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[54] **ARRHYTHMIA COUNTER**
27 Claims, 7 Drawing Figs.

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[52] A61b 5/04

[50] **Field of Search**..... A01B 3/04
128/2.06

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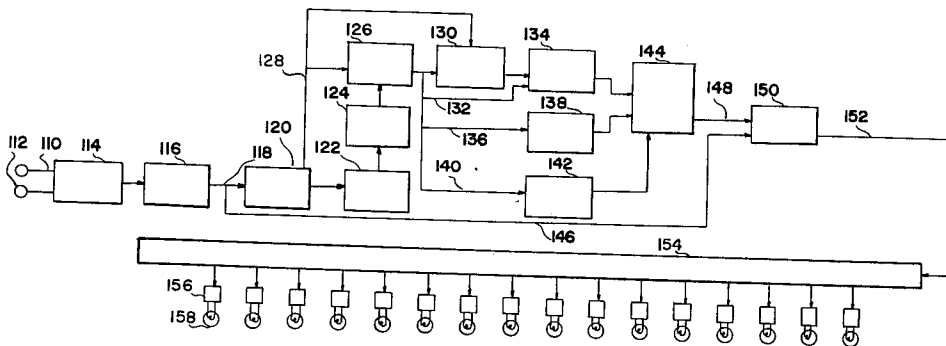
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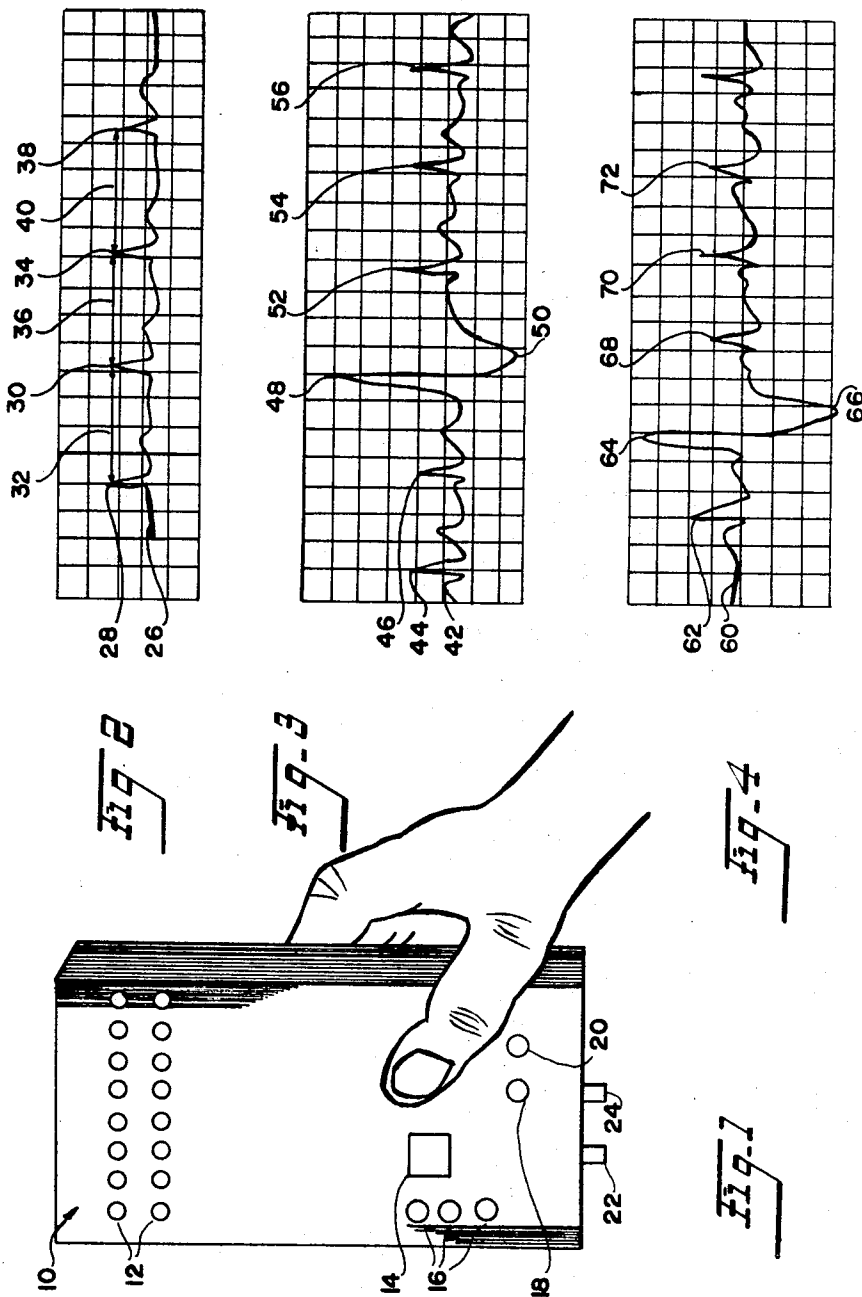
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ABSTRACT: The cardiac generated wave from a patient is analyzed for an arrhythmia condition by measuring time intervals between the R peaks of the cardiac wave, comparing relative duration of successive time intervals, and counting each occasion succeeding time intervals vary in duration by other than a normal amount of time.



