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(54) PULSE RATE INDICATOR

(71) I, PETER GILBERT LALE, a British Subject of, 6, Manland Avenue, Harpenden, Herts., do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to the measurement of pulse rate and provides a pulse rate indicator.

By placing a pick-up transducer at a pressure point—usually but not necessarily on the wrist—pressure impulses from the pulse may be sensed and used to give a digital indication of pulse rate. The invention provides a hand-held unit for allowing pressure pulses to be transduced to electrical pulses for driving an indicator.

According to one aspect of the invention there is provided a hand-held pulse rate indicator comprising an applicator unit housing a transducer responsive to pressure impulses of the pulse to produce electrical pulse signals, the applicator unit having a slab-like nose portion, a flexible transducer pad coupled to or in contact with the transducer, the pad being at and edge of the nose portion, and finger grips provided by opposite faces of the nose portion whereby the pad can be held between a pair of fingers against a pulse point of a patient while allowing the pulse to be felt by at least one of the fingers. This arrangement allows the physician to feel the pulse as the measurement is taken and thereby confirm that the transducer is properly in position. Thus, the physician feels the pulse as is customary but is relieved from the task of counting and timing pulse beats, it being possible to derive an "instantaneous" digital output of pulse rate. Variations in pulse rate are easily detected and measured.

As the two fingers press down on to the artery, pulse pressure is transmitted through the flexible pad to the transducer. The two fingers are able to feel the pulse directly through the skin.

The transducer may comprise bonded wire strain gauges but in a preferred arrangement the transducing element is a piezo-electric device. The mechanical coupling between the pad and the piezo-electric device may be a liquid coupling but in a preferred embodiment is direct, the piezo-electric element or elements being mounted in contact with the flexible pad.

Preferably, the transducer output is connected to drive a pulse rate circuit and there is provided a digital display driven by the circuit to display the pulse rate, the circuit including a display control arrangement which intermittently inhibits the display so that the display is pulsed to give its digital indication intermittently at a frequency corresponding to the repetition frequency of the pulse being measured. This arrangement offers the advantage that the indicated pulse rate will flash in synchronism with the pulse beats and the physician will receive a visual indication of rate apart from the digital read-out. This provides a rough confirmation of the validity of the digital output and also facilitates positioning of the transducer, it being relatively simple to adjust the transducer until the output flashes consistently at an appropriate rate.

Alternatively, with other types of display, the digits may be continuously on view and a synchronous flash be provided by a separate light diode or other device.

In a preferred embodiment of the invention the digital display unit has a blanking input whereby when a signal is applied thereto the display is blanked. Signals are selectively applied to the blanking by means of delay circuit responsive to the pulse inputs, and allow the counter to reset during the blank period.

Power consumption may be decreased by arranging for the display to be on for only a short time after each pulse. Thus, in one arrangement, a monostable multivibrator of 0.1 second is arranged to be triggered at the end of the blanking pulse, this may be arranged to limit the display to 0.1 second, repeated for each pulse.

A zener diode circuit may be used to detect when the battery voltage falls below 4.5V and to cause the right hand decimal point of the display to be illuminated as a warning that battery replacement is required.

Another feature of the invention provides a pulse rate indicator in which there is provided an input circuit of low-current drain which is responsive to input signals from the pulse transducer, the input circuit being effective on receipt of such pulses to switch on the circuit elements with the high current consumption, there being a time-delay unit which switches those parts of the circuit off agains after a withdrawal of the input pulses. In this way no separate switch is required to operate the unit and it cannot be left on inadvertantly. This is a particularly useful feature for a small hand-held battery operated unit.

The invention will further be described with reference to the accompanying drawings, of which:—

Figure 1 is a cross-sectional view of a pulse rate indicator in accordance with the invention;

Figure 2 is a side elevation of part of the indicator of Figure 1;

Figure 3 is an end elevation of part of the indicator of Figures 1 and 2; and

Figure 4 is a circuit diagram of the indicator of Figures 1 to 3.

Referring to Figure 1 the indicator comprises a battery 1, a display driving circuit 2, a digital display 3 and a pulse transducer 4 mounted in the body of an applicator 5 which can be applied, as a hand-held unit, to the wrist of a patient. The body 5 is made of plastics material and its lower part comprises a slab-like nose portion 6 having a rubber cover 7, the lower edge of which constitutes a pad 8 for application to the pulse point.

A pressure transducer 9 comprises four piezo-electric elements 10 attached to a flexible metal strip 11 which runs along the inside of the pad 8. A conductor strip 12 connects the other sides of the elements 10 together. Output from the transducer is taken from the strips 11 and 12 by way of a pair of leads 13. The transducer is urged against the pad by means of a resilient rubber O-ring R which is partially compressed against a fixed part of the body.

