CARDIAC MONITORING APPARATUS FOR A PLURALITY OF PATIENTS

Inventor: Francis I. Dominy, Janesville, Wis.
Assignee: The Burdick Corporation, Milton, Wis.
Filed: Sept. 5, 1968
Appl. No.: 757,607

U.S. Cl. .......................................................... 128/2.06 R
Int. Cl. ............................................................. A61B 5/04
Field of Search ................................................. 128/2.06, 2.05 M, 2.05 R; 346/62, 23

References Cited

UNITED STATES PATENTS
2,098,695 11/1937 Southwick....................... 128/2.06 B
3,517,662 6/1970 Finch et al............... 128/2.06 B
2,400,583 5/1946 White.......................... 128/2.06
3,058,458 10/1962 Daneonan.................. 128/2.06
3,199,508 8/1965 Roth.......................... 128/2.06
3,374,885 3/1968 Gemmer..................... 128/2.06 X
3,478,364 11/1969 Frank...................... 128/2.06 X

A recording device selectively records cardiac or other physiological signals from any one of a group of patients, and each recording includes an integral segment identifying the corresponding patient. A switching circuit connects a selected patient signal line to a signal path coupled to the recording device, either automatically in response to a detected alarm condition or manually. When a patient signal line is connected to the signal path, the signal path is interrupted for a period of time and the recorder motor is energized to reach an operating condition. A signal generator is then operated for a time interval determined by the selected input to apply to the recording an identifying code or marking signal corresponding to the selected input. Thereafter, the signal path is completed and the signal generator is deenergized whereupon the patient's cardiac or other physiological signal is recorded immediately following the recording of the code or marking signal.

3 Claims, 6 Drawing Figures
CARDBIAC MONITORING APPARATUS FOR A PLURALITY OF PATIENTS

FIELD OF THE INVENTION

The present invention relates to apparatus for monitoring any selected one of a plurality of cardiac or other physiological signals. More particularly the invention relates to an improvement for providing each recording with a segment identifying the corresponding patient.

DESCRIPTION OF THE PRIOR ART

Monitoring apparatus has been used in the past for recording a cardiac or other physiological signal of any one of several monitored patients. One known apparatus includes a switching system operable either manually or automatically for interconnecting one of several patient signal lines to the input of a recording device such as an electrocardiograph to produce a recording of a patient signal. In manual operation, any one of the patient signal lines may be selected at will by the operator. In automatic operation, the switching system is controlled automatically to connect the recorder to the patient signal line of any patient having a cardiac or other physiological signal indicating an alarm condition.

One serious difficulty of known monitoring systems is that a doctor or other person reviewing a recording at a subsequent time cannot determine which of several patients corresponds to any particular recording. In automatic operation this problem is particularly acute because the recording device is interconnected with the patient signal lines without the intervention of an operator.

SUMMARY OF THE INVENTION

Among the important objects of the invention are to provide improved physiological signal monitoring apparatus, to overcome disadvantages of known systems, and to provide cardiac monitoring apparatus of the type including a single recorder for making records of cardiac signals of several patients wherein each recording is provided automatically with a code or marking segment identifying the corresponding patient. A further object is to provide such an apparatus wherein no alteration of the recording device is required to the end that any standard electrocardiograph or other recording device can be used.

Briefly, the present invention may comprise a recording device having its input coupled to a signal path together with switching means for coupling any one of several patient lines to the signal path. When a switching operation is made either manually or automatically, the signal path is interrupted and remains interrupted for a period of time. During this period of time a signal generator is operated to apply to the input of the recording device a code or marking signal representing the corresponding patient. At the end of the period of time, the signal path is closed and the code or marking segment of the recording is immediately followed by a recording of the signal existing on the patient signal line of the corresponding patient.

DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the present invention will appear from the following description of an illustrative embodiment of the invention in the course of which reference is made to the accompanying drawings wherein:

FIG. 1 is a block diagram of portions of cardiac monitoring apparatus embodying features of the present invention;

FIG. 2 is a schematic diagram of the switching circuit of FIG. 1;

FIG. 3 is a schematic diagram of the time delay circuit of FIG. 1;

FIG. 4 is a schematic diagram of the timer of FIG. 1;

FIG. 5 is a schematic diagram of the signal generator of FIG. 1; and

FIG. 6 is a schematic diagram of the interrupter switch of FIG. 1.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT OF THE INVENTION

General Description

FIG. 1 of the drawings illustrates in block diagram form a cardiac monitoring system embodying the features of the present invention and designated as a whole by the reference numeral 10. The unit 10 includes a recording device 12 for making recordings of cardiac signal derived from any one of three patients by patient signal detecting units 14, 16 and 18. In accordance with an important feature of the invention, a coding or marking system generally designated as 20 in FIG. 1 serves to provide each recording with a segment serving to identify the patient corresponding to the recording being made.