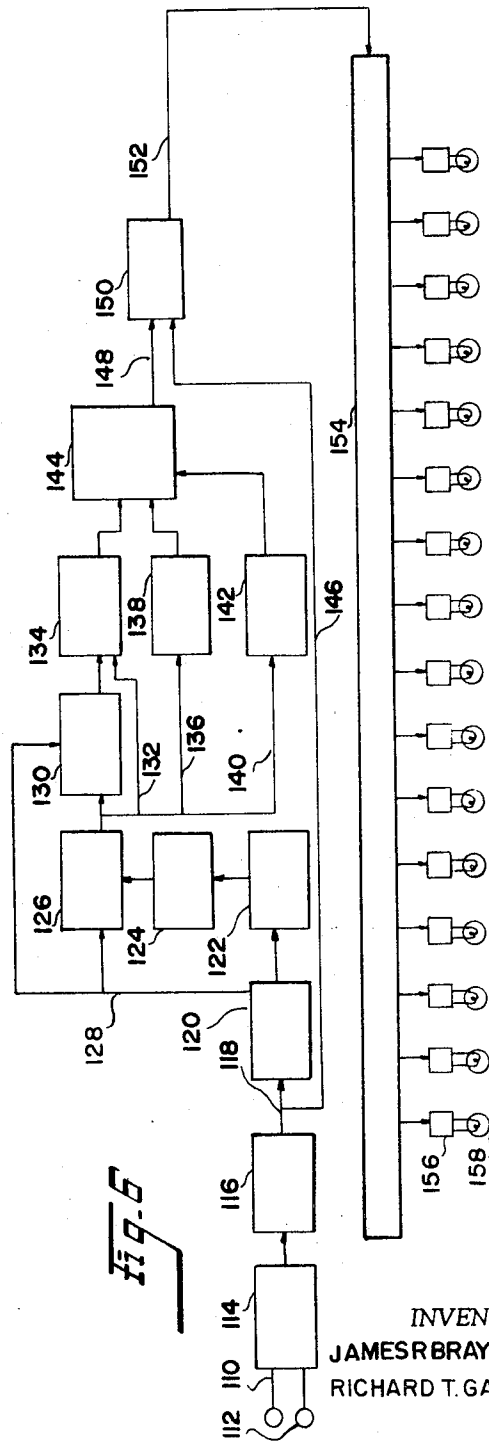
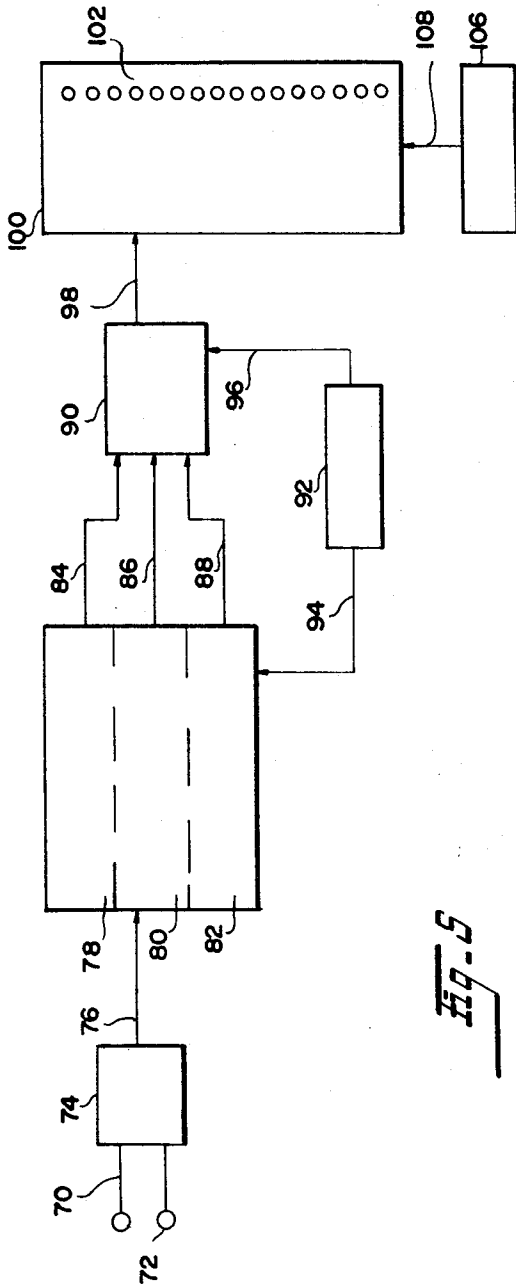


