AUTOMATIC CALIBRATION OF RHEOGRAMS

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The technical principles and construction of an apparatus for automatic calibration of rheograms are described. By its use, the principal characteristics of the calibration mark (duration and frequency of the standard signal) can be unified.

Calibration of the test signal is essential for the obtaining of objective biological information through rheography. The manual method of calibrating rheograms now in use is imperfect and requires improvement. The main cause of distortion of the shape of markers and rheograms in the manual method of calibration is commensurateness of the duration of the marker with the time constant of the amplifier and the duration of the rheographic wave. Hence, it can be concluded that the duration of the marker must be many times shorter than the time constant used when recording rheograms. The optimal time constant of the rheographic amplifier is 0.6-0.7 sec [2]. However, a considerable decrease in the duration of the marker is unacceptable, for to maintain the amplitude of the marker its frequency spectrum must lie within the working band of the amplifier, which in the ink-writing instruments widely used at present is 60-90 Hz. Under these circumstances the shortest duration which can be reproduced with high accuracy is 10 msec.

The chief factor limiting the maximum duration is the lower frequency of the transmission band of the amplifier. A square pulse decay to 5% can be taken as permissible. In that case the maximal permissable duration of the marker will be 50 msec. Experimental verification showed that the optimal duration of the marker is 20-40 msec, depending on the type of recording instrument used. However, markers of this duration are not reproducible by the existing method, so that they must be formed by a pulsed electronic device.

Cases are frequently found in the literature in which experimental results, of considerable interest, are presented without a calibration marker, and merely with an indication of the scale of the recording, which detracts from the authenticity of the material presented. It is therefore essential not only to form a marker of definite duration but also to transmit it automatically.

In the literature on rheography it is customary to illustrate the material presented by oscillographic records on which usually at least five pulsograms are shown. The writers' calculations show that if the marker is put out every 5 pulse waves, the electrical circuit of the instrument is too complex and not sufficiently free from interference. To provide the best technical and economic parameters, the marker should be applied at fixed time intervals. For an averaged normal pulse rate of 60/min, this interval can be taken as 7-10 sec.

In actual multichannel self-writing instruments, the particular dynamic scale which is likely to be used the most is assigned to each channel. In such cases, therefore, arbitrary positioning of the marker is not permissible. For this reason, it was suggested previously [1] that the marker be placed at the end of the catacrotic phase. However, it is a complicated task to calibrate qualitatively in this way by the manual method. The problem can be solved if the work of the automatic calibrator is compulsorily synchronized with the pulse curve or the electrocardiogram.

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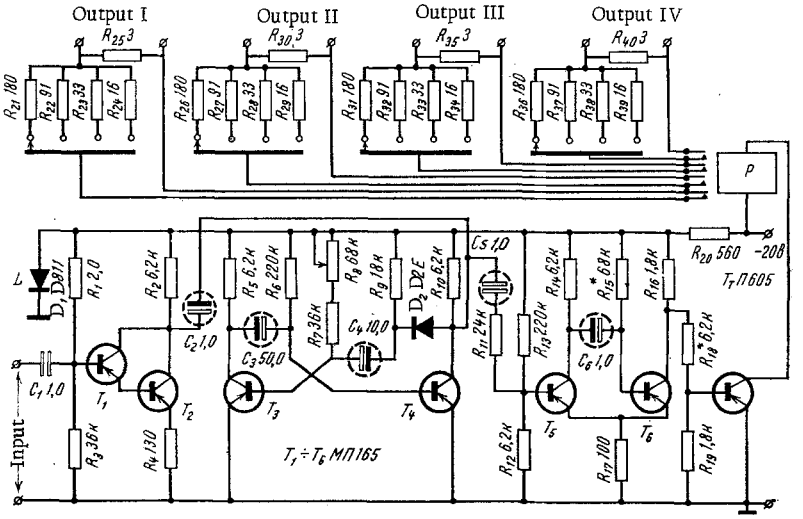

Fig. 1. Theoretical circuit of automatic rheograph calibrator (explanation in text).

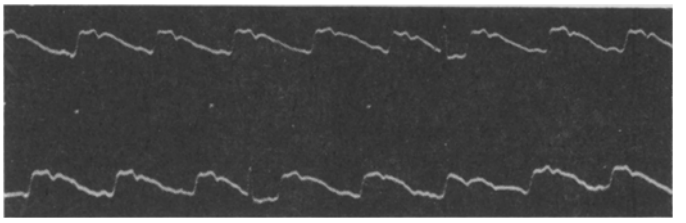

Fig. 2. Rheoencephalogram in the left fronto-mastoid lead.

The theoretical circuit of an automatic calibrator which can work either under conditions of synchronization or in the absence of synchronous pulses is shown in Fig. 1. A voltage of 100 mV from the output of the rheograph or electrocardiograph is fed into the input of the instrument and, after amplification and differentiation, it synchronizes the work of the square pulse generator. A potentiometer allows delay of the marker relative to the end of the anacrotic phase to be selected. The delay multivibrator which operates the relay is then triggered. The relay changes the resistance in the measuring circuit by 0.05, 0.1, 0.25, and 0.5 Ω, respectively, depending on the intensity of the signal tested.

To illustrate the working of the instrument, a rheoencephalogram recorded in a clinically healthy subject, aged 30 years, in the fronto-mastoid lead is shown in Fig. 2. The records show that the calibration marker was applied every time at a certain moment of the catacrotic phase. It is undesirable to have the marker right at the end of the catacrotic phase, because in that case, because of variability in the duration of the rheogram, the calibration marker would sometimes be superposed on the anacrotic phase. It must be emphasized that the ideal case is when the marker of the calibration signal falls on the catacrotic path of the pulse wave at the moment when it passes through zero (the isoelectric line), for then the amplitude of the rheogram signal does not coincide with the amplitude of the calibration signal, and as a result there is no distortion of the amplitude of the calibration signal, because it falls outside the linear segment of the dynamic amplitude characteristic curve of the tract. For this purpose the amplified rheogram signal is formed into pulses, for example, by means of a Schmidt trigger and the univibrator assigning the duration of the calibration pulse is triggered by the corresponding front of these pulses through a logical coincidence circuit. The pulse from a self-excited oscillator, determining the interval between successive calibration pulses, is fed into the other input of the logical coincidence circuit.

The circuit as developed is perfectly applicable also to rheoplethysmography. In automatic analysis of rheograms by means of a computer, in order to identify the value of the marker, it is desirable to change its duration simultaneously with the change in amplitude of the calibration signal. This can be done by narrowing the original pulse for frequency separation of the marker from the rheograms. This, of course, can also be provided for during graphic recording and nonautomatic analysis.

LITERATURE CITED

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