Selective Synchronous Recording of the Ballistocardiogram and Electrocardiogram on a Single Channel

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Identification of ballistocardiographic waves is difficult unless reference can be made to another simultaneously recorded event in the cardiac cycle. By hooking up an electrocardiographic lead in parallel circuit with the ballistocardiograph and interposing a rheostat of variable resistance in series in one of the electrocardiographic lead wires, the electrocardiogram may be selectively tuned in or out of the circuit. At resistances of 50,000 to 100,000 ohms the QRS complex appears only as a small spike preceding the ballistocardiographic waves and readily permits their identification. This simple expedient renders unnecessary the use of multiple recording channels in clinical ballistocardiography.

The introduction of simplified technics for recording ballistocardiograms¹ has placed ballistocardiography within reach of all who possess an electrocardiograph, which may be used to inscribe ballistocardiograms made by electromagnetic, photoelectric or piezoelectric methods. A deterrent to general clinical employment of the ballistocardiograph, however, has been the necessity of employing a multichannel recording instrument for proper recognition of the ballistocardiographic waves by orientation to known phases of the cardiac cycle, such as the electrocardiogram and heart sounds. When ballistocardiographic patterns are abnormal it is difficult or impossible to identify the individual waves properly, unless simultaneous registration is made of another event in the cardiac cycle.

Simultaneous recording of two different wave forms (that is, heart sounds and electrocardiogram) with a single beam tube has been accomplished by use of two valve amplifiers and an automatic high frequency electronic switch which connects their output alternately to the single deflecting plate of the tube.²

A simple expedient which permits simultaneous recording of the ballistocardiogram and the electrocardiogram with freely selective amplitudes of either wave form is illustrated in figures 1 and 2. An electrocardiographic lead is hooked up in parallel circuit with the ballistocardiographic terminals, with a rheostat (variable resistance zero to 1,000,000 ohms)³ interposed in series in one of the electrocardiographic lead wires (fig. 1).

With low resistances the electrocardiogram dominates, but as the resistance is stepped up the amplitude of the electrocardiographic waves decreases to a point where the QRS appears only as a small spike preceding the ballistocardiographic waves with each heart beat. This serves as a convenient reference for timing and identifying the waves of the ballistocardiogram. The appearance of the record with varying resistances is shown in figure 2. When resistance is increased to 200,000 ohms or above, the electrocardiogram becomes imperceptible and undamped ballistocardiographic waves are recorded. During recording of the ballistocardiogram the dial on the rheostat can be rapidly switched so that the electrocardiographic timing reference can be employed conveniently as desired (lower strip, fig. 2).

Simultaneous recording of the ballistocardiogram and electrocardiogram can be achieved by connecting both circuits in series,⁴ but the procedure described offers the advantage of permitting selective damping of the electrocardiogram to a point where it does not disturb the configuration of the ballistocardiographic waves yet permits their identification.

¹ A radio volume control unit serves conveniently.
SELECTIVE SYNCHRONOUS RECORDING ON A SINGLE CHANNEL

Fig. 1. Device for recording ballistocardiogram and electrocardiogram selectively on a single channel. Two electrocardiographic lead wires are hooked up with the ballistocardiograph terminals in parallel circuit, with a rheostat interposed in series in one of the electrocardiogram lead wires. Rheostat resistance is variable by dial from 0 to 1,000,000 ohms.

Fig. 2. Simultaneous recording of electrocardiogram and ballistocardiogram on single channel. At low resistance the electrocardiogram dominates. As the resistance is increased to 50,000 ohms and above, the amplitude of the QRS is markedly diminished so that the QRS complex is visible only as a small spike preceding the ballistocardiographic waves with each beat. This serves conveniently for timing and identification of the ballistocardiographic waves. In the lower strip the resistance is abruptly increased during continuous recording, first to 50,000 ohms and then to 100,000 ohms. Note marked decrease in amplitude of the QRS complex and emergence of the ballistocardiographic waves as resistance is increased.

Synchronous recording of the electrocardiogram with the ballistocardiogram is of value apart from facilitating identification of the waves. In normal subjects the peak of the J wave is attained within 0.25 second from the onset of the QRS complex, whereas in heart disease this interval may be increased to 0.30 second or more, reflecting a lag both in the velocity of left ventricular ejection and acceleration of the blood column in the aorta. In addition to prolongation of the QRS-J peak interval, other abnormalities associated with impaired force of cardiac contraction include slurring, notching and lowered amplitude of the J wave, disappearance of the I wave, and increased prominence of the H wave. Such abnormalities assume greater significance when they are present with respiration suspended, for, as indicated elsewhere, respiratory variation of the
associated with phasic respiratory changes in peripheral resistance and aortic capacity.

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