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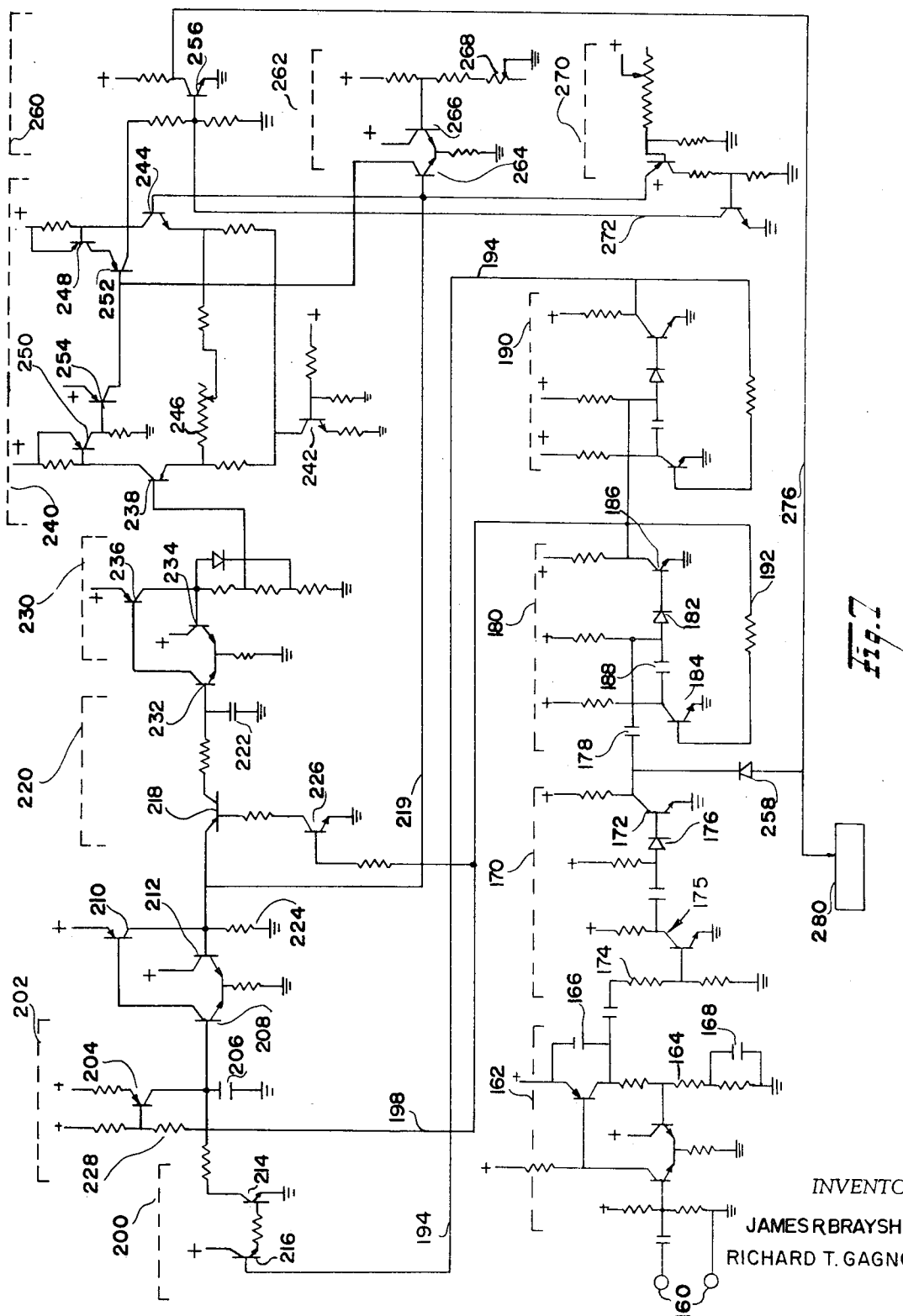
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ARRHYTHMIA COUNTER

SUMMARY OF INVENTION

This invention relates to an arrhythmia sensing device which can be used to take clinical readings of heart action under a wide variety of conditions and outside of the doctor's office, while the patient is performing his normal day-to-day activities.

It has long been recognized that the cardiac wave generated by the heart reflects its condition, both physiologically, and its reaction to stress and fatigue.

The electrocardiograph gives a good and accurate tracing of heart action, but its use is restricted to the medical office, and to those patients whose history or symptoms indicate that a special heart test should be made.

Studies have indicated that the heart gives some warning of impending trouble in many instances, by variation of its normal beat frequency. These signals very frequently go unnoticed by the individual, and often are not found in routine medical checkups.

There is a great need in current medical practice for more information on these patterns of behavior of the heart wherein change in beats or arrhythmia as it is termed, can be studied and evaluated over a prolonged period of time while the patient is in his normal routine of day to day living.

The instrument required for accurate survey must be more than just a heartbeat frequency detector, since the change in frequency in the heart can occur spasmodically.

Important additional information concerning cardiac activity, not observable in beat frequency detector devices, can be obtained by studying the frequency of occurrence of cardiac arrhythmias. These irregularities of heart action are of many different types, ranging from those benign types which occur in perfectly healthy individuals, to those with serious portent which are found only in the presence of heart disease. When these conditions occur, they may persist for only a brief period of time—some arrhythmias, for only the duration of a single heartbeat. Accurate information concerning the frequency of occurrence of the conditions under a variety of circumstances is not available, but it is certain that it varies widely with the individuals, with the state of health, and with the environmental conditions, and degree of stress, psychic or physical, to which a subject is exposed.

The study of electrocardiograms of cardiac patients has provided most of our knowledge of arrhythmias. Clinical experiences demonstrated that they provide information of great diagnostic and prognostic value for cardiac patients. Much less is known about the significance when seen in healthy persons, but it is known that they occur in a variety of circumstances, particularly in times of stress. Research to investigate the frequency and nature of cardiac arrhythmias which occur in a population of normally distributed healthy individuals should result in a significant advance in our knowledge about the response of the heart to the demands of everyday life. Increased knowledge about arrhythmias should also provide new insight regarding their meaning when their occurrence is associated with extreme stress or disease.

Accordingly, it is a principal object of this invention to provide an arrhythmia detector unit which will permit clinical observation and survey of individuals' heart action during various types of activity, and during the course of their normal daily routine.

