United States Patent

[11] 3,599,627

[72] Inventor John Eugene Millen
1521 Pacific Ave., Natrona Heights, Pa. 15065

[21] Appl. No. 790,052
[22] Filed Jan. 9, 1969
[45] Patented Aug. 17, 1971

[54] **METHOD AND INSTRUMENT FOR DETERMINING THE PULSE RATE OF A PERSON WITH AN IMPLANTED HEART PACER**
2 Claims, 4 Drawing Figs.

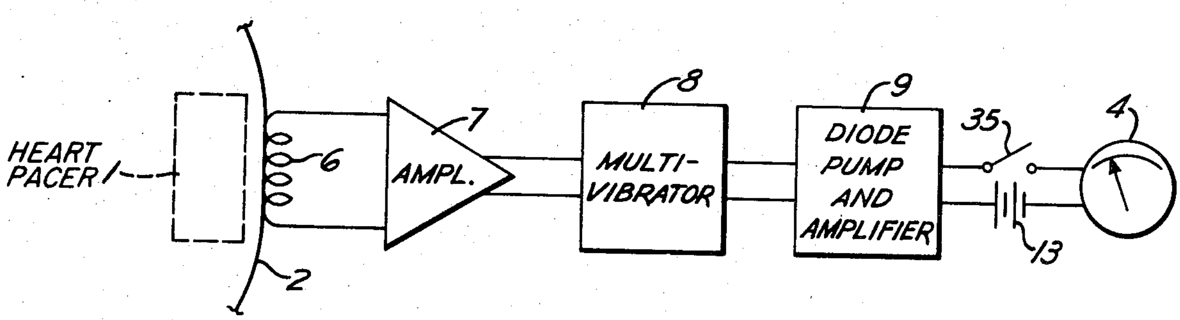
[52] **U.S. Cl.** .... **128/2.05 R,** 128/2.05 T, 128/419 P
[51] **Int. Cl.** **A61b 5/02**
[50] **Field of Search** .... 128/2.05 M, 2.05 P, 2.05 T, 2.06 A, 2.06 F, 2.06 R, 419 P

[56] **References Cited**
UNITED STATES PATENTS

2,492,617	12/1949	Boland et al.	128/2.06 F
2,801,629	8/1957	Edmark, Jr.	128/2.05 T
3,174,478	3/1965	Kahn	128/2.06 F
3,202,149	8/1965	Emmons	128/2.05
3,426,748	2/1969	Bowers	128/2.06

Primary Examiner—William E. Kamm
Attorney—Brown, Critchlow, Flick and Pekham

ABSTRACT: An electrical inductance coil is held against the chest of a person close to an implanted heart pacer to induce in the coil electrical pulses which are amplified to a common level and converted into an electric current. The current is used to operate a meter that indicates the number of pulses per minute produced by the pacer and, hence, the pulse rate.