Figures 2 and 3 show the way in which the applicator is applied to the wrist to measure pulse rate. The physician takes the nose portion 6 between two fingers and, with the assistance of a shoulder S moulded in the rubber cover 7, presses the pad 8 against the pressure point of the patient. Usually this is the wrist. At the same time, the physician can feel the patient's pulse with the fingers he is using to place the applicator. This allows accurate positioning of the applicator and gives the physician tactile confirmation of the reading he obtains from the instrument.

The use of the O-ring R affords isolation between the transducer 9 and the body of the applicator. Tremors of the fingers applying the applicator therefore do not seriously affect the transducer.

Referring to Figure 4, the electrical signals from the transducer (not shown in Figure 4) are applied to the input of a two-stage low-current amplifier comprising transistors 14 and 15 with the polarity selected so that each pulse produces a negative deflection at the output of transistor 15. This output is applied to the input of a monostable circuit 16 which, in response to each pulse signal generates an output pulse of 0.2 secs. duration. These output pulses are applied to a second monostable circuit 17 which generates a 2.0 m.sec pulse from the leading edge of each of the output pulses from circuit 16. The 2.0 m.sec. pulses from circuit 17 are applied to a differentiating circuit 18 and thence to operate an FET switch 19. The output pulses from switch 19 are applied to one input of a ramp generator 20 which generates a ramp voltage beginning at the end of each output pulse from circuit 17. The gradient of the ramp is 1.5 volts per second. The output from the ramp generator 20 is inverted in an inverting amplifier 21. On receipt of the next pulse signal from the patient a switch 22 is closed for the duration of the 2.0 m.sec. pulse from circuit 17 and a capacitor 23 is charged to the level corresponding to the analogue value to which the output of amplifier 21 had reached. Thus, the analogue voltage stored on capacitor 23 is directly proportional to the time interval between two adjacent pulse input signals (first and second signals.)

The ramp generator circuit 20 and 21 then begins generation of a ramp following the second signal for measurement of the interval between the second and third signals. During this time, the analogue voltage stores on capacitor 23 is converted to a reciprocal digital form representative of pulse repetition rate. This is effected by means of a staircase integrator 24 and Schmidt trigger 33. A clock oscillator 25 operates at 2 kHz and provides anti-phase outputs on lines 26 and 27 which control FET switches 28 and 29 respectively. When switch 28 is closed the stored voltage on capacitor 23 is applied through a buffer amplifier 30 to charge a capacitor 31. When switch 29 is closed capacitor 31 is connected to the input of the staircase integrator amplifier 24. Amplifier 24 has a feedback capacitor 32 and the charge on capacitor 32 decreases in a standard decrement each time switch 29 is operated.

The output of the Schmidt trigger 33 is switched to 0 volts at the moment that the staircase integrator is reset and remains at 0 volts until the integrator falls to a preset value. During the is period the pulses from the clock are counted.

A high initial charge on capacitor 31 requires the charge on capacitor 32 to fall by relatively few steps before Schmidt trigger 33 is retriggered and the count is stopped. On the other hand, if the charge on capacitor 31 is low, then the number of integration steps is high. The clock oscillator frequency and the other parameters of the circuit are chosen so that if the heart-beat rate is 200 pulses per minute then the Schmidt trigger 33 is retriggered after 200 decrements of the charge on capacitor 32, this taking 0.1 sec. On the other hand, at the other end of the range of the instrument, a pulse repetition rate of 25 pulses per minute requires an integration time of 0.0125 sec., giving 25 pulses at 2 kHz. Thus, it will be seen that the number of pulses counted is equal to the pulse repetition rate.

The clock pulses which are allowed to be counted while the "disable" is inoperative (Schmidt trigger 33 output at 0 volts) are counted by a three-digit binary coded decimal counter 34. This supplies a seven-segment decoder driver 35 which drives a seven-segment display 36 to give the appropriate pulse rate indication.

In addition to supplying pulses to the timing circuit, the output from circuit 17 provides reset pulses to the switch 22, to a switch 37 for resetting the integrator 24 at the end of each cycle, and to a reset input 38 to the counter 34.

A feature of the invention is the provision of controlling signals to a blanking input 39 for the decoder 35. These signals are derived from the monostable circuit 16 and their effect is to blank the display for a period of 0.2 sec. following each pulse signal. In this way, a flashing indication of the pulse rate is given, the flashing corresponding in repetition frequency to the pulse rate.

