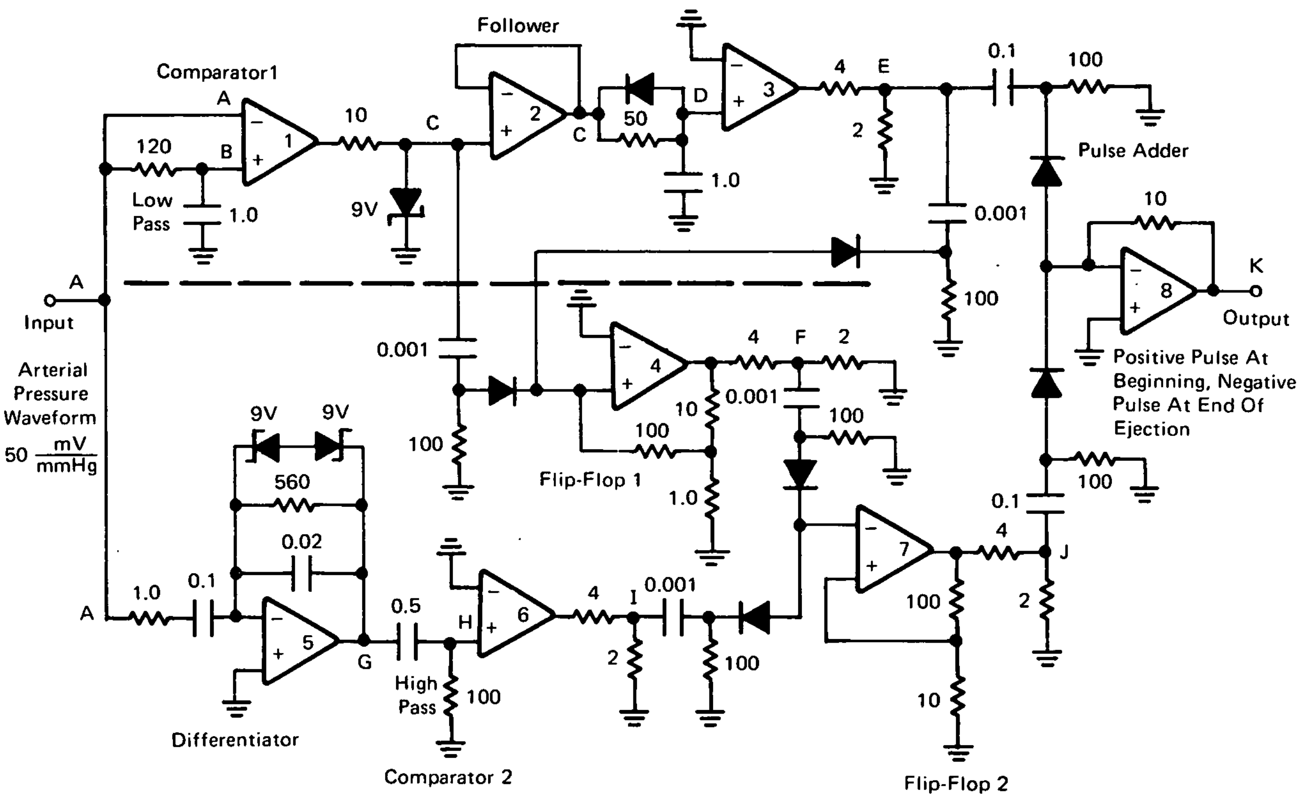
August 1972 B72-10512

NASA TECH BRIEF

Lewis Research Center

Electronic Circuit Detects Left Ventricular Ejection Events in Cardiovascular System



NOTE:
Operational Amplifiers: ±5 mA, ±10V Output; Input Impedance > 1 Megohm; All Resistors Are In Kilohms And All Capacitors Are In Microfarads

PULSE-WIDTH-DISCRIMINATOR

An electronic circuit has been developed which processes the arterial blood pressure waveform to produce discrete signals that coincide with the beginning and end of left ventricular ejection (LVE). The output signals from the circuit provide timing signals for computers that monitor cardiovascular systems. For a typical arterial pressure waveform, LVE begins at the time when the blood pressure rapidly increases due to the heart pumping blood through the aortic valve into the arteries. LVE ends at the waveform dicrotic notch which is a pressure disturbance caused by the aortic valve closure. By detecting these two events, the circuit provides timing signals to the computer.

Openings and closures of the aortic valve are easily identified visually through the use of strip-chart recorders, but difficult to detect electronically, especially when the circuit (or computer) has no memory of past events. To cover a wide variety of situations, the de-

(continued overleaf)

tector must operate for heart rates between 50 and 200 beats per minute and operate reliably for the waveforms that can result from abnormal circulatory dynamics, from irregular heart beats, and from breathing pressures. A detection process based on slope measurements alone is inadequate, since it also detects extraneous oscillations. The approach of using a signal that is initiated when the pressure exceeds its average value has disadvantages of producing late signals and false signals when the pressure wave oscillates through the average value.

The circuit for detecting the beginning and end of LVE is shown in the figure. Signal A is an electrical input signal proportional to the blood pressure in the arteries near the heart. The portion above the dashed line produces a positive pulse at output terminal K when the aortic valve opens at the beginning of LVE. The process below the dashed line produces a negative pulse at K when the valve closes at the end of LVE.

Beginning of LVE is determined by first comparing signal A to signal B. The comparator switches C in a negative direction when A initially increases at the beginning of LVE.

Signal C is quite independent of low frequency components caused by breathing, since the cutoff frequency for signal B is more than two octaves above the breathing frequency. However, C is affected by high frequency components that can result from abnormal circulatory dynamics. Oscillations with frequency content of 6 to 15 Hz can cause A to cross over B and result in C switching during the cardiac cycle. To avoid such problems, C is processed by a pulse-width-discriminator that makes E independent of high frequency switching in signal C.

Signal E switches in the negative direction only once each cardiac cycle at the beginning of LVE. This action produces a positive pulse at output terminal K.

The circuit for detecting the end of LVE is shown below the dashed line. The objective is to produce a negative pulse at terminal K coinciding in time with the positive inflection point that occurs at the leading edge of the dicrotic notch.

Signal H is related to the second derivative of A with respect to time. Signal H changes polarity at the inflection points in the low frequency portion of A. Positive inflection points are signified by signal I switching to a negative voltage. Since waveform A has several inflections, signal I switches several times each cardiac cycle.

The proper inflection point is selected by a logic circuit that uses two flip-flops (operational amplifiers dominated by positive feedback). Flip-flop 1 is switched positive by C and negative by E. This arrangement results in F switching positive only once each cardiac cycle just prior to the dicrotic notch.

When signal F switches to a positive voltage, signal J switches to a negative voltage. The next positive inflection in A switches I to a negative voltage, switches J to a positive voltage, and produces a negative pulse at output terminal K. This output pulse coincides with the end of LVE. Inflections after the dicrotic notch have no effect on J, since J remains latched at a positive voltage until F switches positive in the next cardiac cycle.

The circuit operates reliably for heart rates between 50 and 200 beats per minute and for the variety of waveforms that can result from abnormal circulatory dynamics, from irregular heart beats, and from breathing pressures.

Note:

No further documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B72-10512

Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

Patent Counsel
Mail Stop 500-311
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Source: Vernon D. Gebben and John A. Webb, Jr.
Lewis Research Center
(LEW-11581)