

Dec. 7, 1965

M. ANNIS ETAL

3,221,731

APPARATUS FOR EVALUATING THE CONDITION OF THE HEART MUSCLE

Filed May 31, 1962

4 Sheets-Sheet 1

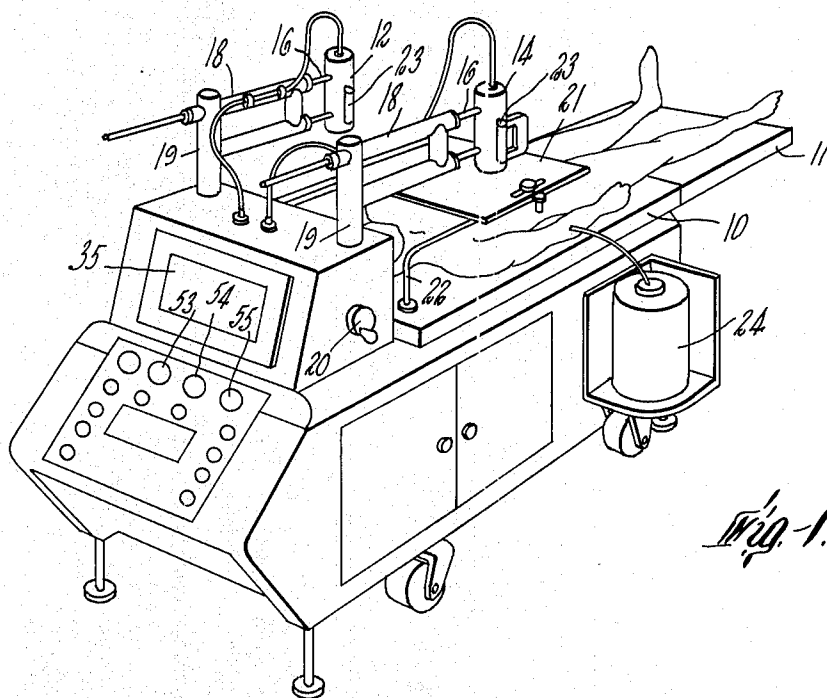


Fig. 1

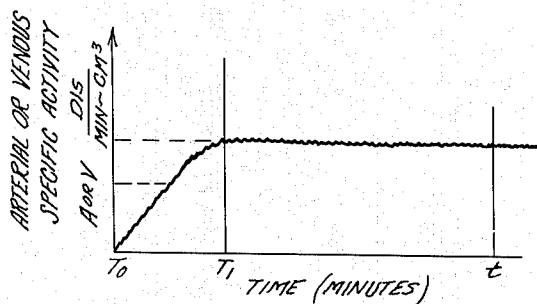


Fig. 2

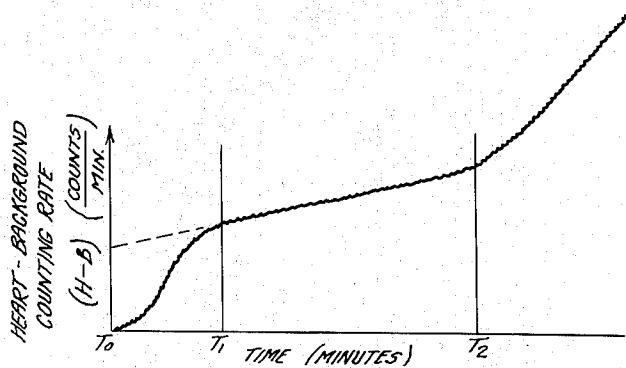


Fig. 3

Dec. 7, 1965

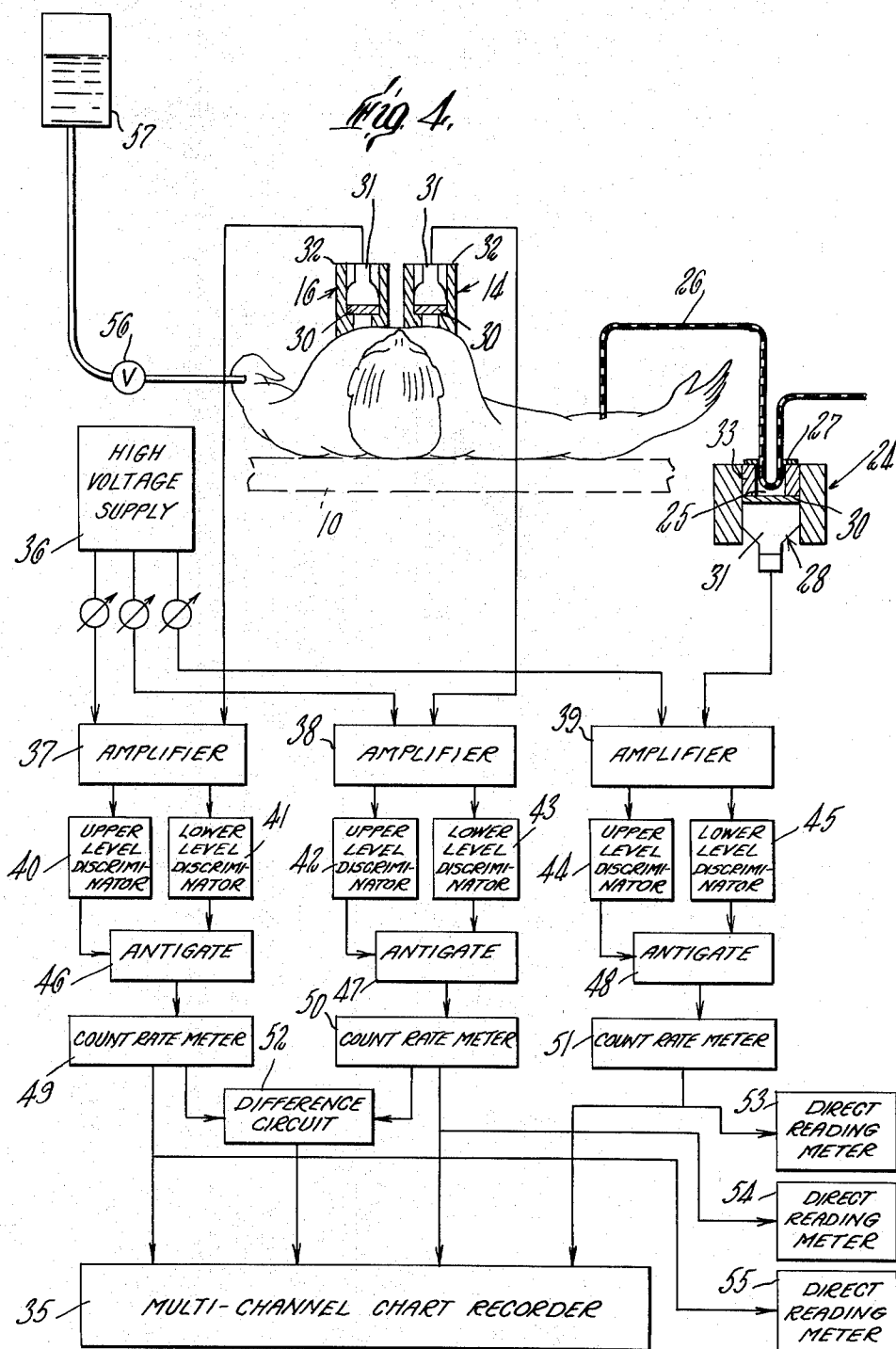
M. ANNIS ETAL

