METHODS

AN APPARATUS FOR COMBINED DIELECTRO-BALLISTO-ELECTROCARDIOGRAPHY

A. B. Kogan and E. A. Tambiev

From the Department of Human and Animal Physiology (Head — Prof. A. B. Kogan) of Rostov University

(Received March 12, 1959. Presented by Active Member AMN SSSR V. V. Parin)

The functions of excitation and conduction of the cardiac muscle may be assessed very accurately and fully from the electrocardiogram; assessment of the contractile function of the heart muscle, characterized by the strength and volume of the systolic contractions, is much more difficult in clinical practice. The electrocardiographic findings are only of indirect significance in this direction; the ballistocardiogram gives more direct information. Some information on the pulsation of the heart and the great vessels is given by roentgenokymography, but the results of this form of examination are hardly comparable with those of electro- abd ballistocardiography. In the estimation of the functional state of the heart, the determination of the mechanical aspect of its activity thus remains the most difficult problem, and this calls for further improvements in technique.

One way of obtaining more direct information about the character of the cardiac contractions is to study the changes caused by these contractions in an external electric field applied to the thoracic region. Depending on the frequency of oscillation of the current of an electric field applied to the part of the body under study, changes in the volume of the organs situated in this part will be reflected by various physical indices. If a direct current is used, for instance, the pulse changes in the volume of the thoracic organs may be recorded as changes in the ohmic resistance together with the polarization capacity [7]. The use of an audiofrequency current [6] or especially a current of a frequency of the order of hundreds of kc [2] reduces the value of the polarization capacity factor and enables the results obtained to be regarded basically as changes in electrical conductivity [3, 4]. With a further increase in the frequency of the electric field, especailly when ultrahigh frequencies are reached (of the order of hundreds of Mc), capacitive conduction of current becomes possible, without having the electrode in contact with the body; in this case the pulsations of the thoracic organs are recorded as changes in the dielectric constant of the condenser formed by the electrode plates [5, 8]. Such a dielectrogram can give a very direct representation of the fluctuations in the volume of the heart and great vessels, the degree of their filling with blood and emptying, and also of other characteristics of the mechanical aspect of cardiac activity.

For the combined investigation of the functional state of the heart, we constructed an apparatus which enables parallel recordings of the dielectrocardiogram, ballistocardiogram, and electrocardiogram to be made. All working parts of the apparatus are fixed to a chair in which the patient sits in a natural position (Fig. 1). On the arms of this polycardiographic chair are cushions (1) soaked in physiological saline, on which the forearms are fixed, for the leads of the electrocardiogram. In the seat of the chair is mounted a system of piezoelectric pick-ups (2) for recording the ballistocardiogram, as suggested by A. V. Bestugin and his coworkers [1]. The electrocardiogram and ballistocardiogram can be recorded jointly in one recording channel by the method suggested by these authors.

The dielectrographic system (3) is assembled in accordance with the scheme outlined in Fig. 2. The system consists of a short-wave generator with a circuit connected inductively to it, the condenser of which acts as a pick-up. This condenser (4) consists of two metal plates fixed to the inside of the arms and the back of the chair,

Fig. 1. General view of the polycardiograph chair.

so that they surround the patient's chest on two sides (see Figs. 1 and 2). Individual differences between patients examined require that the generator be tuned every time by means of a variable condenser (5). This tuning is done while the patient breathes quietly, to a position at which the amplitude of the respiratory oscillations of the current of the generator observed on the microammeter (6) is maximal. Additional control with a variable resistor (7) enables the optimal conditions for the working of the lamp to be selected, by varying the anode voltage.

When the dielectrocardigram is to be recorded in conjunction with the ballisto- and electrocardiograms, the necessary conditions for the recording of the latter are first chosen, after which the generator circuit is tuned to the maximum amplitude of the respiratory oscillations of the current. When the optimum position has been found, the patient is asked to hold the breath in mid-inspiration and the recording is taken. A suitable recording system is a two-channel electrocardiograph, which is easily assembled from two type EKP apparatuses.

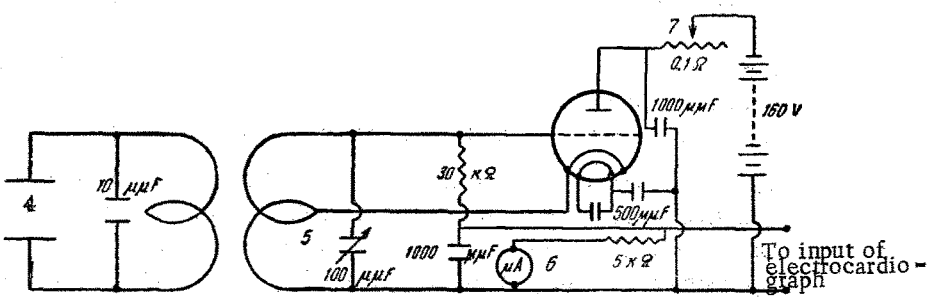

Fig. 2. Scheme of the dielectrographic part of the apparatus

The dielectrocardiogram consists of a combination of oscillations, reflecting the variations in the volume of the heart and of the great vessels during each cycle of cardiac contractions.

