A FOUR-CHANNEL INK-WRITING PHOTOPLETHYSMOGRAPH FP-4

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A photoplethysmograph has many advantages in comparison with a mechanical plethysmograph: it is more sensitive, more rapid, causes less fatigue to the patient when recording vascular responses; it may be used for the study of any portion of the human body; the tissue of the region studied is not compressed; the measurement applies to the degree of filling of only the skin or mucous membrane of a small area of the human body; there are no artifacts which are inevitable when mechanical quantities are being transferred to electrical, etc.

Descriptions have been given of various designs of plethysmometers [6], and of photoplethysmographs for recording by reflected light [10, 11], and for recording light scattered by tissue [7, 8, 9, 12]. Sensitive elements for photoplethysmographs have been described [2], as has also a method for studying venous tone by means of a photoplethysmograph [1].

We have constructed four photoplethysmograph models. Three of them (FP-1, FP-2, and FP-3) have been used for scientific and therapeutic purposes in Alma-Ata over a period of ten years [3, 4, 5]. Here we describe the latest model, the FP-4 (Fig. 1), which has undergone clinical tests in the Kazakh Institute of Marginal Medicine, AMN SSSR, Institute of Normal and Pathological Physiology AMN SSSR and in the Institute of Therapy. Engineer V. A. Lyukhin took part in the preparation of the experimental material.

The FP-4 has sensing devices for recording vascular reactions either by light reflected from or scattered by the tissue. The vascular reactions of the skin and mucous membranes in any part of the head, limbs, or trunk may therefore be recorded.

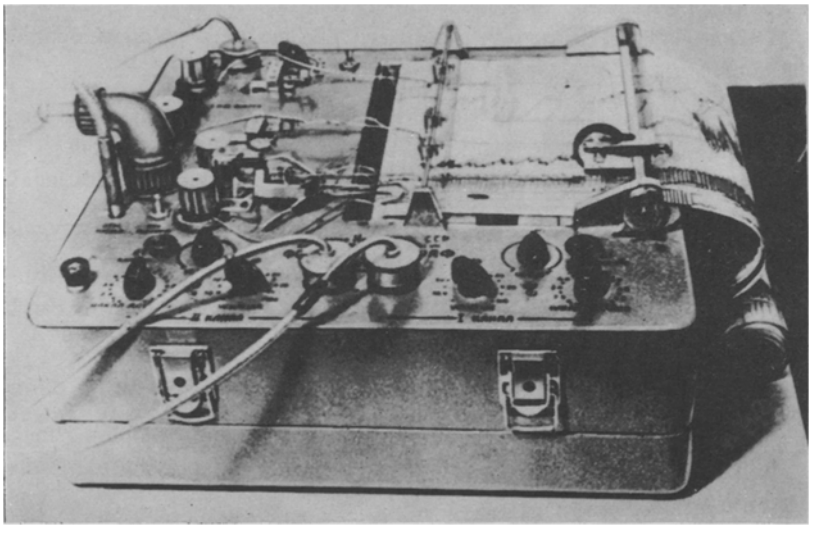

Fig. 1. General view of the FP-4 photoplethysmograph.

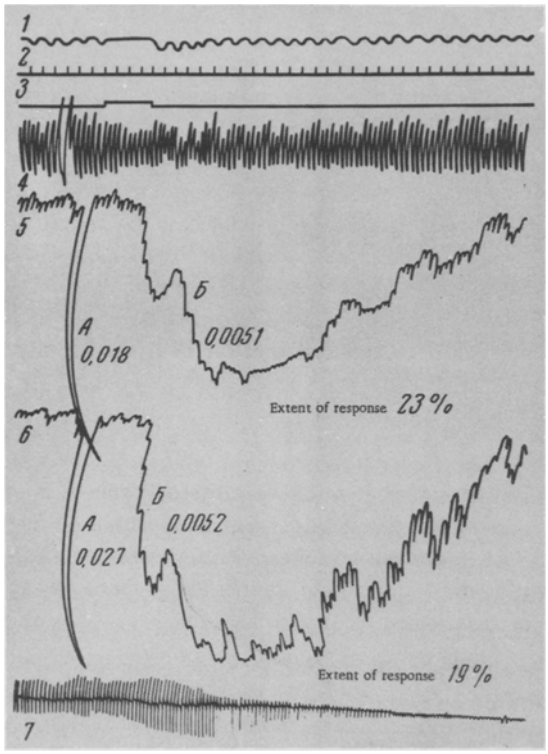

Fig. 2. Sample photoplethysmogram. 1) Pneumogram; 2) time marker (2.5 secs); 3) stimulus marker; 4) pulse volume; 5,6) photoplethysmograms of two fingers (one from each hand); 7) oscillogram of thigh: A) calibrating signal; B) vascular response. The figures indicate the strength of the reaction in millimeters of blood per cm^2 of skin. Paper speed 2 mm/sec.

