

June 23, 1964

R. L. CHAPMAN ETAL

3,138,151

DETECTOR AND ALARM VENTRICULAR IMPULSES

Filed June 11, 1962

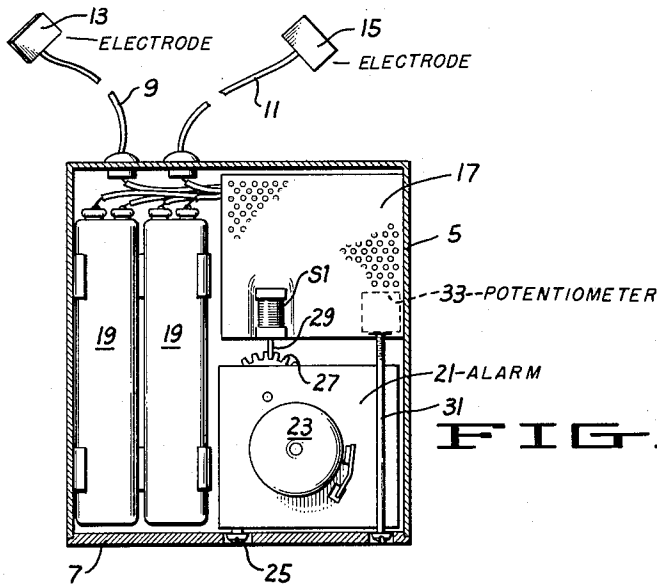


FIG. 1.



NORMAL HEARTBEAT

FIG. 3.



TACHYCARDIA HEARTBEAT

FIG. 4.

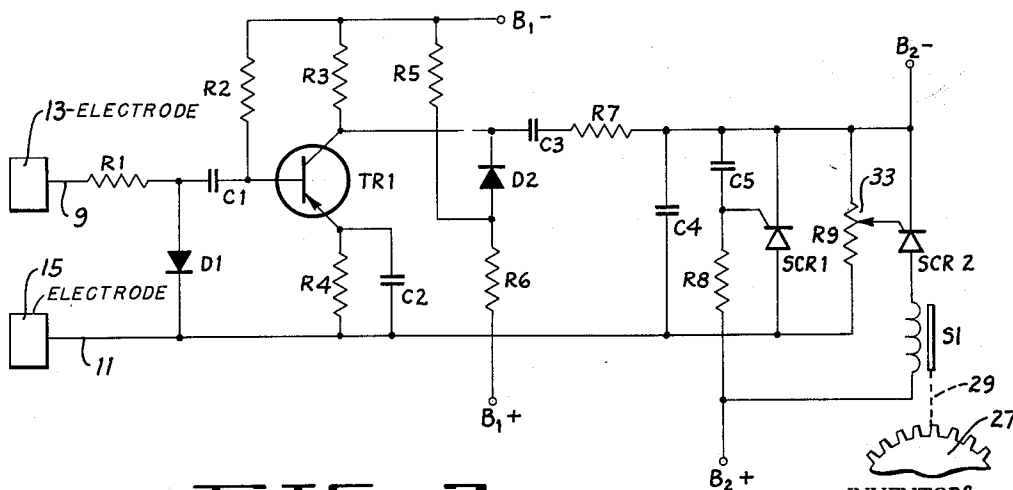


FIG. 2.

INVENTORS
ROBERT L. CHAPMAN
JOHN W. GOFMAN
BY
Eckhoff & Slick
ATTORNEYS

1

3,138,151

DETECTOR AND ALARM VENTRICULAR IMPULSES

Robert L. Chapman, 1279 Boulevard Way, Walnut Creek, Calif., and John W. Gofman, 1045 Clayton, San Francisco, Calif.

Filed June 11, 1962, Ser. No. 201,674

2 Claims. (Cl. 128—2.05)

In health, the heart depends, for continuing function, upon initiation of a regular sequence of electrical impulses followed by regular cardiac contractions. Under the altered conditions caused by closure or disease of the coronary arteries, the regular electrical sequences of impulses may become grossly disturbed, and indeed replaced by a rapid, irregular set of impulses originating in the ventricle of the heart. These rapid, irregular impulses, known as ventricular fibrillation, cause the cardiac muscle essentially to quiver, without opportunity for proper filling, and hence without opportunity to deliver blood out to all the organs. Death can follow this abnormal situation within a matter of minutes, unless the irregularity can be stopped, and a normal heart rhythm can be re-established. It appears quite definite that often such hearts are not irreversibly injured, for if a regular heart beat can be re-established, even apparently dead individuals can be brought back to normal life for years. The reason why such individuals are usually not saved is that the onset of ventricular fibrillation is not appreciated until it is too late. In those instances where ventricular fibrillation happens to occur while a person is under medical supervision, defibrillation by electrical means has been successful, and the person has been brought back to normal.