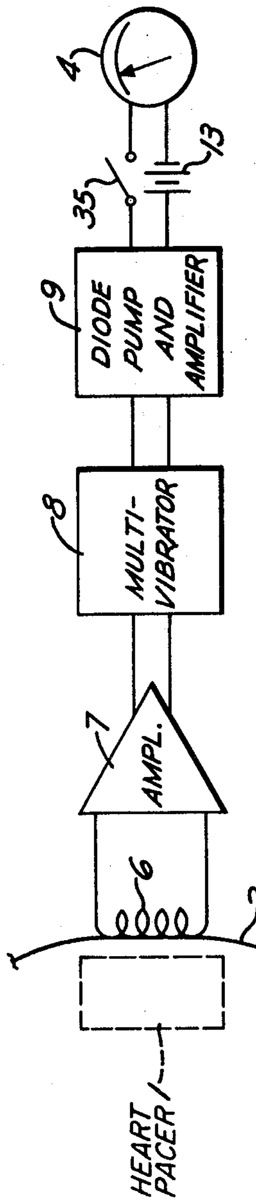


Fig. 2

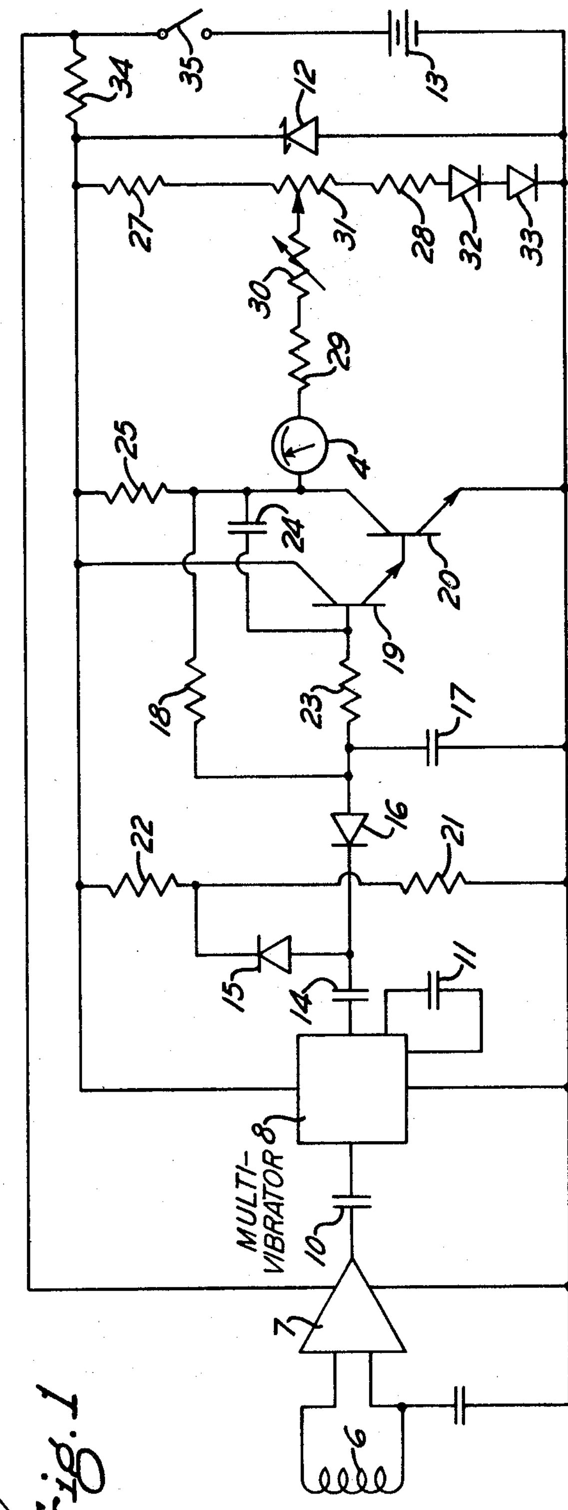


Fig. 3

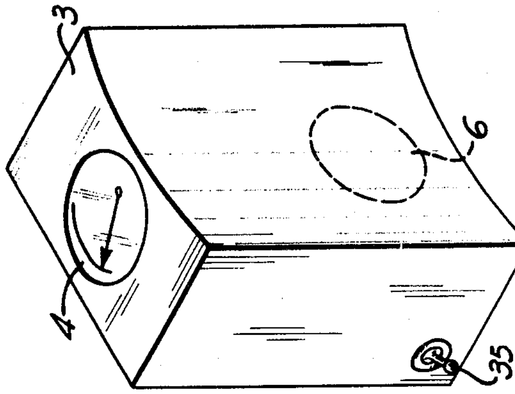


Fig. 1

INVENTOR.

JOHN EUGENE MILLEN

BY

Brown, Critchlow, Flick & Peckham

ATTORNEYS.

