be attached to a person's body and do not require any especially constructed furniture.

Another object is to provide a new and improved electrocardiograph electrode system for rapidly and reliably obtaining electrocardiogram rhythm strips, which is simple and inexpensive in construction.

In accordance with an embodiment of this invention, an electrocardiograph electrode system is provided which can be connected to a patient who is fully clothed. A pair of hand electrodes are provided which are attached to a lap bar that rests on the lap of the patient while he is sitting normally in an arm or armless chair, with his hands resting without tension in a neutral position in his lap. The electrodes contain openings for receiving and supporting portions of the two hands in their neutral position. The electrodes are mounted on a lap bar with the axes of the electrode openings in an angular relation and directed convergingly away from the person, so that a finger, fingers, or the hands are inserted and retained in the electrodes without disturbance of the neutral position. Also, in accordance with one embodiment of the invention, a pair of electrode plates are provided on a floor board, which plates are arranged to receive the stocking feet of the patient as he sits relaxed and with his feet and legs in a normal, untensed position. With these electrodes it has been found that electrocardiograph rhythm strips may be rapidly and reliably taken without any special preparation of the patient or of his body members.

The foregoing and other objects of this invention, the features thereof, as well as the invention itself, may be more fully understood from the following description when read together with the accompanying drawing, in which:

FIG. 1 is a perspective view of one emobdiment of the invention, illustrated in use with a patient for taking an electrocardiogram;

FIG. 2 is a top view of the finger electrode device of FIG. 1, illustrated with a patient's fingers connected thereto;

FIG. 3 is a fragmentary side view of a portion of the finger electrode device of FIG. 2 as seen from the patient's side thereof;

FIG. 4 is a top view of the foot electrode device of FIG. 1;

FIG. 5 is a perspective view of another form of finger electrode embodying this invention;

FIG. 6 is a perspective view of a modified form of the electrode of FIG. 5;

FIG. 7 is a perspective view of another form of hand electrode device embodying this invention; and

FIG. 8 is a perspective view of another form of foot electrode device embodying this invention.

In the drawing, corresponding parts are referenced throughout by similar numerals.

In FIG. 1 a patient is illustrated with his extremities connected to an electrode system embodying this invention, for the taking of an electrocardiogram. The patient sits in an arm or armless chair in a normal, relaxed position, with portions of his hands connected to hand electrodes and his feet resting on a pair of foot electrodes

The finger electrode device **10** includes a lap bar **12** made of wood, plastic, or other insulating material, and about a foot and a half in length. On the upper face of the lap bar a pair of finger electrodes **14** and **16** are mounted in spaced (e.g. several inches) relation. Each electrode **14** and **16** is in the form of a generally cylindrical, open metallic loop formed of thin sheet metal (e.g. copper) and having a mounting ear **18** extending to one side, which is fixed to the lap bar by means of a screw or other attaching element. The single-screw attachment permits pivotal rotation of the electrode to change the direction of the axis of the cylindrical finger opening formed by the loop. These axes of the two electrodes **14** and **16**, shown in broken lines, form an angle **20** corresponding approximately to the angle between the index fingers when the patient's arms rest in the relaxed or neutral position with the hands lying neutrally in the lap in the position of function (i.e. the ulnar side of the hands and lower arms resting on the thighs). The fingers, when so relaxed, are normally extended proximally with the distal phalanx of each flexed to form a hook shape. A person can accommodate some variation in this angle **20** while resting in the neutral position, without producing muscle tension in the arms or hands such as would adversely affect the electrical signals that are detected with the electrodes. An angle in the range of 30–180 degrees is suitable for most people. The pivotal attachment **19** permits some angular adjustment of the electrodes **14** and **16** so that the patient's index fingers can rest comfortably in full contact with the electrode while the hands and arms lie in a neutral position without any significant muscle tension being produced in the arms or hands. The loop electrodes have a slight spring tension to ensure a snug, but not tight, engagement with the fingers.

Electrical conductors **22** are connected to the electrode ears **18** and are lead out through holes in the lap board **12** to terminal connectors **24** at the front edge of the lap board, from which electrical leads **27** are run. The lap bar **12** rests lightly on the patient's lap, for example across his knees. If desired, a pair of grooves may be formed in the under-surface of the lap bar, to fit onto the upper surfaces of the knees or thighs. However, due to variations in body structure, and variations in the rotation of the legs of different patients when resting in the neutral position, and since it is desired that there be no interference with the relaxed position of the legs, it has been found undesirable to provide any special shape to the bottom of the lap bar. Thus, a flat under-surface of the lap bar has been found to be suitable and is easily retained on the lap while taking the EKG. Alternatively, a generally concave under-surface may be used, which would be uniformly applicable to a wide range of body sizes.