The prospects for preventing ventricular fibrillation are good, if it be recognized that often such abnormal heart rhythm is preceded by manifestations of what might properly be called cardiac irritability. Thus, well before many cases of fibrillation, there may exist frequent individual impulses, or runs of impulses due to irritable foci in the ventricle. Further sometimes a regular, fast rhythm originating in such foci occurs and is known as ventricular tachycardia. Any of these, frequency individual ventricular impulses, runs of impulses, or ventricular tachycardia, can be forerunner of the lethal ventricular fibrillation. Thus, if a physician could be forewarned by these events that ventricular fibrillation may be near, appropriate measures can be taken in time to save many lives.

The impulses arising in the ventricles (individual ones, runs of impulses, or ventricular tachycardia) give rise to electrical potentials that are different from the usual electrical potentials making up the electrocardiogram. The magnitude of the potential and its sign are such that they can be distinguished from the normal potentials.

According to the present invention a device is provided to perceive these ventricular impulses and to provide an alarm when they reach a particular frequency (regular or irregular), so that the user is forewarned of an abnormal rhythm and either can take medication on a prearranged basis or can immediately seek medical supervision to intercept possible ventricular fibrillation.

The frequency of abnormal ventricular impulses that require warning varies from person to person. Not every single abnormal impulse means ominous events to follow. However, repeated events usually do. Some individuals almost never show such impulses. In such patients the occurrence of more than some predetermined number of irregular beats even over intervals like 5 to 10 minutes may require attention.

The device of the present invention can be adjusted to the needs of each patient. If, by test, it turns out that

2

30 beats of this type within 30 minutes in a particular person are not worrisome, the alarm system can be adjusted to require some larger number of abnormal impulses before firing. It is to be expected that individualization of the alarm level will be indicated and the present invention is well adapted to this end.

There is a further use for the device in the event that ventricular fibrillation starts immediately without the prior warnings discussed above. An individual who suffers this event will of course immediately have his alarm fired off and it would be immediately apparent what had occurred. The problem now is that the person may appear to have fainted or have fallen and by the time it is recognized as to what has happened, it is too late for treatment.

In the drawings forming a part of this application:

FIGURE 1 is a side view of a device embodying the present invention with one wall of the case removed to show certain of the inner parts.

FIGURE 2 is a schematic diagram of a suitable circuit for carrying out the present invention.

FIGURE 3 is an electrocardiogram of a normal heart-beat.

FIGURE 4 is an electrocardiogram showing the condition of the tachycardia rate.

Referring now to the drawings by reference characters there is shown in FIGURE 1 a device embodying the present invention having a housing 5 with a removable bottom cover 7 and two wires extending from the casing designated 9 and 11 leading to the electrodes 13 and 15. The case 5 contains a transistor amplifier and integrating device 17 with batteries 19 for actuating the same. The case also contains a mechanical alarm device 21 having an audible alarm 23, a winding shaft 25 and a ratchet wheel 27, the alarm normally being held in an inoperative condition by the detent 29 which fits into the ratchet wheel 27. The case also contains a shaft 31 extending to potentiometer 33 within the transistor circuit 17 for adjusting the sensitivity of the device as is hereinafter described in detail.

FIGURE 2 is a schematic diagram of a suitable electronic circuit. The important sections of the circuit shown are: (1) A negative pulse selector; (2) A transistor amplifier; (3) A clipper; (4) An integrator; (5) A timer; (6) A solid state switch; (7) A solenoid and (8) A mechanical alarm.

The features of the circuit are:

(1) Only negative signals are amplified, thus interference by the regular PQRST wave is eliminated, and the negative portion of the tachycardia pulses is amplified.

(2) The output voltage of the amplifier is the same regardless of the strength of the input signals.

(3) The timing circuit resets the system at frequent regular intervals (e.g., 1 minute), thus a warning can be sounded quickly.

(4) The number of tachycardia beats required to actuate the alarm within any given time interval is adjustable to suit the requirements of individual patients.

(5) The alarm may be mechanically driven, as by a spring, thus preventing high current drains on the power supply, thus permitting a smaller power supply.