In the illustrated embodiment of the invention, the unit 10 comprises a cardiac monitoring unit serving to provide electrocardiograms of the heart-induced cardiac wave forms of the monitored patients. The recorder 12 thus may comprise any suitable electrocardiograph machine capable of producing on a suitable record medium such as a paper strip or the like a transcription of the cardiac wave form received at its input. It should be understood however that the principles of the present invention are applicable to the monitoring of any other physiological signals, such as brain wave signals or others, and that the recorder 12 may comprise any suitable recording device, display unit or indicator.

For purposes of convenience in illustration, the monitoring unit 10 is illustrated in connection with three monitored patients, although it will be understood by those skilled in the art that the system may be used with fewer patients and may readily be expanded to accommodate a larger number of patients. The patient signal detecting units 14, 16 and 18 may be of any suitable construction. In the illustrated embodiment of the invention, the units 14, 16 and 18 preferably include suitable known electrodes capable of being attached to the patients for detecting cardiac signals.

In order selectively to interconnect any one of the patient signal detecting units 14, 16 and 18 with the recorder 12, the unit 10 includes a switching circuit generally designated as 22 adapted to be connected to input conductors 24 and 26 of the recorder 12 by a pair of conductors 28 and 30 forming a signal path. The detecting unit 14 for the first patient is coupled to the switching circuit 22 by a pair of conductors 32 and 34 comprising a patient signal line. In a similar manner, the units 16 and 18 are connected to the switching circuit 22 by patient signal lines comprising conductor pairs 36-38 and 40-42. The switching circuit 22 can be operated manually in a manner described hereinafter to interconnect any of the patient signal lines with the signal path conductors 28 and 30 thereby to produce a recording of the cardiac signal of any selected one of the patients.

In accordance with an important aspect of the present invention, the coding or marking system generally designated as 20 operates automatically in response to operation of the switching circuit 22 to interrupt the signal path conductors 28 and 30 and simultaneously to apply to the input conductors 24 and 26 of the recorder 12 a code or marking signal corresponding to the selected patient. This code or marking signal is transcribed by the recorder 12 onto the record medium, after which the selected cardiac signal is also transcribed. As a result, a person referring to the recording at a later time is able to identify the corresponding patient from the recording itself.

More specifically, when the switching circuit is operated to select the patient signal line corresponding to any one of the monitored patients, an operating signal is applied to a time delay circuit generally designated as 36 by way of a conductor 38. Simultaneously, a start signal is applied by way of a conductor 40 to a drive motor 42 associated with the recorder 12, the motor being illustrated in block form in FIG. 1. Where the recorder comprises an electrocardiograph, the recorder motor serves to advance the paper strip or other record medium.
During the time delay period produced by operation of the time delay circuit 36, the motor 42 is permitted to reach an operating condition so that recordings produced by the recorder 12 are not distorted by acceleration of the record medium.

Following completion of the time delay period established by operation of the time delay circuit 36, the coding or marking system 20 serves to apply a code or marking signal to the input conductors 24 and 26 of the recorder 12. In general, the system 20 includes a signal generator generally designated as 44, a timer circuit generally designated as 46, and an interrupter switch circuit generally designated as 48. In accordance with the invention, the timer is controlled in accordance with the selected patient line to operate the signal generator for a predetermined period of time to produce a signal of predetermined duration applied to the recorder input conductors 24 and 26 during operation of the interrupter switch 48.

More specifically, the circuit is operated and following the time delay period established by operation of the time delay circuit 36, a timer operating signal is applied to the timer circuit 46 through one of three conductors 50, 52 and 54, each corresponding to one of the patient signal lines. The timer 46 then operates for an interval of time determined by the conductor through which it receives an operating signal. At the end of the predetermined time interval, the timer circuit 46 is effective to discontinue the operation of the signal generator 44 by a signal applied through a conductor 56 and simultaneously to cause the interrupter switch circuit 48 to interconnect the signal path conductors 28 and 30 with the recorder input leads 24 and 26 by way of a signal applied through a conductor 58.

