CERTAIN RELATIONS BETWEEN THE PULSE AND THE BALLISTOCARDIOGRAM. *Shigeru Ogawa, M.D.* and *Isaac Starr, M.D.*, Dept. of Therapeutic Research, University of Pennsylvania, Philadelphia, Pa.

Both the pulse and the ballistocardiogram are generated by the cardiac contraction and that there should be a relation between them is self evident. However, the pulse is generated solely by left ventricular action. The ballistocardiogram, while chiefly due to left ventricular forces, has a component from the right ventricle. Also, the true mathematical theory relating pulse and ballistocardiogram (Noordergraaf) is extremely complicated, so that the discovery of a simple relation which holds in all circumstances is most unlikely. Nevertheless, it is of interest to try to define the relation in simple terms, with the goal in mind of improving our ability to diagnose abnormalities of the right heart.

During the past few months records of the first derivative of the brachial pulse, secured by appropriate electrical circuits, have been taken simultaneously with ULF ballistocardiograms recording acceleration. From these records of the first derivative of the pulse, the second derivative can be calculated with reasonable accuracy. In many instances the calculated second derivative of the pulse looks very much like the ULF ballistocardiogram secured simultaneously, but in many other instances, found especially in the sick, the resemblance between the two is poor. It may well be that abnormalities of the right heart are a large factor in such differences, but abnormalities of forces manifesting themselves in the pre-ejection phase of cardiac contraction and also factors disturbing the transmission of the pulse may play a part.

AN ANALOG COMPUTER FOR THE HUMAN SYSTEMIC CIRCULATION. *Abraham Noordergraaf, Ph.D.* and *George Peirce, M.S.*, Dept. of Medical Physics, Physics Laboratory, University of Utrecht and the Dept. of Therapeutic Research, University of Pennsylvania, Philadelphia, Pa.

In order to arrive at a better description of the performance of heart and vascular system in terms of the physical principles involved and to create a possibility to perform more detailed measurements under various conditions, an analog computer is under construction. An electrical analog was chosen because of its greater versatility than a hydrodynamic model. Electrical equivalents for the left ventricle, aortic valves, larger arteries and the peripheral resistance are included.

In principle the equivalents of pressure and flow in arbitrary locations in the systemic tree, the plethysmogram and the ballistocardiogram can be recorded as a function of ventricular performance.

The analog was described and some results shown concerning the pulse wave velocity and the change in pulse contour when the pressure wave travels down the arteries. Further improvements were discussed.

CLINICAL OBSERVATIONS ON THE EFFECT OF NITROGLYCERIN ON THE DIRECT BODY ELECTROMAGNETIC BALLISTOCARDIOGRAM AND SPECULATION ON ITS ROLE IN ANGINA. *Nahum Winer, M.D.*, New York, N. Y.

Reports on the effect of nitroglycerin on the ballistocardiogram to date have emphasized increased amplitude particularly that of I-J, with one report noting deterioration of H-I in approximately one-half the cases. The present report is based on qualitative alterations in the ballistocardiogram using the direct body head-foot technic of Dock and recording displacement, velocity and acceleration as described by both Arbeit and Smith.

These studies suggest that nitroglycerin effects are generalized rather than involving specifically any one vascular branch and that three factors determine the resulting curves: (1) the frequency range in which these movements are recorded; (2) the size of dose or sensitivity of the patient to the dosage administered; (3) the time elapsing between administration and recording. Increased amplitudes seem more striking in the lower frequency range of displacement, particularly immediately following administration. Any deterioration of H-I is only suggestive. In the higher frequency range of acceleration the alterations are more particularized: (*A*) *Immediate:* (1) If over-all amplitude is at all increased, it is not as marked as in displacement; (2) H-I deterioration occurs more frequently than not and may be the earliest effect, vitiating any tendency to I-J prolongation. (*B*) *Subsequent:* Usually the alterations are gradually restored. When the dosage is excessive for the individual as manifested by drop in blood pressure due to progressively overwhelming vasodilation, over-all diminution in amplitude follows with deterioration of I-J-K to an M-shaped complex with JR-JL forming the respective peaks.

ULTRALOW FREQUENCY BALLISTOCARDIOGRAM OF THE FROG. *H. Klensch*, Institute of Physiology, University of Bonn, Bonn, Germany.

Imitating the human ULF ballistocardiograph used in our laboratory (manufactured by F. Schwarzer-München) we have built a micro-ULF ballistocardiograph for small animals (frogs, mice, etc.). The table (25 gm.) is suspended on two horizontal swings and critically damped. The displacement of the table is picked up by an inductive system with high time constant. The electric signal is given to an EEG-amplifier. Calibration is possible in the same manner as in human ballistocardiography: A small excenter (100 mg. weight, eccentricity 5 mm.) rotating on the table causes a sinusoidal deflection exactly of 0.01 mm. The average displacement in the frog ballistocardiograph is 0.005 mm. (body weight of frog 50 gm.).

The ULF ballistocardiogram of the frog looks very similar to the human ULF ballistocardiograph although the circulatory system of the frog is different from that of the mammalian. But these differences seem to have no influence on the mechanism and origin of the ULF ballistocardiograph.

Estimation of stroke volume of a frog of 53 gm. by our human formula had a result (19 .ul) not very different from the measured excursions of Ringer's solution in a Straub's cannula inserted into the aortic bulb of the isolated heart of the same frog (= 25 .ul).

THE CHICKEN BALLISTOCARDIOGRAM. *DeWitt Hendee Smith, M.D.*, Princeton, N. J.

Anatomically, the chicken is well constructed to couple to a ULF ballistocardiograph table. The large pectoral muscle and supporting bone has the heart directly behind it. The chicken is easily handled. Older sex link hens were found very tractible, could be induced without anesthesia to lie on the left side with legs