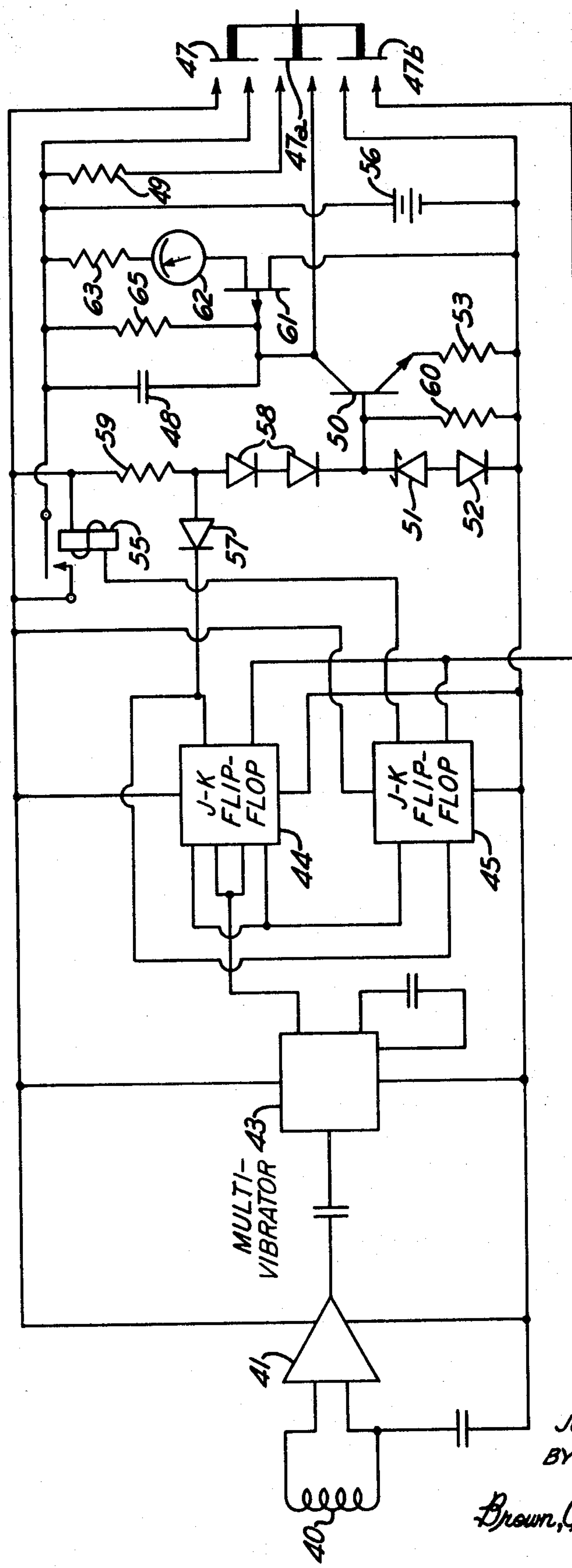


Fig. 4

INVENTOR.
JOHN EUGENE MILLEN
BY
Brown, Critchlow, Flick & Peckham
ATTORNEYS.

METHOD AND INSTRUMENT FOR DETERMINING THE PULSE RATE OF A PERSON WITH AN IMPLANTED HEART PACER

A great many people of all ages, although primarily in the older age group, have weak or defective hearts, the action of which is improved by electronic pacers implanted in the chest area. Such pacers include an electric switch that opens and closes at the same rate that it is desired that the patient's heart should beat. Every time the switch closes, an electrical impulse is sent to the heart to stimulate it to contract. The physician involved in each case is interested in possible fluctuations in the patient's pulse rate, so a daily check of the rate is of great importance. In many cases, changes in the rate are due to instability in the functioning of the pacer. The physician therefore may wish to have a report from the patient at regular intervals, such as daily, of his pulse rate, but many patients find it difficult or even impossible to count their heart beats by taking their own pulse. This is especially true of older people.

It is an object of this invention to provide an electrical instrument, unconnected to the patient's body and his implanted heart pacer, by which he can quickly and accurately determine his pulse rate by visual means. Other objects are to provide such an instrument which is small, relatively simple in construction and easy for anyone to operate.

The invention is illustrated in the accompanying drawings, in which

FIG. 1 is a perspective view of the instrument;

FIG. 2 is a diagrammatic view of the instrument in operative position;

FIG. 3 is a circuit diagram of the instrument; and

FIG. 4 is a circuit diagram of a modification.

Referring to FIG. 2 of the drawings, a conventional electronic heart pacer **1** is indicated in dotted lines implanted in the chest area of a patient just under the skin **2**. As is well known, such a pacer incorporates an electric switching circuit that generates a small electromagnetic field every time the pacer switch closes. At the same time, the pacer sends electrical impulses to the heart, to which it is wired. The instrument disclosed herein is designed to respond to the electromagnetic field of the pacer in such a manner as to produce an electric current that will operate a meter which will indicate the number of pulses per minute.

As shown in FIG. 1, the instrument may take the form of a small box **3** that can be held in the hand and that contains the necessary electrical elements and the meter **4**. The electric circuit includes a signal coil, e.g. an electrical inductance coil **6**, that is mounted in the back of the box so that it can be placed close to the pacer when the box is held against the chest. The electromagnetic field generated by the pacer every time it sends an electrical impulse to the heart will induce in this coil electrical voltage pulses at the same frequency as the impulses sent to the heart. The coil, as shown in FIG. 2, is connected to an amplifier **7** that amplifies the voltage from the coil and sends it to an integrated circuit monostable multivibrator **8**, which amplifies the pulses to a common level and gives them all the same duration. These uniform pulses leave the multivibrator at the same rate as they are received and are conducted to a diode pump and amplifier **9**. The pump and amplifier convert the pulses received thereby into a steady current that is fed to a meter calibrated to show the number of electrical pulses that are required in order to produce any given current for the meter. If, for example, the pacer is sending **70** electrical impulses per minute to the heart, my instrument will pick up those pulses and convert them into a current that is strong enough to move the needle of the meter along its scale to a point where it will indicate that the heart should be beating 70 times per minute.