During the time interval established by operation of the timer circuit 46, a coding or marking signal is coupled from the signal generator circuit 44 by way of a conductor 59 to the interrupter switch circuit 48 where it is applied to the recorder 12 by the signal generator circuit 44. During this period of time, the interrupter switch 48 is in operation disconnecting the signal path from the recorder input. At the end of the predetermined time the interrupter switch reconnects the signal path with the recorder input, and the coding or marking signal is immediately followed by the cardiac signal of the selected patient. In the event that the switching circuit is operated manually to select another set of patient lead conductors, a reset signal is forwarded to the time delay circuit 36 by way of a conductor 60 and the marking system 20 is conditioned to operate once more to provide a code or marking signal.

In some instances it may be desirable to operate the switching circuit 22 automatically to produce a recording of the cardiac signal of any patient whose cardiac wave form indicates an alarm condition or the like. For this reason, there is associated with each of the detecting units 14, 16 and 18 a condition responsive control device 62, 64 and 66 respectively. These devices may be of any suitable type known to those skilled in the art and each is connected to the corresponding patient unit and includes suitable apparatus for producing an output signal on an output conductor 68, 70 or 72 respectively in response to a predetermined cardiac condition. For example, the condition responsive controlling devices 62, 64 and 66 may include valve controlled oscillator devices of the type disclosed and claimed in a copending application of Leslie W. Partridge, Ser. No. 523,790, filed Jan. 28, 1966 now U.S. Pat. No. 3,456,212. In this case, the devices 62, 64 and 66 each serve to produce an output signal if the heart beat rate of the corresponding monitored patient falls below or exceeds predetermined levels. The output conductors 68, 70 and 72 are each connected to the switching circuit 22 automatically to control the operation thereof in a manner disclosed hereinafter.

SWITCHING CIRCUIT

The switching circuit 22 (FIG. 2) controls the interconnection of the patient signal lines 32-34, 36-38 and 40-42 with the signal path conductors 28 and 30. In addition, operation of the switching circuit 22 serves to apply an operating signal to the recorder motor 42 by way of the selector switch 48, to operate the time delay circuit 36 by applying an operating signal to the conductor, and to also establish a predetermined operating interval for the timer circuit 46 by applying an operating signal to one of the conductors 50, 52 and 54.

In general, the switching circuit 22 includes three relays 74, 76 and 78, each corresponding to one of the patient signal detection units 14, 16 and 18. Each relay is provided with a relay operating circuit generally designated as 80, 82 and 84 respectively. These circuits are identical to one another, and although only the relay operating circuit 80 is described in detail hereinafter, identical reference numerals are used to designate identical elements of the circuits 80, 82 and 84.

Operation of the switching circuit 22 is controlled by a selector switch generally designated as 86 including three ganged wipers 86a, 86b and 86c. The circuit 22 may be operated either manually or automatically, and the selector switch 86 is illustrated in the position for automatic operation. In this condition, control of the circuit 22 is effected by signals applied to the circuit by the condition responsive control circuits 62, 64 and 66 on the conductors 68, 70 and 72. Normally, the condition responsive control circuits apply positive voltages to their output conductors. However, in the event of an alarm condition detected by any of the controllers, a relatively negative or ground potential is applied to the corresponding conductor 68, 70 or 72.

Referring for purposes of illustration to relay 74 and its relay operating circuit 80, the relay 74 is normally maintained in a deenergized condition by a normally nonconductive transistor 88. If a ground potential is applied to conductor 68 by operation of the condition responsive control circuit 62, the transistor 88 is placed in a conductive condition by a relatively negative voltage applied to the base of the transistor through a pair of resistors 90 and 92. Current thereby passes between a point of positive potential and ground through an isolating diode 94, the transistor 88 and the coil of relay 74.