The device has two channels for recording the plethysmogram, which makes it possible to demonstrate vascular asymmetry and features the blood circulation in various parts of the body, as well as artifacts associated with muscular movements, etc.

In the FP-4 apparatus the slow variations in the degree to which a part is filled with blood which are due to changes of the capillaries of the veins, and the rapid changes synchronous with the pulse in the arterioles are recorded separately from a particular region. It is therefore possible to ascertain whether the principal change is in the veins or arteries.

It is known that the frequency characteristic of the processes studied demands an appropriate choice of amplifier and recorder. Therefore, if both the rapid and slow components of the plethysmogram were recorded in a single channel it would lead to distortion of the curves.

The ribbon-operating mechanism has two velocities: slow (2 mm/sec) and fast (15 mm/sec). The pulse volume may be recorded at high speed on a third channel, which makes it possible to analyze the changes undergone during a single cardiac cycle. The ink writer and the large amplitude of the trace (100 mm) facilitate interpretation of the plethysmogram.

Static calibration is carried out in units of blood volume by means of a special calibrating device. In this way a quantitative analysis of the strength (extent of the reaction) with reference to the original volume (Fig. 2) may be made.

There are three units: an amplifier with recording device, a power supply, and a set of spare parts.

The amplifiers of the first and second channels consist of symmetrical three-stage dc amplifiers with direct coupling. The voltage amplification is about 20,000. The anode loads of the 12 ZhZL pentodes are large resistances, and therefore the first and second stages operate under low-current conditions so that the power expended and the drift of the zero are small. The output stage is a power amplifier. The magneto-electric recorder is connected in the anode load of the 6N6P double triode.

The amplifier of the third channel is a four-stage symmetrical ac amplifier having an amplification factor of about 80,000. The first stage consists of pentodes, and the remainder of double triodes. This channel serves also for recording the oscillograms; then a special toggle switch is used to introduce an additional resistance.

There are time markers (electromagnetic relay), and a stimulus marker with removable knob.

The element for measurement of blood pressure and for dynamic oscillography consists of a sleeve, a spring manometer, a reducing valve, and a piezotransducer. The minute volume of blood flow can be measured by means of a Gartner capsule.

The respiration was recorded by a pneumatic mechanism simultaneously with the plethysmogram.

The power supply for the amplifiers and for the sensing devices in the photoplethysmograph consisted of a rectifier with electronic stabilization of the anode supply and of the voltage supplying the lamps for the photosensitive elements. The stabilization factor was 1,500.

The weight and dimensions of the photoplethysmograph enable it to be used on patients in tents set up under field conditions.

SUMMARY

The FP-4 photoplethsymograph is a portable instrument enabling simultaneous recordings of vascular reactions and of the pulse volume of the skin and mucous membranes of the body to be taken either by diffuse or by reflected light; records may be obtained from any part of the body. In addition, an oscillogram and respiration curve are recorded on paper strip. The FP-4 enables arteries, arterioles, or veins of any caliber to be investigated, and the circulation time may be measured. A special calibrated device enables a quantitative analysis of vascular reactions to be made.

LITERATURE CITED

1. B. E. Votchal and R. I. Bibikova, Abstracts of Reports of the Scientific Conference of the Military Faculty and the Central Institute for Advanced Medical Training, Moscow (1949), p. 26.
2. M. E. Marshak and V. G. Rogachev, Byull. éksper. biol. (1956), 12, p. 70.
3. V. S. Moshkevich, Zdravookhr. Kazakhstana (1955), 10, p. 30.
4. V. S. Moshkevich, Vestn. AN Kazakhsk. SSR (1960), 10, p. 94.
5. V. S. Moshkevich, Vestn. AN Kazakhsk. SSR (1961), 11, p. 82.
6. E. D. Solov'ev, Byull. éksper. biol. (1953), 11, p. 72.
7. L. E. Gale, and P. M. Scott, J. Am. pharm. Ass. sci. Ed. (1956), 45, 491.
8. A. B. Hertzman, Am. J. Physiol. (1938), 124, p. 328.
9. K. Matthes and W. Hauss, Klin. Wschr. (1938), 17, p. 1211.
10. J. Nieveen, L. B. Van der Slikke et al., Cardiologia (Basel) (1956), 29, p. 160.
11. R. O. Rawon, J. appl. Physiol. (1959), 14, p. 1049.
12. J. Weinman and M. Manoach, Am. Heart J. (1962), 63, p. 219.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