The foot electrode device in one embodiment takes the form of a thin (e.g. a few inches) floor board **26** (e.g. about a foot and a half square) that rests on the floor in front of the chair, and is formed of a suitable insulating

material such as wood or plastic. On the top surface of the floor board, a pair of rectangular metallic plates **28** are attached on which the soles and heels of the patient's feet rest as he sits in a relaxed position. In this position, the upper legs are abducted to the position of comfort and the lower legs and feet are each externally rotated (e.g. 10 to 20 degrees) from the mid-line. The angle of rotation of each foot electrode **28** and **30** from the mid-line is indicated in FIG. 4 by the angle **32**. In order to accommodate a wide range of foot sizes and variations in body structure, each foot electrode may take the form of a large rectangular plate, and the two plates are spaced at the medial line. Thereby, each patient is encouraged to assume his own comfortable, relaxed position of his feet as he sits in the chair, and the electrode plates are large enough to contact his feet, whatever position is assumed. Each foot electrode **28** and **30** is separately connected by conductor (via suitable lead passages in the floor board) to a separate connector terminal **34**, mounted on the side of a vertical support member **36** rising from and attached to the floor board **26**. A pair of connector terminals **38** are also provided for the leads **25** from the finger electrodes. A cable **40** carries four conductors having connector terminals that mate to the connectors **34** and **38**, and cable **40** provides an electrical coupling to an electrocardiograph unit **42** which is illustrated with a conventional oscilloscope display **44**, and incorporates the usual tracing printer.

In operation, it has been found that electrocardiograms may be taken simply and reliably merely by having the patient slip off his shoes and sit fully clothed in an arm or armless chair, with his arms and hands resting in his own comfortable, neutral position in his lap. The finger electrode device **10** is placed across the patient's lap and he inserts his index fingers in the finger electrodes **14** and **16**, without changing them from the neutral position. The fingers are inserted so that they rest snugly in the electrodes, but not tightly nor with tension. The terminals **24** and leads **27** at one edge of the lap bar are directed away from the patient; this arrangement tends to ensure routine placement of the lap bar so that the electrode axes are convergingly directed away from the patient (as indicated by angle **20**). Thereby, the electrodes are naturally oriented to receive, and retain, the patient's fingers in their neutrally resting position. The electrodes, being located at the intermediate portion of the lap bar, are positioned on the patient's lap symmetrically about his median axis as are his hands, and the lap bar is readily adjusted transversely, and the electrodes rotated (though it is usually not necessary) to accommodate significant variations among patients. Though it has not been found necessary, the electrodes may be adjustable along the longitudinal axis of the lap bar (e.g. by providing longitudinal slots through which the fasteners **19** pass) so as to vary their spacing.

The floor board **26** is a lightweight unit which is portable and easily movable next to a chair, so that the patient's feet rest on the foot electrodes **28** and **30** with the legs and feet likewise in the neutral position. No special preparation of the patient is required (though moistening of the electrodes with alcohol prior to use is helpful), good electrode contact is maintained, and, since the electrodes function as receptacles that hold the fingers in place, no significant muscle tension is produced such as to adversely affect the electrical signals that are obtained and measured as long as the patient sits relaxed and comfortable. EKG tracings of good quality are obtained consistently even where there are head and neck movements, so long as the arms are not moved. Where the chair does not permit optimal relaxation, there may be some electrical muscle interference due to leg tension, though it will generally be slight. For many purposes, suitable heart rhythm patterns may be obtained using the finger electrodes alone, with which the muscle interference is generally minimal.

This invention is especially adaptable for obtaining quick physiological screening tests, such as those of heart rhythm patterns. For example, in pre-operative tests of patients undergoing surgery, such electrocardiograph patterns are desirable. With the patient relaxed in a chair, the heart rhythm strip is demonstrated on the oscilloscope screen **44** and if there are any unusual characteristics or abnormalities, a printed trace recording can be made in the usual fashion. Thus a rapid electrical view and trace recording of the heart can be obtained with the patient sitting up, fully clothed, and without special preparation. This viewing can be performed in but a few minutes.

This invention makes possible the taking of electrocardiograms rapidly and as a common routine in any physical examination, and it can be used for children as well as adults, and without requiring the elaborate procedures that usually accompany the taking of an electrocardiogram.