It is a further object of this invention to provide a cardiac monitor which will permit the early detection and control of heart disease.

It is another object of this invention to provide the means for studying cardiovascular reactions under different physiological conditions.

It is a still further object of this invention to provide a device for monitoring heart action for any desired period of time.

It is a still further object of this invention to provide a unit which can make large scale cardiac surveys heretofore impractical with previous types of cardiac equipment.

It is a still further object of this invention to provide a new type of cardiac measurement and analysis previously unavailable without long study and detailed analysis of electrocardiogram tapes.

It is a still further object of this invention to provide a new type of readily available performance data usable for control of cardiac disease.

It is a still further object of this invention to provide more effective means for studying progress of the convalescent coronary patient.

It is a still further object of this invention to provide a device that can be readily used by the patient himself to obtain information on his cardiac activity during his daily routine, or for special periods of activity outside of the medical office.

It is a further object of this invention to provide an economical cardiac monitoring device, permitting a large number of units to be simultaneously used to obtain surveys on cardiac activity and reaction.

It is a still further object of this invention to provide a device which can be operated and interpreted by an unskilled individual.

It is a still further object of this invention to provide a device which will accurately monitor arrhythmia conditions automatically with no need for adjustment for any desired length of time.

It is a still further object of this invention to provide a cardiac monitoring device of small size which can easily be carried on the person of the subject to be studied.

It is the general object of this invention to provide a device which will make more data available concerning the boundary of normal heart action, and will assist in the early diagnosis of heart disease.

These and other object and advantages of the subject invention will become apparent from the following description and claims.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates in perspective the arrhythmia counter unit and its relative size to the human hand.

FIG. 2 shows a cardiac wave on an electrocardiographic strip, and illustrates the method used to determine an arrhythmia condition.

FIG. 3 is an electrocardiograph strip showing the cardiac wave with a premature ventricular contraction.

FIG. 4 illustrates an electrocardiographic strip having a cardiac wave similar to that shown in FIG. 3.

FIG. 5 is a function block diagram of the arrhythmia unit.

FIG. 6 is a more detailed block diagram illustrating the arrangement of major sections of the unit.

FIG. 7 is a schematic circuit of the arrhythmia unit.

DESCRIPTION OF INVENTION

Referring to FIG. 1 the arrhythmia detector generally indicated at 10 can be seen to be relatively small by comparison to the human hand in which it is held. It is possible to place the unit in the subject's pocket, thereby permitting him to carry it on his person without undue inconvenience.

The readout lights are generally indicated at 12, and give a count value for accumulated total of arrhythmia occurrences. There are 16 lights, all of which represent binary output, which makes it possible to count up to approximately 65,000 arrhythmia counts.

A start-stop switch 14 turns on the unit, while the three circles generally indicated at 16 are limit controls for the unit. Circle 18 represents the reset control which will set the unit reading back to zero count.

The arrhythmia unit will not indicate the number of accumulated counts until the read command signal is given through the read control 20.

It should be noted that all these control buttons are recessed, and require an instrument to actuate them to discourage unauthorized changes of setting.

This arrangement allows the medical examiner to adjust the unit to the desired counting criteria, and to reset the unit to zero prior to use. The arrhythmia unit can only be read when the read member 20 is actuated by an authorized individual.

Receptacles 22 and 24 receive the lines from standard ECG-pickup electrodes positioned on the subject's chest.

In FIGS. 2 through 4, the technique of detecting arrhythmias is illustrated. Basically, the interval between R peaks are measured and compared with the succeeding time interval. Successive time intervals are continuously compared and monitored for a time interval differential which exceeds the specified value. Each occurrence of a greater than normal variance will activate a counting circuit in the unit.

This technique for cardiac observation is quite different from the usual approach of merely detecting heart rhythm. The arrhythmia in many instances is of short duration. The occurrences would not show up in a pulse rate check. Furthermore, it is more than likely that brief periods of arrhythmia would never be detected by the electrocardiogram, since such periods are very unlikely to occur while the patient is undergoing an electrocardiogram test.

In many instances of cardiac difficulty, it is extremely important that an early diagnosis be made to prevent further complications. Early detection of the onset of cardiac difficulty may in many instances lead to proper and effective treatment. For example, 90 or more percent of the cases of coronary artery disease manifest an arrhythmia as a terminal episode. Observation of such hospitalized cases has consistently demonstrated the presence of less significant arrhythmias, but no less ominous, prior to a critical manifestation. The present technique for measuring time intervals between R peaks of the wave may provide a ready means to detect early signs of cardiac difficulty.

This technique makes it possible to provide a small, compact, portable detector unit. It measures the cardiac wave output using electronic circuitry and is relatively inexpensive. These characteristics will permit the clinician to monitor the arrhythmia patterns of a large number of people for any given desired length of time, in their daily routine activities.

The two electrodes are merely fastened to the skin of patient on the chest, and the unit can be carried in a large pocket of the patient's apparel.

An electrocardiogram tracing strip is shown in FIG. 2 with a cardiac generated wave 26 thereon. The R peak 28 shows the time and amplitude of a voltage generated on the beat of the heart. A second R peak is shown at 30. The arrowed line 32 notes the time interval occurring between each of the R peaks.

The time interval between R peaks can be very accurately measured. Each of the vertical bars shown on the tracing strip of FIG. 2 represent a 200-millisecond interval. Not shown in FIG. 2 are the finer vertical lines between the spacings which represent intervals of 40 milliseconds.