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Filed May 31, 1962

4 Sheets-Sheet 2



Dec. 7, 1965

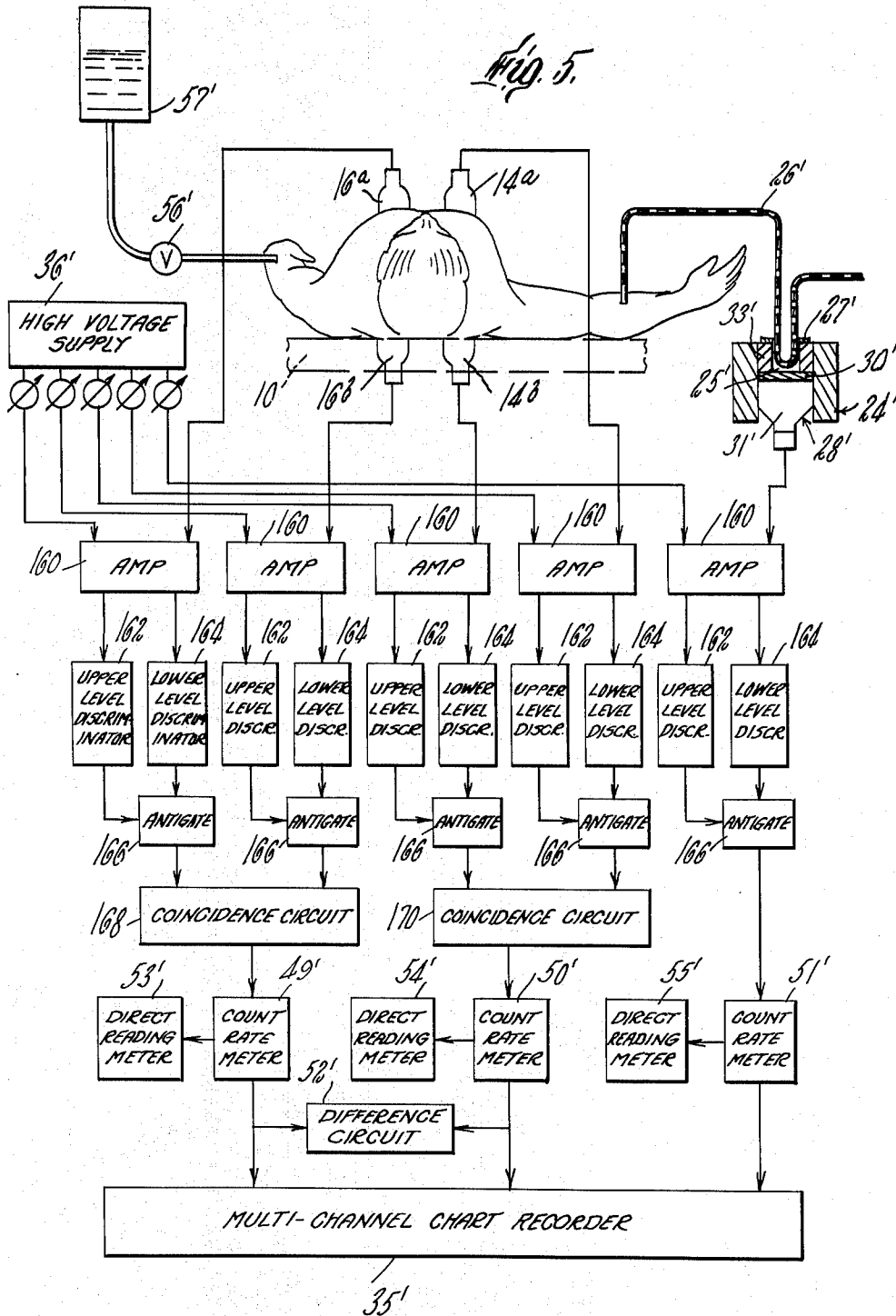
M. ANNIS ETAL

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Filed May 31, 1962

4 Sheets-Sheet 3



Dec. 7, 1965

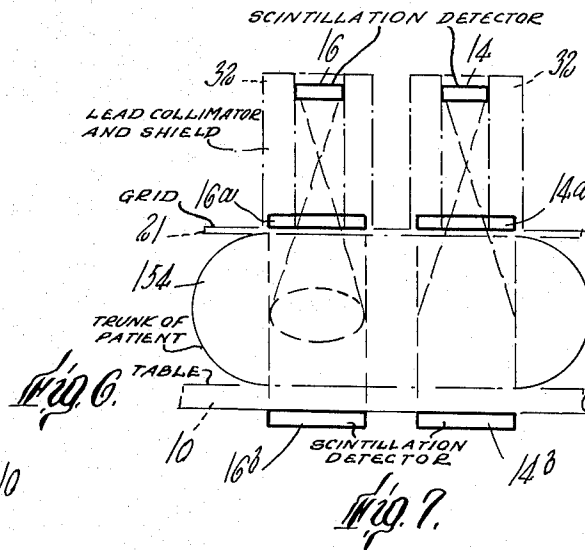
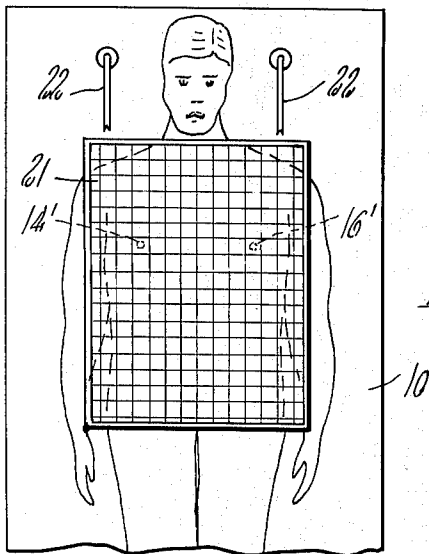
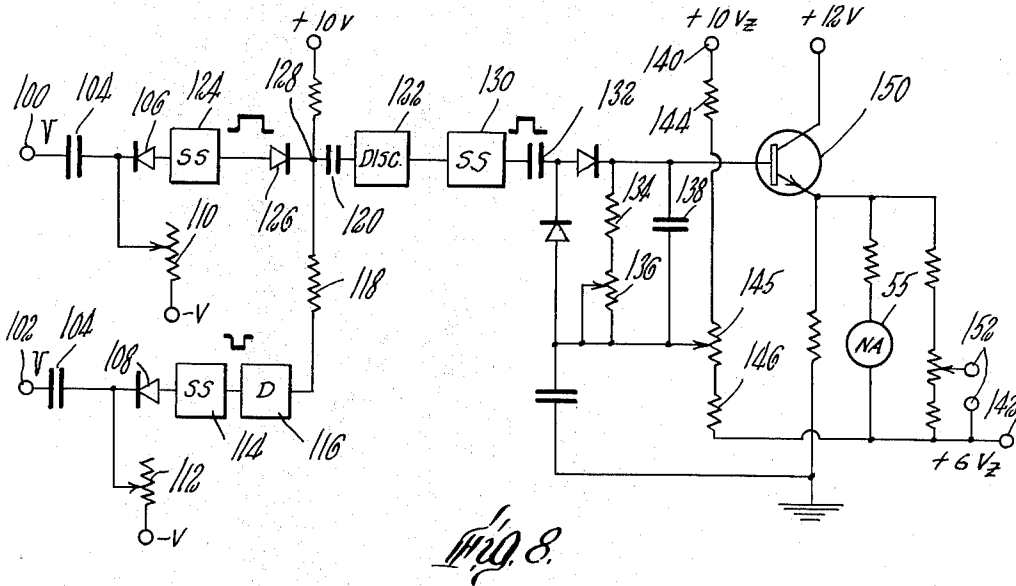
M. ANNIS ETAL

3,221,731

APPARATUS FOR EVALUATING THE CONDITION OF THE HEART MUSCLE

Filed May 31, 1962

4 Sheets-Sheet 4



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3,221,731

APPARATUS FOR EVALUATING THE CONDITION OF THE HEART MUSCLE

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This invention relates to apparatus for evaluating the conditions of the heart muscle (the myocardium) in living beings.