Another feature of the invention is that the input circuit comprising transistors 14 and 15 and monostable circuits 16 and 17 are of low-current drain and a control circuit 40 is effective to provide driving voltage for the high current parts of the circuit (including the ramp generator, staircase integrator and display) only on receipt of input pulses from the transducer 9. Only when a capacitor 41 is charged sufficiently by receipt of input pulses will invertors 42 be switched to give a positive output allowing current to be drawn from the supply. The RC time constant of capacitor 41 and parallel resistor 43 is 5 seconds. This arrangement ensures that when no pulse signals are being received the current drain from the battery is very small. When the transducer is placed over a pulse, signals received are effective to switch on the remainder of the circuit and when measurement is finished, removal of the pulse signals allows the circuit to switch off after the predetermined delay of 5 sec. This ensures that the instrument is not left switched on inadvertently.

Reverting to Figure 4, typical components are:—

Invertors (except Invertor 42): each 1/6 of integrated circuit CD 4049 AE HEX invertor.

FET switches: each ¼ of CD 4066 AE QUAD Bilateral Switch.

Amplifiers: each ¼ RCA CA 324 QUAD Amp.

Invertor 42 is composed of four parallel inverter units for adequate current-carrying capacity.

The invention is not restricted to the details of the foregoing description made with reference to the accompanying drawings. For example, instead of employing an LED display the device may use a liquid crystal display arrangement of any other suitable form of display. Also, instead of being a self-contained battery-driven unit, the indicator may be a remote bed-side instrument and the applicator may comprise only the transducer, with a flexible lead coupling to the indicator.

WHAT I CLAIM IS:—

1. A hand-held pulse rate indicator comprising an applicator unit housing a transducer responsive to pressure impulses of the pulse to produce electrical pulse signals, the applicator unit having a slab-like nose portion, a flexible transducer pad coupled to or in contact with the transducer, the pad being at and edge of the nose portion, and finger grips provided by opposite faces of the nose portion whereby the pad can be held between a pair of fingers against a pulse point of a patient while allowing the pulse to be felt by at least one of the fingers.

2. A hand-held pulse rate indicator as claimed in claim 1 wherein the transducer comprises one or more piezo-electric elements coupled mechanically to the pad.

3. A hand-held pulse rate indicator as claimed in claim 2 wherein for the piezo-electric element or elements, there is provided a mount in contact with the flexible pad and a resilient support to isolate the effect of movements of the body of the applicator unit.

4. A hand-held pulse rate indicator as claimed in claim 3 wherein the resilient support is a rubber O-ring.

5. A hand-held pulse rate indicator as claimed in any of the preceding claims wherein the transducer output is connected to drive a pulse rate circuit and there is provided a digital display driven by the circuit to display the pulse rate, the circuit including a display control arrangement which intermittently inhibits the display so that the display is pulsed to give its digital indication intermittently at a frequency corresponding to the repetition frequency of the pulse being measured.

6. A hand-held pulse rate indicator as

claimed in any of the preceding claims wherein the applicator unit includes a battery-driven pulse rate circuit and a digital display driven by the circuit to display the pulse rate.

7. A hand-held pulse rate indicator as claimed in claim 6 wherein the pulse rate circuit includes a low-current pre-amplifier and pulse detector arrangement effective to energise the remainder of the circuit only when pulses are detected.

8. A hand-held pulse rate indicator substantially as hereinbefore described with reference to the accompanying drawings.

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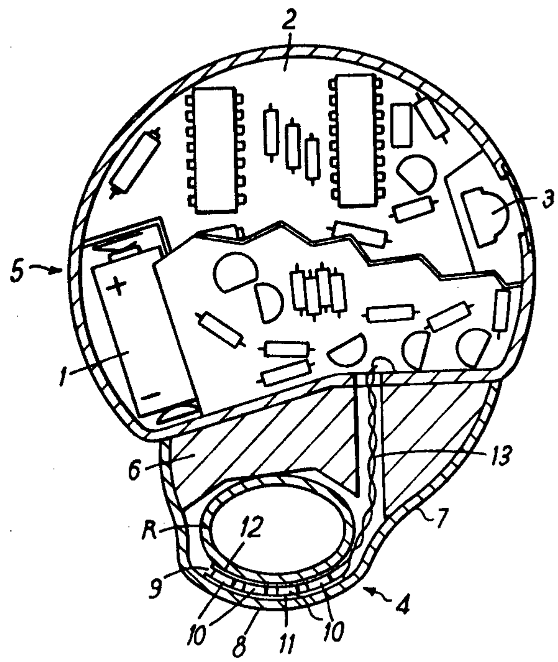
FIG. 1