The electrical circuit of the instrument is shown in more detail in FIG. 3. Small electrical pulses induced in the inductance coil **6** by the switching circuit of the pacer are amplified in preamplifier **7** and then fed through a coupling capacitor **10** to the one shot multivibrator **8**, which produces a standard output pulse. That is, regardless of variations in amplitude of the pulses entering the multivibrator, those leaving it all have the same amplitude and are of the same duration. The only thing that changes is the rate, and that varies with the input rate. Condenser **11** is a timing capacitor for the multivibrator. The output amplitude of the multivibrator is determined by the voltage from a zener diode shunt regulator **12** that is supplied with current from a battery **13** having output power terminals. Each output pulse of the multivibrator charges and then discharges a condenser **14** of the diode pump through a charging diode **15** and a discharging diode **16** and thereby transfers a standard charge to another condenser **17**, the upper terminal of which is maintained at a nearly constant voltage by the feedback action via a resistor **18** of the output amplifier formed by transistors **19** and **20** in the metering circuit. Resistors **21** and **22** provide proper bias for the pump diodes **15** and **16**. Resistor **23** and condenser **24** are part of the feedback network for smoothing the output wave form. Resistor **25** is an output load resistance. If the pulse rate increases, the charge delivered to condenser **17** will increase proportionately and the voltage in the amplifier output required to discharge that condenser and hold its terminal voltage constant likewise will increase proportionately.

The voltage at the amplifier output is monitored by the meter **4**, which has a zero-offset determined by two bias resistors **27** and **28** that damp out pulse rates below a predetermined minimum, and a range determined by the parallel resistance of those two resistors. The meter may be calibrated to give, for example, a low reading of 50 pulses per minute and a high reading of 100 pulses per minute on a linear scale. Thus, resistors **29** and **30** adjust the upper end of the meter scale to 100 pulses per minute while a resistor **31** in series with resistors **27** and **28** adjusts the lower end of the scale to 50 pulses per minute. Diodes **32** and **33** in series with resistor **28** are temperature compensating diodes for the transistor amplifier. The zener diode **12** serves as a shunt voltage regulator to provide constant voltage from battery **13** to the metering circuit during operation, since the metering circuit's calibration stability depends upon its supply voltage stability. Dropping resistor **34** is for the shunt regulator. Rates other than 50 and 100 pulses per minute can be accommodated in this instrument by suitable modification of timing and scaling components. The instrument is turned on and off by a switch **35**.

It will be seen that all a patient has to do in order to take his pulse is to hold this instrument against his chest with the signal coil close to his implanted pacer, close switch **35** while he reads the meter, and then turn off the switch. The meter will point to the number of electrical pulses that the coil must pick up per minute in order to create the current that swings the meter needle to the position on the scale at which it is observed. That number will be the same as the pulse rate of the patient, assuming that the pacer is connected to the heart properly.

The embodiment of the invention illustrated in FIG. 4 operates in the same general way as the one first described herein but, instead of converting a series of electrical voltage pulses into a steady current that operates a meter, the time interval between only two successive electrical pulses determines the current that operates the meter. Voltage pulses induced in a signal coil **40** by the electromagnetic field pulses created by the switching of an adjacent heart pacer will be amplified in an amplifier **41** as before. From the amplifier the pulses will be conducted to an integrated circuit monostable multivibrator **43** which is electrically connected with J-K flip-flops **44** and **45**. The multivibrator amplifies the pulses to a common level to create a standard pulse. When the circuit is first energized by momentary closing of a pushbutton switch **47**, flip-flop **44** is set to the zero state and the other flip-flop to the 1-state by a switch **47*a*** closed with switch **47**, and an integrating condenser **48** is completely discharged by the simultaneous closing of a switch **47*b***. A resistor **49** connected with switch **47*a*** is a capacitor discharge current limiting resistor.