In routine examinations of humans both for an evaluation of general well-being and for diagnosis of minor infirmities or detection of conditions evidenced by ambiguous symptoms, it has been difficult to evaluate the condition of the heart muscle. Since the heart muscle pumps blood throughout the body system and receives its nutriment from a portion of that pumped blood which enters the heart muscle through vessels called the coronary arteries and leaves principally through a vessel called the coronary sinus, a measurement of coronary flow (the blood flow through the heart muscle) would be indicative of the over-all capability of the heart muscle system and such a measurement would likewise be valuable to a physician in diagnosis. One method of attempted measurement has involved, among other things, the insertion of a catheter into the coronary sinus to sense the blood flow at that point. In addition to the physical problems and disadvantages of inserting such an instrument into the heart muscle, such an examination is time consuming and inconvenient, and particularly is unwieldy for use on people having ordinary periodic physical examinations.

Due to the known ability of muscles in general to extract (take up) particular materials, such as rubidium and potassium from the blood, there has been inquiry in the medical profession as to whether phenomena associated with that ability might provide useful information for evaluation of the condition of the heart muscle. Certain of the materials that are extracted by muscles have radioactive isotopes, such as rubidium 86, that produce nuclear particles which can be sensed to provide an indication of the quantity of the radioactive material present. If rubidium 86 was introduced into the bloodstream the heart muscle would extract some of the rubidium from the blood, and the change in radioactivity of the heart muscle is related to the volume of blood flowing through the coronary artery per unit time, that is, the coronary flow. Experiments have been performed on rabbits to verify this, in which such isotopes having been administered for a predetermined time to animal hearts removed from the animal body, and the radioactivity measured, Dr. Richard J. Bing having conducted extensive experiments along these lines. (See e.g. Bing et. al., Myocardial Extraction of Rb⁸⁶ in the Rabbit, Am. J. Physiol, 197, 1175 (1959).)

The amount of radioactive material, K (measured in nuclear disintegrations per minute) which the heart muscle extracts from the blood enables the calculation of the coronary flow (measured in centimeters cubed per minute) by the following logic: if the change in radioactivity of the heart muscle (dK/at) over a short period of time is known, and for the same interval the radioactivity per unit volume ("specific radioactivity" (SR)) of the blood entering the heart muscle from the coronary arteries A (measured in nuclear disintegrations/centimeter cubed-minute) (kept constant during the experiment), and the specific radioactivity of the blood leaving the heart muscle through the coronary sinus V (measured in nuclear disintegrations/centimeter cubed-minute)

are known, then the coronary flow is equal to that rate of change in radioactivity of the heart muscle divided by the difference in specific radioactivities between the incoming and outgoing blood, i.e.,

$$\mu = \frac{dK/dt}{A-V}$$

Unfortunately no practical means exists whereby simultaneous reading of blood entering and blood leaving the heart muscle can be obtained in humans. This, however, does not necessarily prevent use of radioactivity techniques because the measurement of the radioactivity per unit volume of coronary arterial blood alone will enable a determination of the flow rate when the take-up or "extraction" factor of the rubidium by the heart muscle is known—the "extraction" factor, denoted "f," being that percentage of the radioactive material present in the coronary arterial blood which is absorbed by the heart muscle as the blood passes through, i.e.,

$$f = \frac{A-V}{A}$$

According to this second proposition, coronary flow can be expressed as follows:

$$\mu = \frac{dK/dt}{fA}$$

It has been found helpful from the standpoint of analysis to express the change in radioactivity of the heart muscle in terms of

$$\frac{\text{rate of change in heart radioactivity}}{\text{specific radioactivity of arterial blood}}$$

equivalent to a coronary flow in which the radioactive materials were totally absorbed or "cleared" by the heart to cause the observed change in radioactivity of the heart. This "equivalent" coronary flow is denoted as the "clearance" and assigned the notation gamma, i.e.,

$$\gamma = \frac{dK/dt}{A}$$

Then this quantity is divided by the extraction factor (f) to arrive at actual flow volume

$$\frac{\gamma}{f} = \frac{dK/dt}{A-V} = \mu$$

The value of the clearance alone may be helpful to the doctor in diagnosis. Even where the extraction factor varies considerably in the range of flow rates being considered, its value need not be known as readings of clearance of the same patient taken under the same circumstances at intervals of a year or so can indicate changes in the coronary flow that have occurred, a decrease in clearance reading indicating a decrease in flow rate, albeit a non-linear decrease.

Accordingly, a principal object of this invention is to provide improved apparatus for obtaining data useful in the evaluation of the condition of the heart muscle in living beings which does not require insertion of a physical instrument into the heart muscle, and which will enable convenient periodic diagnosis, so that the relative condition of the living being's heart muscle may be determined.

Another object of the invention is to provide improved methods and apparatus for evaluating the condition of the heart muscle by radioactive techniques.

Still another object of the invention is to provide improved apparatus having calibration features which enables the obtaining of reproducible results in the evaluation of heart muscle condition by radioactive techniques.

A further object of the invention is to provide improved radioactive sensors and electronic circuitry arrangements

useful in the radioactive evaluation of heart muscle condition.