This invention is not intended to replace the full EKG tracings which are generally called for in the presence of known heart disease or arhythmias; such full EKG requires the patient to be partially undressed for the application of the electrodes, and substantially in a horizontal position. However, this invention does offer a good, rapid screening procedure for large numbers of patients who ordinarily have not had the full EKG examination. With this invention, EKG screenings could be provided as a part of routine hospital admission examinations, in various out-patient services, and routine examinations in a doctor's office, as well as in mass physical examinations such as those provided by the military, and in conjunction with the mobile roentgen-ray units that perform chest X-rays on a community-wide basis. In all of these procedures, this invention affords a basis for rapid and reliable coupling of an EKG unit to a patient for scanning the heart; the interpretation of the required records can then be subsequently performed by a physician, together with computer analysis of the large quantities of data thus acquired. The ease with which an EKG tracing can be performed with this invention may make it unnecessary to have specially skilled technicians supervise the patient. For example, with a simple set of printed instructions a patient can sit in a chair, insert his fingers in the lap bar electrodes, and his stocking feet on the floor board electrodes. Unless the amplitudes of the oscilloscope trace fall within certain indicated limits, the patient knows that his body is not completely relaxed, and when they do so fall, a reliable tracing may be obtained.

The unit illustrated in FIG. 1 is a semi-permanent type of construction, in which the vertical terminal member may be also used for holding the finger electrode device when not in use. Simpler construction forms are also contemplated. For example, a simple, flat floor board **26** may have the connector terminals **34** and **38** connected directly to it, and the floor board **26** and lap bar **12** may comprise the entire electrode assembly, which may be quite small and readily portable (e. g. supplied with a convenient carrying handle) and easily stored in a closet or cabinet drawer. The floor board is not limited to any particular form (e.g. it may be oval or circular) and the lap bar may likewise assume various shapes and configurations (e.g. a rod or disc). The invention may also take the form of a simple attaché or carrying case which opens flat to provide a horizontal foot electrode in each of the two portions of the case, together with a lap bar which may rest in the case when not in use and may be readily placed across the patient's lap. The hinged connector of such an attaché case may contain the terminal connectors **34** and **38** for quick connection to the electrocardiograph unit **42**.

In FIG. 5, another type of finger electrode is shown, which takes the form of a metallic cone **50** which is mounted on the lap bar **12** by means of a suitable fastener **19'**, which permits pivotal adjustment of the axis of the cone. An electrical conductor **22'** is connected to the

apex of the cone. A pair of such cone electrodes **50** are mounted on the lap bar **12** in a manner similar to that described above with respect to FIG. 2, so that the axes of the two cones converge to form the angle **20**. The cone shape of the electrode **50** is especially suitable for receiving fingers of different sizes, and due to its taper a snug contact for fingers of different sizes is ensured.

In FIG. 6, a modified conical finger electrode is illustrated; a cone **52** (which may be formed of metal or of an insulating material such as clear plastic) is mounted on the lap bar **12** in a similar fashion. Within the cone **52** a tapered metal electrode plate **54**, having a bent lip **56** at its wide outer end, is fixedly attached at its narrow inner end, and is biased by springs **58** in a direction tending to partially close the mouth of the cone. The patient inserts his finger in the cone **52** by pressing against the lip **56**, and continues to press against the plate **54** as he inserts his finger to a comfortable position. The light spring force provided by springs **58** ensure good, snug contact with the finger.

Another form of the invention is illustrated in FIG. 7, in which a lap bar **60** is provided having an angular shape. (Alternatively, an arcuate shape may be used.) The lap bar **60** includes two arms **62** and **64** forming an angle **66** corresponding to the angle **20** (FIG. 2) of the converging hands (or fingers) as they rest in the neutral position in the patient's lap. Two hand electrodes **68** and **70** are formed as U-shaped, thin, metallic sheets. The electrodes **68** and **70** are pivotally mounted to the upper face of the lap bar **60** by means of fasteners **19''** inserted through their lower closed ends. These electrodes **68** and **70** are positioned with their axes **68'** and **70'** extending generally along the arms **62** and **64** so that they converge to form the angle **20**. In use, the lap bar **60** is placed across the patient's lap and oriented so that the apex **72** thereof is directed away from the patient (FIG. 7 is viewed in a direction facing the patient). The patient inserts his hands in the electrodes **68** and **70**, with the ulnar edges thereof down. In the neutral position of the patient's hands, a moderate amount of rotation of the forearm is generally accommodated to assume this position without producing an excessive amount of muscle tension such as would adversely affect the electrical signals being measured. No muscle tension is required to retain the hands comfortably in the electrodes, and contact is made at the ulnar edge of the hands. A slight amount of spring tension may be provided in the electrodes **68** and **70** to ensure a snug contact along the palm and back of the hand. The electrodes **68** and **70** may also be used to receive the fingers rather than the palms of the hands. In addition, smaller sized electrodes, but of the same general shape and configuration, may be employed to receive but a single finger in the manner illustrated in FIG. 7.