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG.2

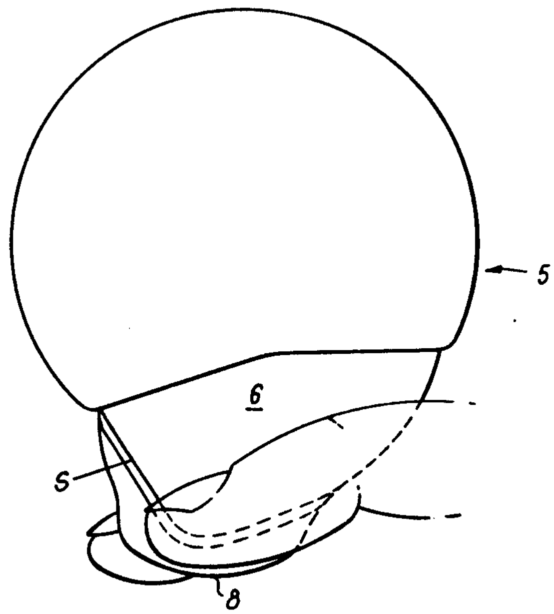
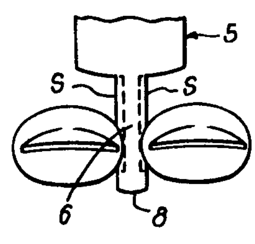


FIG.3



1594205 COMPLETE SPECIFICATION

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Sheet 3

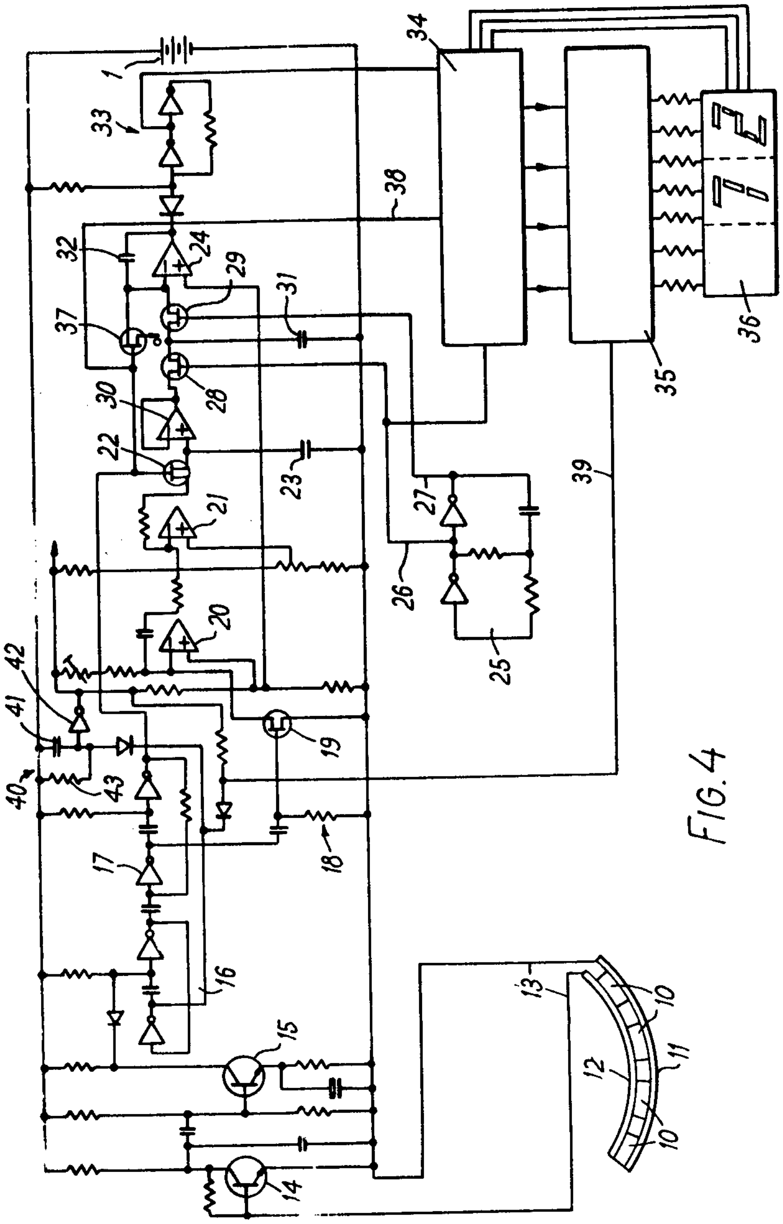

FIG. 4