Fig. 3 shows the ratio between these oscillations and those of the ballistocardiogram to the waves of the electrocardiogram. A fall in the curve indicates a decrease in the volume as the result of the systolic expulsion of blood from the ventricles, which begins at the point 1 on the curve. At point 2 the decrease in the volume of the ventricles is compensated by an influx of blood into the atrium and by displacement of the heart. Point 3 corresponds to the end of ventricular systole and the beginning of the pause. During the pause the heart is filling with blood: quickly at first (to point 4) and then with small changes in volume.

The dielectrocardiogram shows considerable changes both in connection with the varying functional state of the normal heart and in different pathological conditions. Some examples of dielectrocardiograms of patients are shown in Fig. 3.

SUMMARY

The author describes the construction of an apparatus for combined dielectro-ballisto- and electrocardiography. The dielectrocardiogram reflects the pulsations of the heart and of the large blood vessels as changes of the dielectric constant in the condenser formed by metal plates between which the person under observation is sitting. Samples of recordings obtained in disturbances of the cardiac activity are presented.

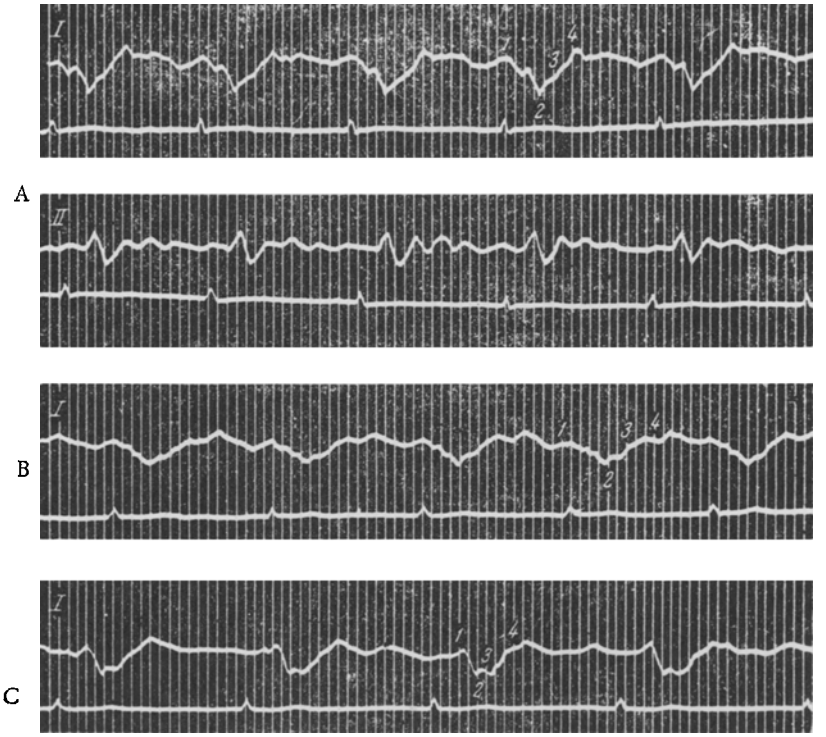

Fig. 3. Recordings of the dielectrocardiogram with the electrocardiogram (I) and the ballistocardiogram with the electrocardiogram (II). A) Patient A. L., aged 26 years, neurasthenia; B) patient R. P., aged 28 years, mitral incompetence; C) patient N. Sh., aged 39 years, stage II hypertension.

LITERATURE CITED

[1] A. V. Bestugin, D. I. Ivanov, V. B. Malkin et al., Fiziol. Zhur. SSSR 43, 9, 906 (1957).

[2] A. A. Kedrov, Klin. Med. 19, 71 (1941).

[3] A. A. Kedrov and A. I. Naumenko, Fiziol. Zhur. SSSR 35, 3, 293 (1949).

[4] A. A. Kedrov and A. I. Naumenko, Problems of the Physiology of the Intracranial Circulation and Their Clinical Elucidation (Leningrad, 1954)[In Russian]

[5] E. Atzler and G. Lehmann, Arbeitsphysiologie 5 (1932), p. 636.

[6] W. Holzer and others, RKG. Rheokardiographie (Wien, 1946).

[7] S. Koeppen, Münch. med. Wschr. 90 (1943), p. 607

[8] L. Rosa, Ztschr. ges. exper. Med. 107 (1940), p. 441.