The invention comprises, for use with injection of radioactive material into the blood system, the means and steps for: measuring the radioactivity of the arterial blood, preferably by extracting arterial blood from the patient and conducting it through a well counter; measuring at the left side of the chest the radioactivity of the heart muscle and chest for its radiation; and measuring the radioactivity of the complementary (right) side of the chest of the patient for its radiation. Electronic circuitry responsive to the radiation sensors generate analogue signals representative of the difference between the radioactivities of each of the two chest readings (left and right), as well as absolute values of these radioactivities, and the arterial radioactivity. These analogue signals are suitably displayed, for example on a multi-channel pen recorder and enable calculation of the clearance for the experimental test period.

Thus the invention provides for measurement of values to establish the heart clearance and thus to evaluate the condition of the myocardium by electronic means. Among the features of the invention are means for insuring readings are taken at the same complementary spots each time the patient is examined. Yet another important feature of invention lies in the use of a positron emitter, such as rubidium 84, as the radioactive material. Its positrons create upon annihilation two oppositely directed gamma rays. These are coincidentally detected by detectors on the front and back of the body enabling the elimination of most of background counts arising outside by cylinder defined by the front-back pair of coincidence detectors, and thereby simplify the evaluation apparatus in certain respects.

These and other objects, features and advantages of the invention will be understood as the following description of preferred embodiments progresses in conjunction with the drawings, in which:

FIG. 1 is a perspective view of the machine constructed in accordance with principles of the invention;

FIG. 2 is a graph that might be generated by the machine establishing the specific activity of the arterial blood in disintegrations per min. per cubic centimeter of blood, plotted against the abscissa of time;

FIG. 3 is a graph similar to FIG. 2 of the raw count difference between two chest counters, indicating the total heart reading less the body background, therefore representing the changes in radioactivity of the heart muscle;

FIG. 4 is a partially diagrammatic and partially cross-sectional view of the apparatus of FIG. 1, indicating one arrangement of elements for generating the information shown in FIGS. 2 and 3;

FIG. 5 is a partially diagrammatic and partially cross-sectional view of a modified apparatus indicating a second arrangement of elements for generating the information shown in FIGS. 2 and 3;

FIG. 6 is a diagrammatic view looking down upon the apparatus of FIG. 1 showing the positioning grid;

FIG. 7 is a diagram comparing the detector arrangements of FIGS. 4 and 5; and

FIG. 8 is a diagram of a recording channel of the apparatus shown in FIG. 4, partially in block form and partially in schematic form.

Referring to FIG. 1, the machine comprises a table 10, having a hinged extension 11, that is adapted to receive a reclined patient. A pair of radiation detectors 12 and 14 are mounted for positioning above the patient on slidable rods 16 which telescope into tubes 18, the latter extending horizontally from upright columns 19. The columns 19 are mounted for pivotal movement to swing the detectors over the table and a handwheel 20 is geared to the columns 19 for raising and lowering the detector units by ordinary gearing (not shown). A positioning grid 21 fixed on supports 22 provides a reference to aid

in locating the detector units relative to the patient. An aid in positioning the detectors a focused light source 23 is mounted on each detector to project a pencil beam perpendicular to the grid.

A well detector 24 is supported at one side of the table 10, and as seen in FIG. 4, comprises a well zone 25 into which a tube 26 extends and is held by clamps 27, and a radiation detector element 28 for detecting the products of radioactive disintegration emitted by the material in the tube. The tube 26 extends from an artery of the patient into the well and then is connected to a suitable discharge vessel. The counter enables the radioactivity of the arterial flow to be indicated.

Each of the detectors 12, 14 and 28 is adapted to count gamma radiation, and preferably comprises a mass of gamma radiation sensitive material 30 such as a thallium activated sodium iodide crystal and an associated photomultiplier 31, both encased in a hermetically sealed, light tight aluminum cartridge. In detectors 12 and 14 a vertically disposed open lead cylinder 32 with one end aimed at the patient defines an area and collimates radiations from that area to the sensitive material 30 disposed at the other end of the tube. The well counter 24 is of conventional type enclosed within lead walls 33.

A multichannel chart recorder 35 is linked by electronic circuitry shown in block form in FIG. 4 to these three detectors. The circuitry includes a high voltage supply 36, signal amplifiers 37-39, upper and lower level discriminators 40-45, logical anti gates 46-48, count-rate meters 49-51, a difference circuit 52 and output meters 53-55. The chart recorder is adapted to receive the output of each of these count-rate meters and to record changes with respect to time, e.g. FIGS. 2 and 3.

The direct reading output meters 53-55 permit the instantaneous reading of the outputs of all three detectors. The output of the well detector 28 (indicated in FIG. 2) is most important in the beginning stages of a test in that this permits the continual observation of the radioactivity of the blood stream as it builds up to the testing level and enables control of the radioactivity to a constant level in conjunction with infusion control 56 which regulates the amount of rubidium in saline solution 57 or other suitable radioactive material entering an arm vein of the patient.

The graph of FIG. 3 provides an indication of the radioactivity of the heart muscle and depends upon the fact that the radioactivity sensed by the detector 14 on the complementary side of the body gives a value representative of the background read by the heart detector 16. The difference circuit 52 takes the count signals from detectors 14 and 16 and generates a signal representing their difference. This difference is recorded directly as shown in FIG. 3.