Relay 74 includes four normally open sets of relay contacts, two of which close upon energization of the relay to interconnect the patient signal line conductors 32 and 34 with the signal path conductors 28 and 30. An additional set of relay contacts closes to apply ground potential to the conductor 40 to initiate operation of the motor 42 associated with the recording device 12. The final set of relay contacts closes to apply a positive voltage by way of a pair of diodes 96 and 98 to conductors 38 and 50 thereby to control the operation of the time delay circuit 36 and the timer circuit 46. It should be understood that relay operating circuits 80, 82 and 84 and associated relays 74, 76 and 78 operate in a corresponding manner if an operating signal is applied to either of the conductors 70 or 72 by the condition responsive control circuits 64 or 66.

In order to prevent interference between operation of the relay control circuits 80, 82 and 84 in the event that alarm signals are received simultaneously from more than one of the condition responsive control circuits, the switching circuit 22 is provided with a lockout arrangement whereby only one of the relays 74, 76 or 78 can be operated at one time. If the relay 74 is operated, for example, a relatively positive voltage is applied by way of diodes 100 and 102 to the junctions of resistors 90 and 92 of relay control circuits 82 and 84. This positive voltage renders the base electrodes of the corresponding transistors 88 positive to such an extent that they cannot be placed in a conductive condition by a relatively negative signal applied by the conductors 70 and 72. In a similar manner, the relays 76 and 78 are effective to disable the other relay operating circuits by virtue of diodes 104, 106, 108 and 110.

In order to control the operation of the timer circuit 46 in accordance with the patient lead selected by the switching circuit 22, the relays 74, 76 and 78 apply a positive operating potential to the timer circuit by way of conductors 50, 52 and 54 respectively. When the relay 76 operates, the positive voltage is applied to conductors 38 and 52 by diodes 112 and 114.
Similarly, operation of relay 78 applies a positive potential to conductors 38 and 54 by way of diodes 116 and 118. As noted above, the switching circuit 22 may be operated manually rather than automatically through manipulation of the selector switch 86. If the switch 86 is moved from its illustrated automatic operation position to one of its other three positions, the switching circuit 22 is effective to interconnect selected one of the patient signal detecting units 14, 16 or 18 to the signal path conductors 28 and 30 through operation of a selected one of the relays 74, 76 or 78.

If the selector switch 86 is moved to one of its three alternate positions in order to select one of the patient signal detecting units, automatic operation is prevented. More specifically, the wiper 86c engaging any one of the three alternate terminals applies a positive voltage by way of diodes 120, 122 and 124 to the junction of resistors 90 and 92 of all three of the relay operating circuits 80, 82 and 84, thus preventing automatic operation in a manner similar to the manner described above in connection with the lockout arrangement.

The wiper 86c is effective to bring about energization of a selected one of the relays 74, 76 and 78. Referring for purposes of explanation to the relay 74, if the wiper 86c is moved downwardly one step from its illustrated automatic position, ground potential is applied by way of a resistor 126 to the base electrode of the corresponding transistor 88, thereby rendering the transistor 88 conductive to energize relay 74. A similar operation takes place if the switch wiper 86c is moved to the next two positions for operating the relays 76 or 78.

Operation of the selector switch 86 between any of its alternative positions also serves to short the time delay circuit 36 and the marking system 20. When the switch 86 is moved, wiper 86b moves in break-before-make sequence between a series of grounded switch terminals. In the interval of time during which wiper 86b does not contact a terminal, a relatively positive voltage is applied to conductor 60 through a resistor 127 in order to reset the time delay circuit 36 and the marking system 20.

TIME DELAY CIRCUIT

The time delay circuit 36 illustrated in schematic form in Fig. 3 serves to initiate operation of the timer circuit 46 and the signal generator 44 a predetermined time after operation of the switching circuit 22. During this time interval, the motor 42 associated with the recording device 12 begins to operate and brings the record medium up to speed so that a signal applied to the recording device is not distorted by acceleration or the like.

When a positive operating signal is applied to the conductor 38 by operation of the switching circuit 22, a capacitor 128 begins to charge at an exponential rate through a resistor 130. The positive voltage difference existing across the capacitor 128 is divided by resistors 132 and 134 and a portion is applied to the base-emitter junction of a normally nonconductive transistor 136. After a predetermined time interval, the transistor 136 is rendered conductive to energize the winding of a relay 138 shunted by a bypass diode 140.