The first standard pulse from the multivibrator flips flip-flop 44 from the O-state to the 1-state, thereby unclamping the base of a current source transistor 50 and permitting it to charge condenser 48 at a constant rate of current determined by the diode drop of two base bias diodes 51 and 52, the base-emitter diode drop of transistor 50, and the emitter resistor 53. The second output pulse from the multivibrator returns flip-flop 44 to the O-state which clamps the base of transistor 50 and cuts off its output charging current to condenser 48. Simultaneously, the second pulse flips flip-flop 45 to the zero state and prevents further pulses from affecting flip-flop 44. Because flip-flop 45 holds a power relay 55 closed when the flip-flop is in the 1-state to which it is set by the starting switch 47, the circuit is deactivated automatically by the second pulse flipping flip-flop 45 to the O-state, is insensitive to further pulses, and no longer loads the battery 56.

Current source turnoff input diode 57 and turnoff bias diodes 58 are connected with the other diodes and with a current source turn-on bias resistor 59. A current source turnoff resistor 60 is connected with the base of transistor 50.

The condenser 48 is charged, by the constant current from transistor 50 between the first and second pulses, to a voltage that is proportional to the interval between those two pulses. Therefore, the voltage to which the condenser is charged is a direct measure of the pulse period and an inverse measure of the pulse frequency. The condenser voltage is monitored by a source follower field effect transistor 61 driving a meter 62 in series with a calibrating resistor 63 selected to give a 50 to 100 pulse per minute scale on the meter, or any other desired scale. This scale is nonlinear and must be calibrated appropriately. Since the indicated pulse rate decreases as the time interval between pulses increases, thereby increasing the current, the movement of the meter needle should be from right to left with increasing current and decreasing pulse rate so as to permit use of a conventional scale with the calibration increasing from left to right. The field effect transistor 61 connected to the meter may have to be selected for a predetermined value of gate threshold voltage.

The meter will continue to show a reading until condenser 48 discharges through a slow discharge resistor 65. The latter is necessary in order to reduce the meter circuit drain on the power source to zero when the instrument is not in use.

The instruments disclosed herein also can be used for determining whether or not all of the electrical impulses from the electronic pacer are getting through to the heart. This determination can be made by taking a patient's pulse manually in the ordinary way while simultaneously using the new instrument to indicate the number of electrical impulses the heart pacer emits per minute. If the instrument meter shows more electrical impulses than there are actual pulse beats, then it will be known that some of those impulses are not reaching the heart, due to a poor electrical connection or for other reasons.

I claim:

1. An instrument for determining the number of times per minute that an implanted heart pacer sends an electric impulse to the heart, comprising a signal coil adapted to be held against the chest close to the pacer to induce in the coil electrical pulses at the same frequency as said electrical impulses, a pair of power terminals adapted for connection to a source of a potential, a voltage divider connected between said power terminals and including at least one temperature compensating diode, an amplifier connected to said power terminals, means connecting said coil to the input of said amplifier, a monostable multivibrator connected to said power terminals, means connecting the output of said amplifier to said monostable multivibrator whereby a pulse at the output of the amplifier will activate said monostable multivibrator to produce a pulse of fixed width and amplitude, a pair of resistors interconnecting said power terminals, a first condenser and a first diode in series connecting the output of said multivibrator to the junction of said series-connected resistors, a series-connected current path including said first condenser and a second diode and a second condenser connecting the output of said multivibrator to one of said power terminals, transistor amplifying means, means connecting the junction of said second diode and said second condenser in said series-connected current path to the input of said amplifying means, and a meter connected between the output of said amplifying means and a point on said voltage divider for indicating the integrated value of said pulses and, hence, the number of times per minute that said implanted heart pacer sends an electrical impulse to the heart.

2. An instrument for determining the number of times per minute that an implanted heart pacer sends an electrical impulse to a heart, comprising a signal coil adapted to be held against the chest close to the pacer to induce in the coil electrical pulses at the same frequency as said electrical impulses, monostable multivibrator means connected to said coil for producing a pulse of constant width and duration each time a pulse is induced in said coil, a pair of flip-flop circuits connected to the output of said multivibrator, switch means for causing one of said flip-flop circuits to assume one of its two stable states while causing the other of the flip-flop circuits to assume the other of its two stable states, a pulse at the output of said multivibrator causing the respective flip-flop circuits to reverse their stable states, a capacitor, means connecting the output of one of said flip-flop circuits to said capacitor to initiate charging of said capacitor upon the occurrence of a pulse at the output of said monostable multivibrator means, means coupled to the output of the other of said flip-flop circuits for terminating charging of said capacitor upon the occurrence of the next succeeding pulse at the output of said monostable multivibrator means, and meter means for indicating the magnitude of the charge on said capacitor which is built up in the time period between two successive pulses at the output of said monostable multivibrator means.