The lap bar **60** may also be employed to receive hand and finger electrodes of other forms, such as those in FIGS. 3, 5 and 6; and the electrodes **68** and **70** may be employed with the lap bar **12** of FIG. 2. In addition, U-shaped electrodes for receiving fingers may be used to receive the patient's fingers with his hands oriented in a palms-down direction while resting neutrally in his lap. Here again the rotation of the forearm to assume a different position does not affect the generally neutral state of the muscles. Likewise, such electrodes may be used to receive the palm of the hand in the palm-down orientation. For the latter palm-down orientation of the hand, U-shaped electrodes are generally preferred, so that a natural, comfortable resting and retention of the hands is ensured after they are inserted in the electrode from the upper, open end thereof. However, if desired, fully or partially closed loop-shaped electrodes may also be employed. In addition, where finger electrodes are employed, a plurality thereof may be provided to receive several of the fingers of each hand.

In FIG. 8, another form of foot electrode is illustrated. Each foot electrode takes the form of a pair of pivoted plates **74** and **76**, hinged to the floor board **26** by pins **78** and biased by light springs **80** to form a tapered funnel for receiving a foot therebetween; a pair of such electrodes are provided as shown in FIG. 4. The patient's foot slides between the plates **74** and **76**, spreading them apart, and the springs **80** ensure good, snug contact with the sides of the foot. The electrical conductor **33** may be connected to one or both of the electrode plates **74** and **76**. Various other forms of foot electrodes may be provided to engage one or more of the different surfaces of the foot. For example, for the purposes of handling children, a hobby horse may be adapted to receive the child in the saddle, and stirrup electrodes may be provided to receive the child's feet; in place of a lap bar a rod may be fixed across the neck of the hobby horse, with U-shaped electrodes to receive the child's hands or fingers which rest and are retained lightly therein.

Another form of foot electrode consists of a metal plate spring-biased down to engage the top of the foot and retain it snugly in a retaining member such as a stirrup. A pair of such electrodes permits the patient to relax more readily since he feels that his feet are retained in a relaxed position without requiring his attention.

It will be apparent to those skilled in the art that various other forms of this invention may be provided. The above described embodiments are presented as illustrative and not limiting to the scope of the invention.

Accordingly, a new and improved EKG system is provided which does not require any special furniture or modification of furniture. The devices employ are simple and inexpensive in construction, and reliable electrocardiogram rhythm strips are produced rapidly and conveniently.

What is claimed is:

1. An electrocardiographic system comprising electrode means for deriving physiological electrical signals from the hands of a person; and means for supplying said signals to an electrocardiograph;

said hand electrode means including an electrode mounting device, a pair of electrodes each having at least one receptacle opening for receiving and supporting a portion of a person's hand in contact therewith, means mounting said electrodes in spaced relation on said device with the respective axes of the receptacle openings of said electrodes in a converging angular relation, and means for mounting said device across the lap of a seated person with said electrode axes convergingly directed away from the person and said electrodes adjacent the hands thereof neutrally resting in the lap and substantially symmetrical about the median axis of the person;

said signal supplying means including separate terminal means connected to said electrodes.

2. An electrocardiographic system as recited in claim **1**, and further comprising additional electrode means for deriving physiological electrical signals from the feet of a person; said feet electrode means including an electrode mounting device including means for positioning said device on a floor, a pair of electrodes each having a surface for separately engaging a portion of a foot of a person in a seated position and having the feet neutrally extended.

3. An electrocardiographic system as recited in claim **1**, wherein each of said hand electrodes includes a tubular metal portion for receiving the neutrally extended index finger of a hand.

4. An electrocardiographic system as recited in claim **1**, wherein each of said hand electrodes includes a member metal portion for receiving the neutrally extended index finger of a hand.

5. An electrocardiographic system as recited in claim **1**, wherein each of said hand electrodes includes a member having a U-shaped cross-section for receiving and supporting the lunar side of a portion of a hand.

6. An electrocardiographic system as recited in claim 1, wherein said electrode mounting means includes means for pivotally retaining said hand electrodes on said device for adjustment of the directions of the opening axes thereof.

7. An electrocardiographic system as recited in claim 1, wherein each of said hand electrodes includes a metallic element forming a side of said electrode opening, and means for spring biasing said metallic element to engage a portion of a hand positioned in said opening.

8. An electrocardiographic system as recited in claim 1, wherein said mounting device includes a bar having the electrodes mounted on one side thereof.

9. An electrocardiographic system as recited in claim 8, wherein said bar includes two elongated members joined at one end thereof and forming an angle therebetween corresponding generally to a neutral angle of the hands, and said electrode mounting means includes means for respectively positioning said electrodes in spaced relation on one side of said members and with the opening axes substantially therealong.

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WILLIAM E. KAMM, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,450,133 June 17, 1969

Alexander A. Birch, Jr.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 69, "member" should read -- conical --; line 75, "lunar" should read -- ulnar --.

Signed and sealed this 21st day of April 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents