objectively the effects of various factors exerted on an intact animal on the permeability of the hemato-ophthalmic barrier. The same photographs can also serve for the study of the permeability of skin vessels; the values of S are determined for the hairless or almost hairless skin of the eyelids or around the eyes.

Figure 1 illustrates the course of change in permeability, as shown by photographs of fluorescence of a rabbit's eye, taken (a) a day before the Gasserian ganglion had been injured, (b) 3 hours later, and (c) 48 hours later. The photographs were taken 15 minutes after intravenous injection of fluorescein. Figure 2 presents the results of photometric treatment of the negatives. The degree of blackening of the relevant part of the negative (S) is expressed as the logarithm of the ratio of the intensity of light passing through the background parts of the negative to that passing through the exposed part.

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INTERPRETATION OF HUMAN PLETHYSMOGRAPHIC DATA

E. N. Kondratev (Moscow)

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The shortcomings of the techniques employed in the plethysmographic examination of human subjects emerge clearly from a study of the subject.

In particular, insufficient attention has been paid to the nature, magnitude, and frequency of distortions of the plethysmograms, due to movements of the subject. V. V. Yakovlev has shown, in experiments on dogs, that effects interpreted as plethysmographic reactions were in reality due to tonic contractions of the muscles of the extremity.

O. Bruns [12] has reported similar occurrences. It appeared that the subject (plethysmography of the arm) is usually unaware of contractions of his muscles such as can give a spurious vascular effect. From a comparison of plethysmographic tracings with those obtained as a result of muscle contractions registered in response to various stimuli (flexing and straightening the foot, pain, heat, cold), O. Bruns came to the conclusion that the use of plethysmography is justified only for the study of temperature effects, and even then only after special training of the subjects, who were enabled, by means of a separate device, to become conscious of "unconscious" movements of the arms, and to control them.

It should be noted that O. Bruns' observations were made chiefly with the aid of rubber bulbs in contact with the arm, and connected with the registering system (he makes a passing mention of the use of a galvanometer for this purpose, by one of his co-workers). It follows that some of the weaker movements, which might have had a distorting effect on the plethysmograms, were not recorded.

The object of the present research was to ascertain the effect of weak muscular contractions on a plethysmogram, obtained by one of the present-day techniques.

EXPERIMENTAL METHODS

Plethysmographic records were taken from the terminal phalanx of a finger of the left hand of 22 subjects, by the method of pneumatic finger plethysmography.

A glass cap is placed on the phalanx, and is connected by a rubber tube with a special micromanometer (1), fitted with a small mirror for photoregistration of the smallest pressure changes in the system (the micromanometer was mounted in the place of the vibrator of the oscillograph.

Slight movements of the finger were recorded by means of a flexible carbon powder rheostatic detector (1), attached to the finger and to the glass cap by strips of plaster (Figure 1).

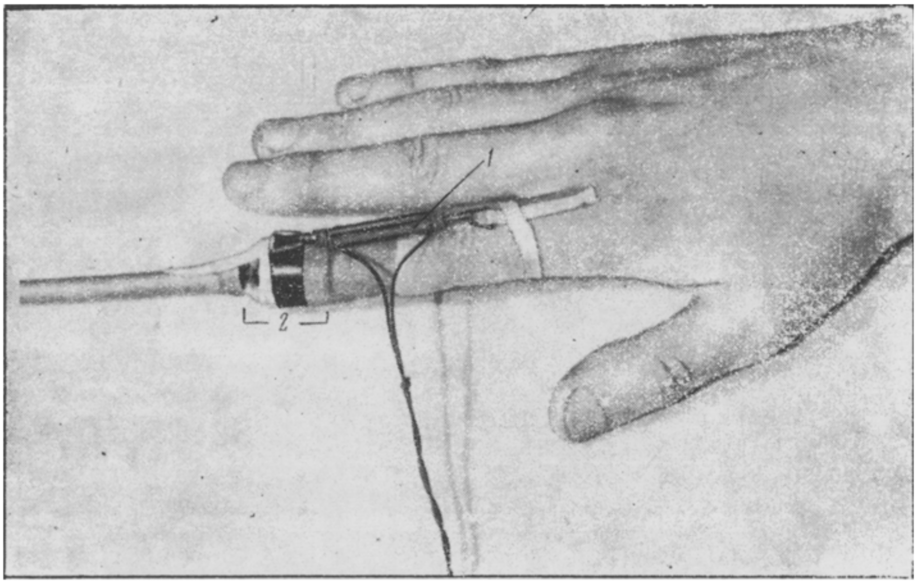

Fig. 1. Attachment of a carbon powder counter to a finger, for recording its movements. 1) Carbon powder counter; 2) glass cap.

The detector was connected in series with the oscillograph in such a way that its extension raised the tracing on the photosensitive paper, and its shortening lowered it. The detector and the vibrator were fed from a 3.2 v battery, through a potentiometer of resistance 450-600 ohms.

The sensitivity of the counter was sufficient to register slight, almost imperceptible movements of the finger. In many cases the finger movements record showed fluctuations due to the pulse, evidently transmitted through the skin of the finger to the detector. Respiratory movements were registered by means of a slightly modified laryngophone receiver fixed to the chest by means of elastic tape, and connected with the input of the oscillograph.

The recordings were taken continuously for 11 minutes for each experiment. A yellow and a red lamp (6 v; 7.5 w) were switched on in succession for 2 seconds at $1^1/_2$ minute intervals.

The subjects were examined in this way for 3 days in succession, and they were told at the beginning of each experiment to lie still, and not to move their fingers.

EXPERIMENTAL RESULTS

It appeared that the number of "involuntary" movements of the fingers varied considerably for a given subject on different days. On occasions, there were several such movements per minute of registration.

In some cases the occurrence of finger movements could be detected from the nature of the distortions of the plethysmogram (Figure 2, a). In the case shown in Figure 3, however, it would not have been clear, except from the recordings of finger movements, whether the steep decline of the plethysmographic tracing (after a deep inspiration) is primarily a vascular reaction, or whether it was due to a finger movement, as happened a few seconds before. Other distortions of plethysmographic tracings due to muscle contractions are less frequently encountered, such as spikes (Figure 2, c), slight dips in the curves following finger movements (Figure 2, b), in which cases it would not be possible, without a recording of finger movements, to know whether and when the latter took place, on the basis of the plethysmogram alone. In some cases such smooth dips in the plethysmographic tracings undergo distortion as a result of previous abrupt finger movements (Figure 2, d).

An additional visual check showed that the spike effect can be produced by a slight voluntary movement of the finger, taking place a little earlier. Distortions of the tracings can also be produced by slight, continuous pressure, almost imperceptible to the eye, of the terminal phalanx into the cap; in such cases deviations of the finger movement control curve may still be seen. Finally, there are cases in which slight movements of the finger do not affect the plethysmographic tracing.

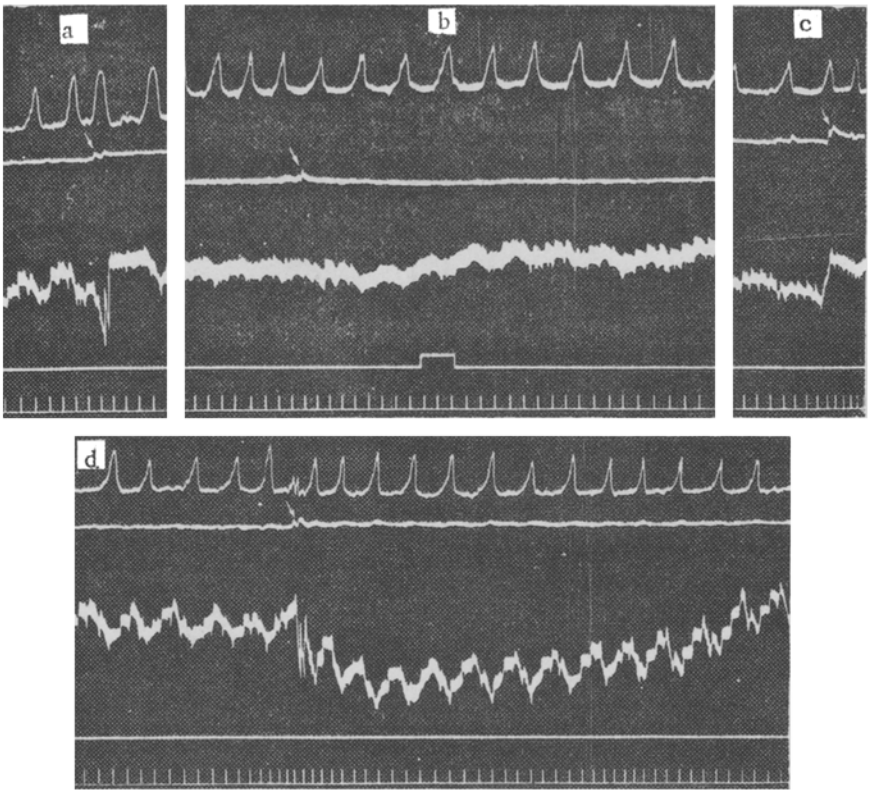

Fig. 2. Distortions of the plethysmogram due to "involuntary" movements of the finger. Explanation of tracings (from above down): respiration; record of finger movements; plethysmogram; signal showing when lamps switched on; time signals (1 second). Separate experiments.

We were not, as a rule, able to perceive finger movements which might be ascribed to the motor component of the orientational reaction; this may possibly be due to the low intensity of the light stimuli.

The finger movements may arise in consequence of various interoceptor effects [3, 9], or of irradiation of impulses from the respiratory center to the motor areas [2, 4, 6]. We not infrequently noticed that the subjects took isolated deep breaths, and these were in some cases followed not only by vasostriction, but also, as in Figure 3, by subsequent finger movement.

Simultaneous registration of finger movements and of respiration thus makes it possible to achieve a more objective evaluation of plethysmograph curves.

An insufficiently objective evaluation of plethysmographic data is apparent in the work of a number of authors [7, 8, 11], who have reproduced tracings suffering from obvious distortion due to movements. Thus, for example, Figure 8 of L. B. Perelman's paper [8] shows the vascular reaction recorded from the right arm in response to graded needle-pricks of the left arm. The steep and stepwise decline in the plethysmograph tracings bears a general resemblance to that of Figure 3.

The reaction described by Perelman was observed in a patient in response to a prick, after a series of unfulfilled warnings that the prick was about to take place; this should, in the opinion of the author, have led to an inhibited state of the cerebral cortex of the subject. In this case the dip in the plethysmograph curve was $2^1/_2$ times greater than before elaboration of the extinguishing inhibition. The author draws the theoretically important conclusion that cortical inhibition causes positive subcortical induction, which affected the nature of the response to the needle-prick.

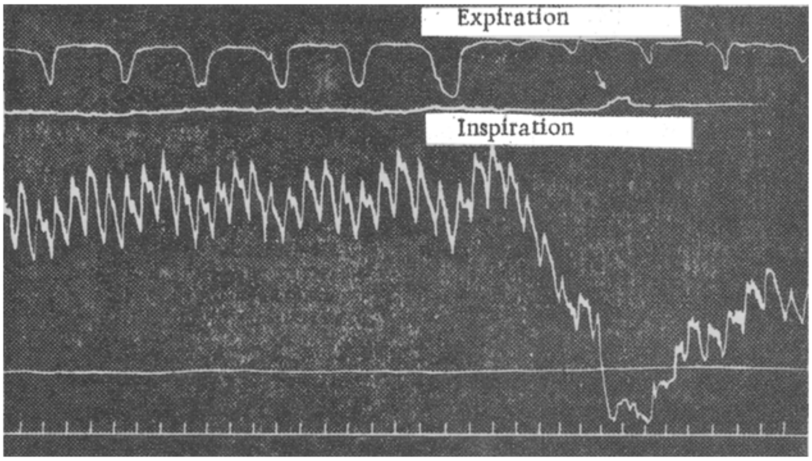

Fig. 3. A single, deep inspiration, constriction of vessels, and movement of the finger, in succession. Explanation of tracings as for Figure 2. The respiratory movements are recorded in the opposite direction to those of Figure 2.

A different conclusion might, however, be drawn if we take into account the almost certain distortion of the recording of the reaction by movements of the patient. During the gradual development of extinguishing inhibition in the cortex an enhancement in excitability may have arisen in some of its regions; for example, in the motor analysor area. A prick inflicted at this stage on the right arm may also have led to a muscle contraction in the other arm, and so have produced the impression that a very strong vasomotor reaction had occurred. It is thus evident that, unless precautions are taken to register movements of the extremity from which plethysmographic recordings are being taken, the value of the data given by plethysmograph of the human is greatly diminished, irrespective of the nature of the stimulus applied.

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