This technique was developed after an analysis of a large number of electrocardiograph tracings. Measurements were made by conventional calipers of the successive R—R intervals and the differences therebetween were calculated. Sinus rhythm (sinus bradycardia, normal sinus rhythm and sinus tachycardia), and premature ventricular contractions, either isolated or bigeminal, were studied.

It was found that the time interval differences between successive R peaks, give a good means of detecting any irregularity in the cardiac wave, and that these irregularities would be evident where the time interval difference was greater than 120 milliseconds.

For example, in the study of premature ventricular contractions, only a very small percentage of the maximum time interval differences were 120 milliseconds or less, indicating that reasonable separation of premature ventricular contractions could be obtained by the time interval difference analysis.

A working value of 120 milliseconds for the difference in time between successive R—R peak intervals has been established as a good workable figure, without which all but a low percentage of arrhythmia irregularities would fall. An il-

lustration as to how the analysis is made is illustrated in FIGS. 2 to 4.

Referring to FIG. 2, a cardiographic wave tracing 26 is shown on a section of an electrocardiographic strip. An electrocardiographic tracing on such a strip illustrates graphically the action of the heart as represented by the wave tracing produced from an electrical voltage emanating from the heart and picked up by the ECG-electrodes attached to the patients chest.

The vertical lines of the strip represent time intervals of 200 milliseconds, while horizontal lines represent voltage amplitude.

In FIG. 2 we have an illustration of the analytical approach which is the subject of this invention. The cardiac wave tracing 26 has an R peak 28 generated when the heart beats, and a second R peak 30. The time interval indicated by the distance 32 between the R peaks 28 and 30 is measured in milliseconds. The succeeding heart time interval between R peak 30 and R peak 34 is measured along the line 36 to give the second time interval. The difference between the two intervals is then calculated and if the value is greater than 120 milliseconds, it is noted and recorded as a count. Similarly, the difference in time represented by lines 36 and 40 is calculated, and if that difference is greater than 120 milliseconds this is also recorded as a count. If the value is less than 120 milliseconds, no count is made.

It should be noted that the representations of the electrocardiographic strips do not show the four light vertical lines representing 40 millisecond intervals, which make it possible to measure intervals to within 20 milliseconds.

The time intervals 32, 36, and 40 respectively measure 840, 800, and 860 milliseconds, and illustrate four normally conducted beats. The two successive time interval differences are 40 milliseconds and 60 milliseconds, which is well within the 120-millisecond value.

In FIG. 3, the electrocardiographic wave 42 shows five normally conducted beats and one premature ventricular contraction. The successive R—R peak intervals measure respectively 680, 640, 760, 700, and 720 milliseconds. The respective differences are 40, 120, 60 and 20 milliseconds. In this instance one count should be recorded. The premature ventricular contraction wave is indicated at 50.

In FIG. 4, a representation of an electrocardiographic strip having cardiac wave tracing 60 with five normally conducted beats and one premature ventricular contraction is shown. The time interval between R peaks 62 and 64 is 520 milliseconds. The ventricular contraction lengthens the time interval between R peaks 64 and 68 to 760 milliseconds, and the difference between these two time intervals is 240 milliseconds. One count should be recorded for this difference. The time interval between R peaks 68 and 70 is 620 milliseconds. The difference between these two time intervals is 140 milliseconds, and therefore should receive a second count. The time interval between R peaks 70 and 72 is 580 milliseconds, the normal time interval range for this cardiac wave form, with the time interval difference between this and the preceding time interval being only 40 milliseconds. In this instance the premature ventricular contraction wave 66 results in two time interval differences greater than 120 seconds and two counts should be recorded. For ventricular contractions, from one to three counts of greater than 120-millisecond time interval differences may be recorded.

Various types of electric circuitry can be devised to pick up and count the R peaks, and sense successive time interval differences. The following FIGS. 5 through 7 illustrate one embodiment that can be used. The arrhythmia unit to be described is small and compact, as can be seen in FIG. 1, and can readily be carried on the person. The unit is transistorized, and is powered by batteries which can give up to 72 hours of continuous operation.

FIG. 5 shows a functional block diagram of the unit showing in diagrammatic form two electrocardiogram input electrodes 70 and 72 which pass the signal to the amplifier unit 74. The

signal is then passed along line 76 to the beat interval analyzer which contains three time interval detector units. Bradycardia detection section 78 picks up those beats which are slower than the normal beat frequency for a cardiac wave. An arrhythmia detector 80 will detect those waves having a regular rhythm but containing a premature contraction or other irregularity. The tachycardia detector unit 82 will detect those cardiac waves where the rhythm is faster than normal. Output signals are sent from these units along lines 84, 86, and 88 to the counter accumulator 90. The unit is powered by a battery 92 which supplies current along lines 94 and 96 to the counter accumulator and beat interval analyzer.

The output signal from a counter accumulator is supplied along 98 to the binary readout unit 100 which has a plurality of readout lamps 102. Battery 106 supplies an independent source of current to the readout unit along line 108. The readout unit 100 is a 16-bit binary readout device.

In FIG. 6, a more detailed breakdown of the component electronic circuits is shown. The electrocardiogram pickup electrodes 110 and 112 supply a wave to the electrocardiogram wave amplifier 114. This signal is supplied to the counter pulse gate 116 and sent along line 118 to the ramp storage pulse generator 120.

