THE HEART SOUND PREPROCESSOR

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Man's concern with the health of his heart is unending, whether he journeys to the Moon or through the daily, ubiquitous traffic on his way home from work. Some improvements and innovations in bio-instrumentation have emanated from recent scientific developments in our space endeavors.

For example, the technology developed for signal and data processing has been applied to improving diagnostic techniques in the area of phonocardiography (PCG), the graphic recording of the sounds of the heart generated by the functioning of the aortic and ventricular valves. The implementation of an automatic PCG signal processing system is enhanced if the signal can be treated in the same manner as other physiological signals. With this in mind, the relatively broad bandwidth of the PCG signal (20 to 2,000 Hz) has been reduced to less than 100 Hz by the use of a heart sound envelope. The circuit transforms positive and negative PCG signals to an all positive signal, the amplitude of which is proportional to intensity. Such transformation results in a visual representation of sounds and their temporal relations similar to the aural impression of the ear. Diagnostic information related to intensity and timing is retained. The transformed signal has been obtained by full-wave rectification of the PCG signal, envelope detection of the rectified wave, and low pass filtering of the resultant envelope. This is graphically illustrated in Figure 1.

Figures 2 and 3 show examples of this process. The top trace in Figure 2 represents the frequency response of the microphone used to obtain the heart sound, and the bottom trace represents the same signal after being channeled through the preprocessor. (The traces in Figure 3 are reversed.) Figure 2 shows a normal heart, and one can see that the pattern is very symmetric and smooth, each peak representing the proper closing of a valve. The second heart pattern (Figure 3) is similar to the first. However, note the split or cusp at the peak of this pattern. This represents a split heart sound and may indicate trouble in valve closure. As one can see, if we

were to rely solely on the audio representation of this heart sound, it would
be very difficult to detect this condition.

The advantages of our approach are (1) the signal eliminates sometimes
false interpretations based on attempts to analyze frequency content of the
phonocardiogram, (2) reduced bandwidth requires less computer core
storage, (3) simpler signal pattern recognition programing techniques can be
employed, and (4) quantitative rather than qualitative information may now
be obtained and recorded for more objective interpretation. The low cost
and small size of components make this device feasible for incorporation
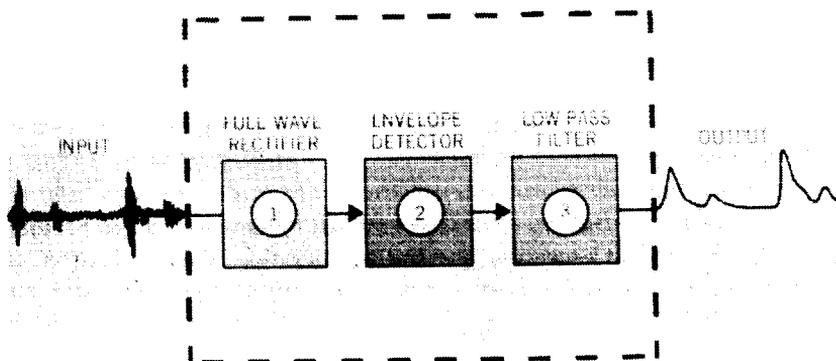with a heart sound microphone as the input to a physiologic data
acquisition system.
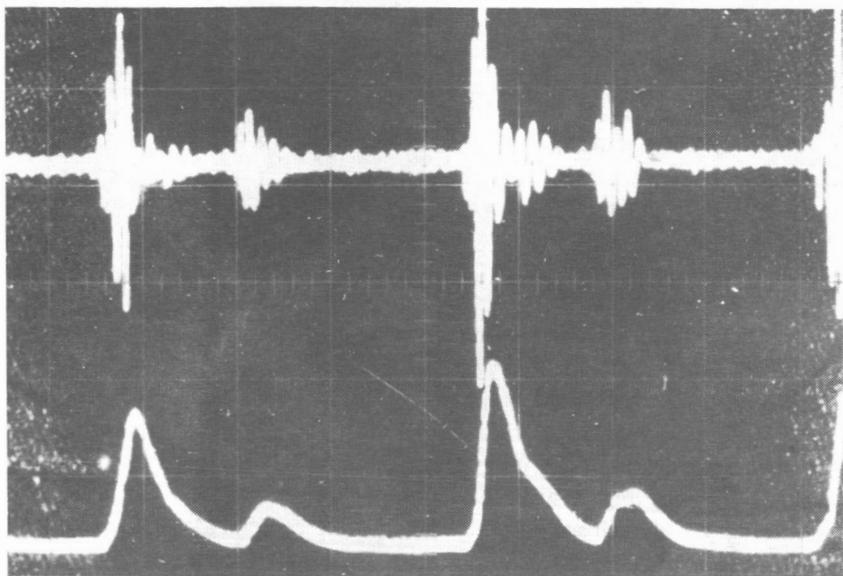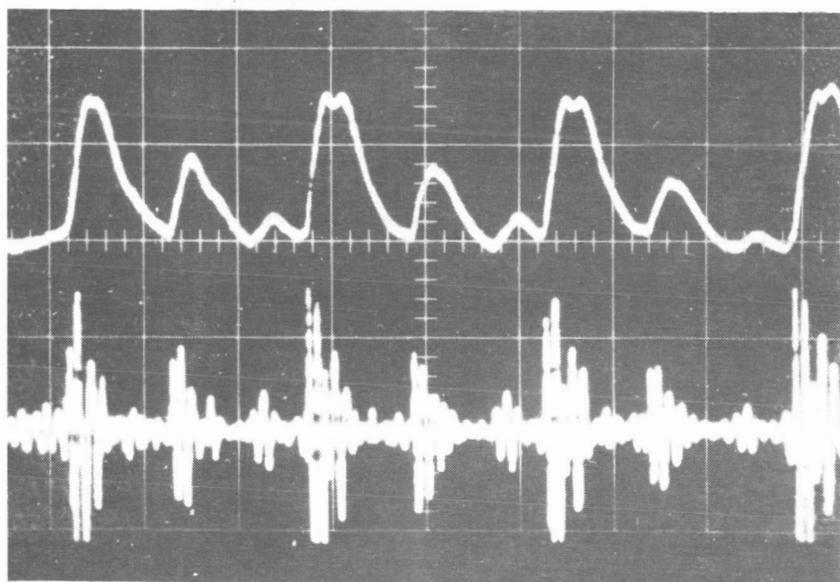

Figure 1--Heart sound preprocessor.

Figure 2

Figure 3