Referring to the diagram of FIG. 6, the points 14', 16' at which the detectors 14, 16 are positioned over the body are on the same traverse line, and equally spaced from the line of symmetry of the patient. Where a patient is to be examined at periodic intervals, each year for example, a suitable mark such as a tattoo or a bit of X-ray detectable material may be placed at those points to provide references for the detectors. (The X-ray detectable material assists in correlating the location of the body organs with the detector locations for aid in diagnosis and evaluation.)

The positioning grid 21 is located over the chest of a patient in a predetermined location relative to the detectors 14, 16 and the table 10. This member may be a suitable rigid plastic material transparent to light and gamma rays and has a series of suitably spaced grid markings. Before the test begins the grid is aligned with the patient, such as by aligning a particular traverse mark with the top surfaces of the shoulders, and the center of the grid with the center of the patient's body, thus bringing other markings over the patient's chest. Where the patient's chest has been previously marked those marks

are employed to achieve most precise positioning. The detectors 14, 16 are brought over the body and their positions with respect to the grid member are determined and recorded, insuring that the next time the patient is examined, the detectors will be placed in the same position; they are thus also positioned in alignment to the tattoo marks. The detector 16 sees a predetermined area (as defined by the collimating tube 32) including the heart, the chest and back muscles and the blood in those muscles. The detector 14 sees an identical area on the complementary side of the body which includes only the chest and back muscles and the blood in that area. Other muscles of the body as well as the heart extract rubidium from blood. But by centering the background detector 14 at a suitable point relative to the line of symmetry of the body, it is found that substantially the same amount of such muscles is seen by each of these detectors, and by electronically subtracting the complementary radiation reading from the heart radiation reading, compensation is obtained for rubidium in muscles other than the heart.

After the detectors 14, 16 have been properly positioned relative to the patient, radioactive material (in this case rubidium 86) is infused at a controlled rate into the patient and the radioactivity of the blood is observed at direct reading meter 53 and/or on the recorder 35 until a constant level of arterial radioactivity is reached as indicated in FIG. 2, which level is subsequently maintained. At the same time the radioactivity sensed by the heart and background detectors 14, 16 is also recorded, producing a curve somewhat similar to that illustrated in FIG. 3 which according to some experimental evidence may have a substantially constant slope after the specific radioactivity of the arterial blood has reached equilibrium. In any event, the slope of this curve at any time measures the rate of uptake of the heart muscles, which rate is a function of the blood flow into the heart through the coronary artery as explained above. After this measurement has progressed over a period of time with the patient at rest, say fifteen minutes, the table extension 11 is lowered and an exercise device such as a bicycle exerciser is positioned adjacent the patient's legs and the patient exercises according to an established schedule during which time the radioactivity measurements continue and a graph of increased slope is produced, as indicated in FIG. 3, indicative of the increased blood flow through the heart muscle.

Due to factors which vary from person to person, such as the size of the heart, it is believed that the magnitude of the absolute clearance will also vary from person to person. However, as each detector unit "sees" only a portion of the heart muscle, which portion has constant area dimensions, the variation in clearance measurement values for this limited region of heart, due to differences in the volume of the heart muscle "seen" from person to person, is substantially reduced, and the "partial" clearance so derived may prove significant for diagnosis.

The clearance data that are obtained through use of this apparatus may be even more usefully related for comparison purposes through use of the concept of "specific clearance." With reference to the graph of FIG. 3, from time T_0 to some short time T_1 radioactive material is introduced into the blood, but the arterial concentration has not reached the desired value. After time T_1 , however, the radioactive material in the blood has reached this value, and subsequently is maintained constant. Since the rate of radioactive material absorption by the heart muscle is nearly constant over the time T_0 to T_1 , extrapolation of the slope of the counting rate curve of FIG. 3 during the rest period back from time T_1 to time T_0 (as indicated by the dotted line in FIG. 3) will lead to an intercept (at T_0) which will give an indication of the radioactivity of the volume of blood within the heart volume surveyed by the detector. The ratio of the slope of the curve of FIG. 3 at any time to the aforementioned intercept has been denominated "specific clearance."

Since the ratio of enclosed blood volume to heart muscle volume does not vary so widely from person to person, this "specific clearance" provides an indication of heart muscle tone independent of heart size, and may be more meaningful for comparisons of the rates of uptake of radioactive material by different persons.