The relay 138 includes normally open relay contacts 138a and 138b (Fig. 4) for controlling the operation of the timer circuit 46. In addition, the relay 138 includes a normally open set of relay contacts 138c (Fig. 5) controlling the operation of the signal generator circuit 44. Accordingly, a predetermined time after operation of the switching circuit 22, the relay 138 is energized in order to operate the timer 46 and the signal generator 44. This time interval is determined by the RC time constant of the circuit including the resistor 130 and the capacitor 128, and is chosen to enable the recorder motor 42 to reach full speed prior to the time a signal is applied to the recorder input conductors 24 and 26.

Each time the selector switch 86 of the switch circuit 22 is operated, the time delay circuit is reset. More specifically, when a positive potential is applied to the conductor 60 by movement of the switch wiper 86a, a transistor 142 is rendered conductive to allow the capacitor 128 quickly to discharge through a small value resistor 144. Consequently, deenergization of relay 138 conditions the timer 46, the signal generator 44 and the interrupter switch 48 for reoperation.

TIMER

The timer circuit 46 illustrated schematically in Fig. 4 is energized in response to operation of the timer delay circuit 36 and serves to discontinue the operation of the signal generator 44 and the interrupter switch 48 after a predetermined time interval. The duration of the time interval is determined in accordance with the patient signal line selected by the switching circuit in such a manner that the duration of the signal serves to identify the corresponding patient.

As illustrated in Fig. 4, the timer circuit 46 reaches a known prior to operation of the relay 138 by the time delay circuit 36. In this condition, a transistor 146 is maintained in a nonconductive condition due to connection of its base electrode to ground through a resistor 148. Thus the conductors 56 and 58 are maintained at a relatively positive potential by virtue of connection to a source of positive potential through a resistor 150. In addition, a capacitor 152 carries a charge of a predetermined potential on one side of the capacitor is connected to a source of positive potential through a resistor 154 and the other side of the capacitor is connected to ground through a blocking diode 156 and the resistor 148.

When the relay 138 is operated by the time delay circuit 36, the normally open sets of relay contacts 138a and 138b are closed. Closure of contacts 138a grounds the relatively positive ground potential thereby to disconnect the base of transistor 146 through resistors 135 and 136. Closure of the contacts 138b interconnects the conductors 50, 52 and 54 through resistors 158, 160, and 162 to the capacitor 152. Because a positive voltage is available at one of the conductors 50, 52 and 54, the capacitor 152 begins to discharge and then to charge in reverse polarity until the voltage of the base electrode of the transistor 146 reaches a predetermined value level at which the transistor 146 becomes conductive. When the transistor 146 becomes conductive, the voltage on the conductors 56 and 58 drops to a potential approximating ground potential thereby to discontinue operation of the signal generator 44 and the interrupter switch 48.

Operation of the switching circuit 22 serves to apply a positive potential to a predetermined one of the conductors 50, 52 or 54 depending upon which of the patient signal detecting units 14, 16 or 18 is selected. The period of time between operation of the relay 138 and the time at which the transistor 146 becomes conductive depends upon the RC time constant of the circuit including the capacitor 152 and the respective resistances 158, 160 or 162. In accordance with the invention, the resistances have different values chosen so that the period of time during which the signal generator 44 operates differs for each patient unit. In this manner, the duration of the signal from the signal generator 44 received by the recording device 12 provides an indication of the corresponding patient whose signal is recorded.

SIGNAL GENERATOR

The signal generator 44 (Fig. 5) functions to provide a code or marking signal to be applied to the recording device 12 for purposes of identification immediately prior to the selected cardiac signal. Furthermore, the coding is accomplished by operating the signal generator for a predetermined time interval established by the timer circuit 46.