The device operates in the following manner:

The resistance of R1 is made to be large (a few hundred thousand ohms). When positive signals are received from electrode 13 the diode D1 conducts with a forward resistance of the order of 0.1 ohm. Thus R1 and D1 form a voltage divider, and the voltage passed by the D.C. blocking condenser C1 to the base of the transistor TR1 is so small that no significant action is induced in TR1. When a negative signal is received, D1 does not conduct and C1 passes the full signal to the base of the transistor which is biased by resistor R2 from the nega-

tive side of the power supply B1. The collector voltage of TR1 is received from B1 via the isolation resistor R3. Emitter bias is controlled by resistor R4, while the frequency response of the amplifier is controlled by C2, whose value is such that the amplifier will pass signals of a few cycles per second without significant attenuation. The output of the amplifier is clipped by the circuit comprised by the diode D2 and the resistors R5 and R6. R5 and R6 form a voltage divider which supplies bias voltage to the clipping diode D2. The value of R5 and R6 is adjusted so that D2 will be biased to limit the voltage of all signals to that of the smallest signal that will be received. The clipped negative pulses are then transmitted via the D.C. blocking condenser C3 to the integrator circuit formed by R7 and C4. The time constant of R7 and C4 is made small (of the order of 1 millisecond) by a small value of R7 so that fast, rapidly recurring pulses will charge C4, but C4 must be relatively large in value so that the discharge time constant of C4 and R9 (which may also have a large value) will be long compared to the cycle time of the timing circuit. Thus each tachycardia beat adds an equal increment of charge voltage to C4, and the voltage on C4 truly represents the number of tachycardia beats that have been received. The timing circuit is comprised of the condenser C5, the resistor R8, and the silicon controlled rectifier SCR1 which acts as a switch. C5 charges from the power supply B2 via R8. The values of C5 and R8 are adjusted so that the voltage which builds up on C5 will be sufficient to trigger the switch SCR1 at the end of the desired cycle time period. When SCR1 is triggered it conducts and shorts out the charge on C4, thus whatever charge which has built up on C4 during the cycle time period will be discharged and the circuit will recycle. R9 is an adjustable voltage divider which controls the voltage applied to the trigger of the silicon controlled rectifier SCR1. R9 is set so that the voltage on C4 from a preselected number of tachycardia beats (which occur within the cycle time period) will trigger SCR2. When SCR2 conducts, current from the power supply B2 is passed through the solenoid S1 whose movable armature mechanically withdraws the pin 29 which actuates the alarm mechanism. The alarm mechanism is preferably small, for example, the type used in alarm wrist watches is suitable.

It is recognized that variations on the device and its application are possible. For example:

(1) The transistor amplifier could be replaced by a step up transformer, or magnetic amplifier.

(2) A multivibrator, or other, pulse generating circuit could be incorporated between the amplifier and the integrator so that the size and shape of the pulses received by C4 would be completely independent of the input pulses.

(3) The time delay relay type circuitry could be used instead of the timing and alarm circuit shown.

(4) The device could be designed for permanent type installation in hospitals (or other such places) so that a number of patients could be monitored simultaneously from a central station (e.g., a nurse's station). A recording device, of the continuous paper tape type, could be connected across C4 to provide a permanent record of tachycardia rates. The resistor R8 could be made variable so that the time cycle period could be varied.

(5) Modifications could be made so that the number of tachycardia beats occurring in each burst of such beats, and the number of bursts per time interval, could be detected.

(6) Instead of transistors, vacuum tubes can be used. We claim:

1. In a heart tachycardia detector:

(a) a pair of electrodes adapted to be applied to the body;

(b) an alarm device adapted to be set off when a ventricular tachycardia series of predetermined duration is received by the said electrodes;

(c) and electrical circuitry connecting the said electrodes and the said alarm device, said circuitry comprising in combination, a selector for permitting passage to the rest of the circuitry of only the negative portion of the tachycardia pulses, an amplifier for amplifying the said negative portions of the tachycardia pulses, a clipper connected to the said amplifier for limiting the output voltage of the said amplifier to a predetermined maximum, an integrator connected to the clipper for receiving the clipped negative pulses from the said clipper and a timer connected with the said integrator for discharging the said integrator whereby to reset the integrator periodically.

2. The device of claim 1 wherein means are provided for varying the number of negative tachycardia pulses required to fire said circuitry to set off said alarm device.

References Cited in the file of this patent

UNITED STATES PATENTS

2,492,617	Boland	Dec. 27, 1949
2,699,465	Hamilton	Jan. 11, 1955
2,801,629	Edmark	Aug. 6, 1957
2,815,748	Boucke	Dec. 10, 1957
2,821,188	Pigeon	Jan. 28, 1958
2,829,637	McCormick	Apr. 8, 1958
2,854,968	Wright	Oct. 7, 1958
3,002,185	Bases	Sept. 26, 1961
3,048,166	Rodbard	Aug. 7, 1962

OTHER REFERENCES

Sarbacher: Encyclopedic Dictionary of Electronics pub. 1959 by Prentice-Hall, pp. 259, 260, 639, 993, 1301.