A portion of a channel of the electronic circuitry connected between the radiation detector 16 and the recorder 35 is shown in FIG. 8. The signal from the photomultiplier is applied via amplifier 37 to the input terminal 100 of the upper level discriminator 40 and the input terminal 102 of the lower level discriminator 41. Each pulse is coupled by capacitors 104, 104 to a discriminating network which includes a diode 106, 108 and a biasing potentiometer 110, 112 respectively. This bias supplied through potentiometer 110 is fixed at a voltage level so that the discriminator diode 106 will only pass an input signal having a greater voltage. In similar manner the lower level discriminator diode 108 will only pass an input pulse having a voltage value greater than that determined by the bias supplied by potentiometer 112. If the input signal has a magnitude between those two ranges (which define a "window" of response to nuclear particles sensed by the detector 16) the single shot (monostable multivibrator) 114 generates a pulse which is passed by delay unit 116 through resistor 118 for coupling by capacitor 120 to a discriminator 122. However, if the input signal has a magnitude greater than the bias potential on diode 106 single shot 124 is energized to produce a positive output pulse of substantially greater duration than the output pulse supplied by single shot 114. That output pulse is applied through diode 126 and biases the junction 128 so that the negative pulse supplied by single shot 114 is inhibited. If the input signal is of proper magnitude, i.e. if the upper level single shot has not fired, it is passed by discriminator 122 and causes the single shot 130 to produce a shaped positive output pulse which is coupled by a capacitor 132 to an RC integrator circuit which includes resistor 134, calibration potentiometer 136 and a capacitor 138. This integration circuit is referenced to Zener diode voltages applied to terminals 140 and 142. By selecting Zener diodes having closely matched temperature coefficients and mounting them next to one another the drift of the zero setting of output meters 55 and 35 due to the effect of temperature fluctuations is minimized. The output signal from the integrator is applied to a series of three emitter follower transistors (indicated as a single transistor 150 for simplicity) which are operated in the constant beta region for linearity. The output signal from the emitter is applied to the meter 55 and also at terminals 152 for application to the recorder 35.

A second embodiment of the invention is illustrated in FIG. 5 in which a positron emitter type of radioactive material such as Rb^{84} is infused into the blood system. More positrons are generated per disintegration of Rb^{84} decay than gamma particles are generated per disintegration of Rb^{86} decay. At annihilation of each positron two gamma particles are produced which move in opposite directions. Two detectors 14a, 14b or 16a, 16b are positioned in front and back of the patient's body and define a cylinder of surveillance. The necessity of a lead collimator shield is eliminated in this configuration and hence the detectors may be positioned more closely, a significant advantage which increases the overall detection efficiency.

A further advantage of this second embodiment lies in the ability to accurately calibrate the machine without putting a radioactive source within the patient's body. After the patient is placed on the table 10, for calibration purposes a radiation source of known strength is positioned on one side of the patient's body near detector 14a, for example, and directly opposite detector 14b. The coincidence response of detectors 14a and b is noted. The calibrating source is then similarly placed near the

position of detector **16a** opposite detector **16b** and the counting rate meter circuitry of detectors **16a** and **16b** is adjusted so that it indicates the same response as did the circuitry of detectors **14a** and **14b**. In this manner the manner the detector circuitries are compensated for any difference in radiation absorption of the body portions in the cylinders of surveillance of the detector systems. This simple compensation technique provides accurate results since the gamma particles generated from positron decay travel along the same path through the same absorber as the calibration particle so that the total absorption effect on the two particles resulting from positron decay is the same as on the single particle that traveled through the body from one side to the other.

The relative positioning of a detector arrangement sensitive to radiation emitted by Rb^{86} is indicated in FIG. 7. As there indicated the volume surveyed in the Rb^{84} system is a cylinder accurately defined by the geometry of the detectors rather than a cone of increasing cross-section as in the case of the Rb^{86} system; and therefore the portions of the heart muscle sensed may be established with greater definiteness and different areas may be easily sensed without question of possible overlap of the sensed areas. A set of detectors defining relatively small sensing areas may be moved as a unit over various areas of the heart muscle so that the radioactive uptake in different portions of that muscle may be compared and evaluated. Due to the fact that more counts are obtained per unit dose from Rb^{84} and the solid angle to which the Rb^{84} detectors are responsive is greater, this arrangement has greater efficiency.

In this arrangement two sets of detectors **14a**, **14b** and **16a**, **16b** are employed. The lower detectors are mounted beneath the table **10** and are arranged so that each lower detector and its corresponding upper detector can be vertically aligned while they are being appropriately positioned for the measurement. Each detector has an associated output channel including an amplifier **160**, upper level discriminator **162**, a lower level discriminator **164**, and a logical gate circuit (antique) **166**. The outputs of each set of channels associated with corresponding detectors are applied to a coincident circuit **168**, **170** which provides an output only if both of the associated detectors have sensed a particle within the predetermined magnitude range at the same time, as will occur almost exclusively only when a positron has produced two gamma rays in annihilation within the detection area. This arrangement thus screens out background radiation effects and enables an accurate measurement of the clearance of the heart muscle to be obtained.

Thus it will be seen that the invention provides an important clinical tool for the evaluation of the condition of the heart muscle by radioactive techniques. This apparatus may function both as a research tool as an aid in obtaining additional information about the human body in general, and also as a diagnostic tool particularly useful in conjunction with periodic checkups through which degeneration of the heart muscle as evidenced by a change in coronary flow, for example, may be determined.

While preferred embodiments of the invention have been shown and described, various modifications thereof will be apparent to those having ordinary skill in the art and therefore it is not intended that the invention be limited to the described embodiments or to details thereof and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

What is claimed is:

1. A machine for determining the condition of the heart muscle for use with means for infusing radioactive material of the type absorbed by the body muscles into the blood system of a patient,
said apparatus comprising in combination,
means for monitoring the radioactivity of the patient's blood and providing a signal indicative thereof,
two radiation detector units,

each of said radiation detector units being mounted for adjustment in complementary position relative to the chest of the patient, one on the left side and the other on the right side,

circuitry responsive to each detector unit for providing a signal indicative of the sensed radiation,
means for subtracting the signal from the detector unit positioned relative to the right side of the patient from the signal from the detector unit positioned relative to the left side of the patient to provide a difference signal,
and means for recording said blood radioactivity signal and said difference signal as functions of time.