The ramp voltage is sent through a ramp reset pulse unit 122 and to a timing ramp reset 124 which signal is supplied to the timing ramp generator 126. A signal is also sent from the ramp storage pulse generator 120 along line 128 to the timing ramp storage unit 130. The timing ramp generator supplies a signal to the ramp storage unit 130, and along line 132 to the differential comparator 134. A signal is also sent from the timing ramp generator 126 along line 136 to the long interval detector 138. This unit would be the equivalent of unit 78 in FIG. 5, and would sense a bradycardia condition.

The timing ramp generator also sends a signal along line 140 to the short interval detector 142, which is equivalent to the tachycardia unit 82 of FIG. 5.

The output from the differential comparator and the long interval and short interval detectors are supplied to an OR-function unit 144.

The counter pulse gate circuit 116 when it originally receives the amplified electrocardiograph signal sends its pulse out along line 146 to the counter pulse generator 150, where it coincides with the signal supplied from the differential comparator and interval detector units passed through the OR-function unit 144 and along line 148 to the counter pulse generator.

The output of the counter pulse generator is supplied along line 152 to the 16-bit binary counter 154.

The 16-bit binary counter 154 has 16 readout lamp drivers with a corresponding readout lamp, each of which reflect accumulated count in binary form. The readout lamp drive 156 is typical of the remaining 15 drivers, and readout lamp 158 is typical of the corresponding readout lamps.

Briefly, the electrocardiogram signal is received through the pickup electrodes, amplified, the R peaks detected, and a ramp pulse generated, the voltage value of which increases proportionately with time lapse. This voltage is supplied to the timing ramp storage unit 130 which successively stores each ramp voltage coincident with a beat and saves it for comparison with the following ramp voltage coincident with the next beat.

The storage unit is connected to a differential amplifier which senses the signals supplied to it from each of the two voltage sources and sends out a signal if the difference between the two represents more than, for example 120 milliseconds. This signal pulse is then supplied to the binary counter which registers a count.

A more detailed explanation of the operation of the unit is illustrated in FIG. 7, which shows a detailed schematic thereof.

To make a cardiac check of a patient, the arrhythmia unit is connected to the patient by means of the ECG-electrodes electrodes which are placed on the subject's chest. The elec-

trodes usually are disk-shaped, and have a 2 or 3-foot length of conductor wire attached to it. The free end of one of the wires is inserted in the receptacle 22 of the arrhythmia counter of FIG. 1 while the free end of the second wire is inserted in the receptacle 24 of the arrhythmia counter.

The time interval difference between successive intervals of R—R occurrences of a cardiac wave is then measured and counted by the unit.

Time interval difference analysis will permit the screening of large numbers of people with little or no difficulty or inconvenience, and will permit the detection of arrhythmias manifested by irregularity of beat, such as sinus pause and arrest, various types of premature beats, and atrial fibrillation. It is possible by sensing the absolute R—R time interval values to also analyze the various regular bradycardias and tachycardias.

Referring to FIG. 7 the cardiographic signal is applied through the electrocardiograph pickup electrodes indicated at 160 and drives the amplifier unit 162. The amplifier is a linear feedback unit where the gain is determined by resistor 164. The band-pass characteristics are determined by capacitors 166 and 168 and are chosen to emphasize the predominant R component of the ECG-waveform and to discourage response from all of the other signals. The plus leads are 9 volts.

The analog output of the amplifier unit 162 drives the counter pulse gate 170 which produces a positive rectangular pulse at the collector of transistor 172 at each beat. When current through resistor 174 causes emitter base junction at 175 to become forward biased the collector voltage, at 175, drops to zero, placing a momentary negative potential at the anode of diode 176. This causes the transistor 172 collector to rise momentarily to 9 volts.

When this voltage returns to ground, a negative spike is coupled through capacitor 178 to the ramp storage pulse generator circuit 180, where it is applied to the anode of diode 182. This momentarily turns off the transistor 186, causing a positive rectangular pulse at its collector. This turns on the transistor 184 and maintains transistor 186 in the "off" stage until capacitor 188 charges sufficiently to allow diode 182 to turn on transistor 186 again, bringing its collector to zero.

The ramp reset pulse generator circuit is indicated at 190. Termination of the ramp storage pulse initiates the ramp reset pulse. Operation of stage 190 is identical to stage 180.

Initially, an R component of the ECG-wave triggers the counter pulse gate 170. Second, the ramp storage pulse is generated; third, the ramp reset pulse is generated.

The output from the ramp reset pulse generator 190 is transmitted along lines 194 and 196 to the timing ramp reset circuit 200. This circuit is directly connected to the timing ramp generator circuit 202 which consists of the current source through transistor 204 and an integrating capacitor 206. This combination produces a linear ramp at the base of transistor 208. Transistors 208, 210 and 212 form a voltage follower that provides a low-impedance ramp output to drive other circuitry. The ramp is returned to zero, when transistor 214 is turned on by transistor 216, the latter being driven by the ramp reset pulse. Transistor 218 is part of the timing ramp storage unit generally indicated at 220. It couples capacitor 222 to the output of the voltage follower across resistor 224 of the voltage follower circuit when transistor 226 is turned on by the ramp storage pulse.

Thus every time a heart beat (R component) is detected, the instantaneous ramp amplitude is stored in capacitor 222 with the ramp storage pulse. While this is occurring, the ramp voltage is frozen by loss of current through resistor 228 in circuit 202.