The signal generator 44 comprises a low frequency phase shift oscillator including a network of resistors 164, 166 and 168 and capacitors 170, 172 and 174 connected between the collector and base electrodes of an oscillator transistor 176 in a manner familiar to those skilled in the art. When the relay 138 is operated by the time delay circuit 36, the normally open set of relay contacts 138c close to supply a positive operating signal to the oscillator through resistors 178 and
180. At this time the oscillator begins to operate and an oscillating output signal is applied to the conductor 59 through a resistor 182 and a voltage dropping circuit including voltage dividing resistors 184 and 186 in parallel with the negative terminal of the battery. An oscillating output signal is also applied to the conductors 188 and 190. The frequency of operation of the signal generator 44 is preferably quite low so that the individual oscillation excursions applied to the recording device 12 are visible when transcribed on the recording medium. The signal generator is operated by the timer circuit 46 for a period of time equal to a predetermined discrete number of waveforms and so adjusted that the number of excursions and the number of times the signal generator must be energized is in a one-to-one correspondence is established between the number of excursions and the numerical designation of the patient. In the event that the oscillator signal unit is not in operation, the relay 138 of the time delay circuit 36 is opened, and contacts 138a. and 138b are closed. Furthermore, the timer circuit 46 is in a conductive condition so that a relatively negative potential applied to the conductor 188 maintains the interr varser switch transistors in a nonconductive condition. In the initial condition, the signal generator 44 is not in operation. More specifically, since the timer circuit 46 is in a conductive condition, a relatively negative potential is applied to the conductor 59 and maintains the interr varser switch transistors in a nonconductive condition. In order, for example, to record the cardiac signal of the patient designated as patient 1, the selector switch 86 is moved to a position one step from its illustrated position. This operation causes the time delay circuit 36 and the code or marking system 20 to reset. More specifically, operation of the selector switch 86 causes the thyristor contacts 86a and 86b to move momentarily between these contacts and a positive voltage is coupled through resistor 127 and conductor 60 to the timer circuit 46. The relay 138 is in a conductive condition and maintains the voltage of the oscillator transistors 176. More specifically, the relay 138 becomes conductive after a predetermined time sufficient to permit the recorder motor 42 to reach full speed.

INTERRUPTER SWITCH

The interrupter switch (FIG. 6) serves to interrupt the connection between the signal path conductors 28 and 30 and the recording input conductors 24 and 26 during the interval of time following operation of the switching circuit 22 and until the timer circuit 46 completes its operation. As noted above, a positive potential is applied to the conductor 58 by the timer circuit 46 until the timer circuit 46 of the timer circuit becomes conductive. As can be seen in FIG. 6, this positive potential is applied to the base electrodes of a pair of transistors 194 and 196 through resistors 198 and 200, thus grounding the signal path conductors 28 and 30 through resistances 202 and 204. During this period of time that the signal generator 44 is in operation, the output signal from the signal generator is applied to conductor 59 through a diode 206 to the recorder input lead 24. As a result, the code or marking signal produced by the signal generator is forwarded to the recording device 12 and is recorded on the recording medium. When the timer circuit 46 is conducted, a relatively negative ground potential is coupled through conductor 58 and resistors 198 and 200 to the end that transistors 194 and 196 are rendered nonconductive thereby to isolate conductors 28, 30, 24 and 36 from ground. At this time, the cardiac signal from the selected patient signal detecting unit is forwarded to the recording device through resistors 208 and 210 and is recorded immediately following the code or marking signal.

REVIEW OF OPERATION

The operation of the cardiac monitoring unit 10 of the present invention will be readily understood by those skilled in the art in view of the preceding description. In order to review one complete cycle of operation, it is assumed that the patient detecting input 16 is initially connected to the recording device 12 through the switching circuit 22 and the interrupter switch 48, and a recording is being made of the cardiac signal of the patient designated as patient 2. In this condition, switching circuit 22 is effective to interconnect the conductors 36 and 38 with the signal path conductors 28 and 30. More specifically, the selector switch 86 is moved two steps from its illustrated position, and switch wiper 86c operates relay operating circuit 82 in order to energize relay 76. In addition, the interrupter switch circuit 48 is not in operation, and the signal path conductors 28 and 30 are coupled to the input conductors 24 and 26 of the recorder 12. This condition results from the fact that the preset patient signal leads 36 and 38 and the timer circuit 46 are conditioned to maintain the interrupter switch in a deenergized state. More specifically, the relay 138 of the time delay circuit 36 is energized, and contacts 138a. and 138b are closed. Furthermore, the timer circuit 46 of the timer circuit 46 is in a conductive condition so that a relatively negative potential applied to the conductor 59 maintains the interrupter switch transistors in a nonconductive condition. In the initial condition, the signal generator 44 is not in operation. More specifically, the timer circuit 46 is in a conductive condition, a relatively negative potential is applied to the conductor 59 and maintains the interrupter switch transistors in a nonconductive condition. In order, for example, to record the cardiac signal of the patient designated as patient 1, the selector switch 86 is moved to a position one step from its illustrated position. This operation causes the time delay circuit 36 and the code or marking system 20 to reset. More specifically, operation of the selector switch 86 causes the thyristor contacts 86a and 86b to move momentarily between these contacts and a positive voltage is coupled through resistor 127 and conductor 60 to the timer circuit 46. The relay 138 is in a conductive condition and maintains the voltage of the oscillator transistors 176. More specifically, the relay 138 becomes conductive after a predetermined time sufficient to permit the recorder motor 42 to reach full speed.
At this time, the relay 138 is energized to initiate operation of the signal generator 44. Contacts 138c close to energize the oscillator transistor 176, and the oscillator output signal is coupled to the recorder input lead 24 through resistor 184, conductor 59 and diode 206. This output signal, comprising a code or marking signal, is transmitted by the recorder 12.