2. The machine as claimed in claim 1 wherein said radioactive material is rubidium 86 and each said detector unit includes a nuclear radiation sensitive material disposed in a collimating cylinder of nuclear radiation absorbing material.

3. The machine as claimed in claim 1 wherein said radioactive material is rubidium 84 and each said detector unit includes two nuclear radiation sensors of similar area disposed on opposite sides of the patient's body.

4. The machine as claimed in claim 1 and further including a table for supporting said patient and a reference grid positioned in fixed relation to said table for assisting in accurately positioning said detectors relative to the patient.

5. A machine for determining the condition of the heart muscle for use with means for infusing radioactive rubidium isotopes into the blood system of a patient, said apparatus comprising in combination,
a table for supporting the patient in reclined position,
means for monitoring the radioactivity of the patient's blood and providing a signal indicative thereof,

two radiation detectors,
each detector comprising a collimating tube and radiation sensitive material disposed within the tube,
and each being mounted for adjustment in complementary position over the chest of the patient, a first one on the left side and the second one on the right side thereof for providing pulse signals in response to the sensed radiation,
circuitry connected to each detector including discriminator means and integrator means for providing an analogue signal indicative of the sensed radiation,
means for subtracting the analogue signal from the second detector from the analogue signal from the first detector to provide a difference signal,
and means for recording blood radioactivity signal, said analogue signals and said difference signal as functions of time.

6. A machine for determining the condition of the heart muscle for use with means for infusing radioactive rubidium isotopes into the blood system of a patient, said apparatus comprising in combination,
a table for supporting the patient in reclined position,
means for monitoring the radioactivity of the patient's blood and providing a signal indicative thereof,

two radiation detectors,
each detector comprising a set of radiation sensors disposed on the back and front of the patient's body in aligned position to define a sensed area,
each set of radiation sensors being mounted for adjustment to complementary positions over the chest of the patient, a first set on the left side and the second set on the right side thereof,
and each radiation sensor providing pulse signals in response to the sensed radiation,
circuitry connected to each radiation sensor including discriminator means and integrator means for providing an analogue signal indicative of the sensed radiation,
means for subtracting the analogue signal from the second set from the analogue signal from the first set to provide a difference signal,

9

and means for recording blood radioactivity signal, said analogue signals and said difference signal as functions of time.

7. A machine for determining the condition of the heart muscle for use with means for infusing a saline solution of rubidium 86 into the blood system of a patient, said apparatus comprising in combination, a table for supporting the patient in reclined position, a reference grid in fixed, spaced relation to said table for assisting in positioning the patient relative to the machine,

means for obtaining samples of the patient's blood, detector means arranged to receive said blood samples and to provide a signal indicative of the radioactivity thereof,

first and second gamma radiation detectors, each of said radiation detectors being mounted for positioning over the chest of the patient, said first detector on the left side over the heart muscle and the said second detector in complementary position on the right side,

electronic circuitry responsive to each detector including discriminator means for providing a pulse signal indicative of sensed radiation from the body of the patient,

counting means for providing cumulative signals indicative of the total radiation sensed by each detector, means for subtracting the cumulative signal from the second detector from the cumulative signal from the first detector to provide a difference signal,

and means for recording blood radioactivity signal, said cumulative signals and said difference signal as functions of time to provide data relating to the condition of the heart.

8. The machine as claimed in claim 7 wherein said discriminator means includes voltage responsive circuitry for passing signals having a voltage within a predetermined range only,

and said counting means includes a resistance capacitance integrator circuit connected across a regulated voltage supply.

9. A machine for determining the condition of the heart muscle for use with means for infusing a saline solution of rubidium 84 into the blood system of a patient, said apparatus comprising in combination, a table for supporting the patient in reclined position, a reference grid in fixed, spaced relation to said table for assisting in positioning the patient relative to the machine,

10

means for obtaining samples of the patient's blood, detector means arranged to receive said blood samples and to provide a signal indicative of the radioactivity thereof,

first and second gamma radiation detectors, each of said radiation detectors including two aligned spaced radiation sensors adapted to be disposed in front of and in back of the patient's body to define an area for sensing,

said detectors being mounted for positioning over the chest of the patient for sensing an area of the chest as defined by the location of said sensors,

said first detector being positionable on the left side over the heart muscle and the said second detector being positionable in complementary position on the right side,

electronic circuit responsive to each detector including discriminator means for providing a pulse signal indicative of the sensed radiation from the body of the patient,

counting means for providing cumulative signals indicative of the total radiation sensed by each detector,

means for subtracting the cumulative signal from the second detector from the cumulative signal from the first detector to provide a difference signal,

and means for recording blood radioactivity signal, said cumulative signals and said difference signal as functions of time to provide data relating to the condition of the heart.

10. The machine as claimed in claim 9 wherein said discriminator means includes voltage responsive circuitry for passing signals having a voltage within a predetermined range only,

and said counting means includes a resistance capacitance integrator circuit connected across a regulated voltage supply.

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