After transistor 218 is again returned to the off state, the ramp is reset with the ramp reset pulse. Capacitor 222 still holds the instantaneous ramp voltage at the exact moment of the last beat. This voltage is a measure of the time interval between the last beat to the previous one. Thus, the previous beat-to-beat interval is stored as the voltage in capacitor 222, and through the compensated voltage follower unit 230 con-

taining transistors 232, 234, and 236, is applied to the base of transistor 238. Transistor 238 is part of the differential comparator unit 240. This unit is made up of transistors 238, 242, 244, 248, 250, 252, and 254.

Transistor 242 is a current source providing an emitter current for the emitters of transistors 238 and 244. These three transistors make up a differential amplifier whose gain is determined by the setting of potentiometer 246. If the base voltage of transistor 238 is too far above that of transistor 244, the latter will turn off and transistor 248 will no longer conduct.

If either transistors 248 or 250 stop conducting, transistor 252 will be turned off (via the transistor 254 inverting gate if transistor 250 turns off), and the collector voltage or transistor 256 of the counter pulse generator unit 260, will rise to 9 volts.

This will cause the counter unit 280 shown at the lower portion of the schematic to register one count when the counter pulse gating diode 258 connected between transistor 172 and counter 280 is ungrounded.

Thus, each time a beat is detected, diode 258 is ungrounded and the differential comparator will register a count if the instantaneous ramp voltage at the base of transistor 252 is too far above or below the stored voltage on the base of transistor 238.

These voltages, as was previously mentioned, are a measure of the present pulse interval and the previous pulse interval. Their comparison constitutes arrhythmia detection which is defined here as any pulse interval which differs from the previous interval by more than a fixed amount which is determined by the potentiometer 246.

Immediately after this comparison is made, the ramp voltage is frozen, stored in capacitor 222 (the previously stored voltage is lost) for the next comparison, and then rapidly brought to zero where it begins again to measure the next interval.

The ramp output also drives its tachycardia detector which is a differential comparator comprised of transistors 264 and 266. If the ramp voltage driving the base of transistor 264 is less than the transistor 266 base voltage set by potentiometer 268, transistor 252 will turn off, turning transistor 256 off, and causing a positive 9-volt signal to go to the counter when the gating diode 258 is ungrounded.

The counter pulse generator unit 260 is connected to the counter unit 280 by line 276.

The counter unit consists of a cascaded chain of binary flip-flops whose states indicate the accumulated count in binary form.

The state of the counter is read by a multiple query circuit which simultaneously senses the states of all 16 flip-flop stages and lights each lamp if its corresponding flip-flop stage is at a 9-volt state.

The circuit controlling read out is actuated by the clinic. It should be noted that the ramp output also drives the bradycardia detector 270.

The adjusting of the unit for a desired time interval is made by inserting a key within the appropriate one of three openings 16. The button 14 is pressed to activate the arrhythmia counter.

After 30 seconds have elapsed, voltages within the counter will stabilize and the reset key is THEN inserted in reset opening 18. This sets the counter to zero. From this point on, all counts for each irregularity beyond the acceptable time interval differences between successive R peaks and for each R—R interval which is too long or too short will be made.

The test can be made for any desired period of time. The counts will be accumulated in the unit, but the binary lights 12 will not give any indication of the accumulated count during the course of the test.

Once the test has been concluded the arrhythmia counter is turned over to the clinic, where the operator inserts an appropriate key into the opening 20 to turn on the binary readout lights 12. The arrhythmia counter must be left on until

the accumulated count is taken, after which the button 14 is pressed off to conserve battery life. The clinic will have a chart which will give the number of counts registered for each readout light. The values of each of the readout lights are then totaled to give the total count. Using 16 binary units, as illustrated, will permit a total reading up to some 65,000 counts. This is more than adequate to conduct a long time and comprehensive survey of a patient for any given length of time. The arrhythmia unit, since it is transistorized, can be powered for 72 hours using a small transistor battery.

CONCLUSION

It can be seen that this device will provide an economical, and a portable arrhythmia unit which will permit the study of a large number of persons over prolonged periods of time.

This has not been possible heretofore because of the bulkiness of equipment, the cost of the same, and the need for a skilled technician.

The arrhythmia unit of the subject invention provides a new type of instrument which will greatly increase the available knowledge concerning arrhythmia conditions. The knowledge thus gained will be extremely helpful in detecting cardiac irregularities in a patient or in many instances where the occasional electrocardiograph would not reveal a latent condition.

While the invention has been described in connection with a preferred embodiment thereof, it will be understood that it is capable of further modification, and this application is intended to cover any variations, uses or adaptations of the invention following in general the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains, and as may be applied to the essential features hereinbefore set forth as fall within the scope of the invention or the limits of the appended claims.

Having thus described our invention, what we claim is:

1. A cardiac monitor unit comprising:

- a. means for detecting time intervals between successive R peaks on a cardiac wave,
- b. means for comparing the time difference between successive R time intervals to a preselected time difference value established as normal, and
- c. means for registering the total number of occasions successive R peak time intervals differ from each other by more than the preselected normal difference value.