The timer circuit 46 controls the duration of the code or marking signal. When relay contacts 138a and 138b are closed, timer capacitor 152 begins to discharge and then charge in opposite polarity due to current flowing from the switching circuit 25 by way of conductor 52 and timing resistor 158. After a predetermined period of time, the transistor 146 is rendered conductive in order to discontinue operation of both the signal generator circuit 44 and the interrupter switch circuit 48. The value of resistor 158 is chosen so that the time interval of operation of the timer circuit is equal to one period of oscillation of the oscillator. As a result, one low frequency oscillation peak is recorded on the record medium to identify the selected patient, designated as patient 1.

More specifically, when the transistor 146 is rendered conductive, the transistor 192 of the signal generator 44 is rendered conductive to shunt the oscillator transistor by virtue of a relatively negative voltage applied to the conductor 56. As a result, oscillations cease.

The code or marking signal is followed immediately by the cardiac signal of the selected patient. When the transistor 146 of the timer circuit 46 is rendered conductive, a relatively negative voltage coupled through the conductor 58 and resistors 198 and 200 renders nonconductive the interrupter switch transistors 194 and 196. Thus the cardiac signal is coupled from the signal path conductors 28 and 30 to the input conductors 24 and 26 of the recording device.

The recording produced by the cardiac monitoring unit 10 is therefore characterized by a first segment comprising a transcription of the code or marking signal, and an immediately subsequent transcription of the cardiac signal of the selected patient. The unit 10 continues to record the selected cardiac signal until such time as the selector switch 86 of the switching circuit 22 is again operated.

In automatic operation, the sequence of steps is similar to manual operation, except as concerns reset of the time delay circuit and thus of the marking system 20. In automatic operation it is not necessary for the reset operation to be effected rapidly since the transition between selected inputs is not likely to occur as quickly as with manual operation. Accordingly, when a cardiac recording is discontinued in automatic operation due to termination of an alarm condition, the corresponding relay 74, 76 or 78 is deenergized. The capacitor 128 of the time delay circuit 36 discharges through the resistors 132 and 134, rather than rapidly through the low value resistor 144 and transistor 142. When the capacitor 128 has discharged, the remainder of the reset operation is carried out in the manner described above.

Although the invention has been described with reference to details of the illustrated embodiment, many other modifications may be devised by those skilled in the art which fall within the scope of the present invention. The details of the illustrated embodiment should not be taken to limit the scope of the invention which is defined in the following claims.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. Cardiac monitoring apparatus comprising in combination a switching circuit having an output and having a plurality of inputs each adapted to receive a cardiac signal, selector means coupled to said switching circuit for operating said switching circuit to interconnect said output and a selected input, a recording device having an input, a timer, first connecting means operably connected between said switching circuit and said timer and operable in response to operation of said switching circuit to operate said timer to establish a time interval having a duration dependent on the selected input, a signal generator, second connecting means operably connected between said switching circuit and said signal generator and operable simultaneously with said first connecting means in response to operation of said switching circuit to operate said signal generator to produce a marking signal during said time interval, said signal generator having an output connected to said recording device, and means coupled between said switching circuit output and said recording device input for disconnecting said switching circuit output from said recording device input during said time interval and for thereafter connecting said switching circuit output and said recording device input.

2. The cardiac monitoring apparatus of claim 1, said signal generator comprising a low frequency oscillator, said time interval being chosen to provide a discrete number of pulses corresponding to the selected input.

3. The cardiac monitoring apparatus of claim 1, further comprising a drive motor for said recording device, means for energizing said motor upon operation of said switching circuit, and a time delay circuit for operating said timer a predetermined time after operation of said switching circuit.