2. The cardiac monitor unit of claim 1, wherein:

- a. the detecting means includes plural electrodes adapted to be connected to the user and worn under clothing,
- b. the circuits of the unit are transistorized and powered by a small battery which will provide power for more than 24 hours of service,
- c. the unit can be carried in a pocket to permit the user to carry the unit on his person without difficulty, whereby a patient cardiac activity can be continuously monitored over a prolonged period including his usual daily activities.

3. The cardiac monitor unit of claim 1, wherein:

- a. the comparing means includes settable means for varying the preselected time difference value.

4. The cardiac monitor unit of claim 1, wherein:

- a. the preselected time difference value is 120 milliseconds.

5. The cardiac monitor unit of claim 1, including:

- a. bradycardia and tachycardia responsive circuits, connected to the detector means and the register means for producing a control signal respectively indicating long and short duration R intervals.

6. An arrhythmia comprising:

- a. sensing means for detecting R peaks in a cardiac wave,
- b. circuit means connected to the sensing means for measuring the time interval between the most recent R—R peaks of a cardiac wave and the time interval between the immediately preceding R—R peaks,

- c. comparison circuit means connected to the measuring circuit means for comparing the difference in the time intervals and producing a signal when the difference between the time intervals is greater than a preselected clinically significant time difference,
- d. counting means connected to the comparison circuit and responsive to the signal produced, for counting each occasion when the successive R—R time interval differences exceed the preselected time difference and recording the total number of such occasions.
- 7. The arrhythmia unit as set forth in claim 6, wherein:
 - a. said unit is battery powered and portable and can be carried on the person of the subject whose cardiac pulse is to be monitored.
- 8. The arrhythmia unit as set forth in claim 6 wherein:
 - a. readout means is provided for giving an accumulated total number of counts.
- 9. The arrhythmia unit as set forth in claim 6, wherein:
 - a. readout means is provided which is operable by the medical examiner to give a total number of counts.
- 10. An arrhythmia unit as set forth in claim 6, wherein:
 - a. readout means is provided for giving a total number of accumulated counts, and
 - b. reset means is provided for erasing the previously accumulated total count.
- 11. The arrhythmia unit as set forth in claim 6, wherein:
 - a. adjustable circuit means is provided for varying the preselected time difference value between successive time intervals at which a count is made.
- 12. The arrhythmia counter unit as set forth in claim 6, wherein:
 - a. said sensing means includes two chest pickup electrodes and associated electrical means for producing an electrical output signal.
- 13. The arrhythmia counter unit as set forth in claim 6, wherein:
 - a. said measuring means includes electrical pulse generating means responsive to the amplitude of said R peak pulses.
- 14. An arrhythmia counting unit as set forth in claim 6, wherein:
 - a. said measuring means includes a linear feedback amplifier having a band-pass value which attenuates all but the R component of the electrocardiograph waveform.
- 15. The arrhythmia counting unit as set forth in claim 6, wherein:
 - a. said measuring means includes electrical storage means for producing a voltage dependent upon the time interval between said R peaks.
- 16. The arrhythmia counter unit as set forth by claim 6, wherein:
 - a. said electrical storage means is a capacitor.
- 17. The arrhythmia counter unit as set forth in claim 6, wherein:
 - a. a pair of electrical storage units are alternatively actuated to reflect the length of time between succeeding R peak pulses.

- 18. The arrhythmia counter unit as set forth in claim 6, wherein:
 - a. said measuring means includes a linear voltage generator actuated by an R peak pulse which is a measure of the time interval between R peaks.
- 19. The arrhythmia counting unit as set forth in claim 6, wherein:
 - a. said comparison means includes a differential comparator.
- 20. The arrhythmia counter as set forth in claim 6, wherein:
 - a. said counting means includes a cascaded chain of binary flip-flop units.
- 21. The arrhythmia counting unit as set forth in claim 6, wherein:
 - a. said counting means includes a binary counter.
- 22. The arrhythmia counter as set forth in claim 21, wherein:
 - a. readout means is connected to said binary counter and which includes a plurality of readout lamps.
- 23. An arrhythmia unit, comprising:
 - a. means for detecting the R peaks of a cardiac wave,
 - b. electrical voltage generating means connected to the detecting means and responsive to the time interval between said R peaks of said cardiac wave,
 - c. an electrical storage element which receives the voltage generated by said electrical voltage generating means,
 - d. a differential comparator circuit connected to the electrical storage element and responsive to the voltage therein, including circuitry referenced to a preselected clinically significant time difference, so that a signal is produced from the differential comparator circuit when the voltage of the electrical storage element reflecting the time difference between succeeding R—R peaks of a cardiac wave exceeds the preselected time difference, and
- 24. arrhythmia unit as set forth in claim 23, wherein:
 - a. bradycardia detector means is connected in circuit for detecting R peak frequency below a preselected frequency level and transmitting a signal to the counter means;
 - b. tachycardia detector means connected in circuit for detecting R peak frequency above a preselected frequency level and producing a signal which is supplied to the counting means.
- 25. The arrhythmia unit as set forth in claim 23, wherein:
 - a. said counter means includes a binary counter, and
 - b. readout lamps connected to said binary counter which give a reading of total counts of the output from the differential comparator.
- 26. The arrhythmia unit as set forth in claim 23, wherein:
 - a. said differential comparator circuit includes means for actuating said counting means at different time interval differences between successive R peaks of a cardiac wave.
- 27. The arrhythmia unit as set forth in claim 23, wherein:
 - a. resettable readout means for the total number of output signals from said differential comparator circuit is connected to the counter means.

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