USE OF ELECTROCHEMICAL RECORDING IN MEDICAL INSTRUMENTS

N. K. Golobokii

UDC 615.471:616-073.97-073.96

The development of medical instruments for recording various physiological processes is seriously hampered by the lack of a reliable and inexpensive writing system.

The most popular photographic and ink recording methods do not always satisfy the needs of practical medicine for a fast, accurate, and convenient recording method. As a result, various other recording methods such as heat, electrothermal (electric starks), electromechanical (with carbon paper), air flow, etc., are resorted to.

It is thus worthwhile to evaluate the feasibility of using the so-called electrochemical recording method for this purpose.

Electrochemical recording has recently been used extensively in phototelegraphy as one of the fastest, least expensive, and most simple and convenient methods of providing high-quality images (in black and white, halftones, or even color). Directly or indirectly these qualities can be used with advantage in medical electrography as confirmed by comparative data on the most popular contact recording methods using paper tape (see Table 1).

Data in the table indicate that electrochemical recording possesses some very useful properties.

Electrochemical recording is based on the formation of dyes on the surface of paper impregnated by certain chemical reagents when an electric current passes through it. The circuit most frequently used for electrochemical recording is shown in Fig. 1. The supply voltage E is applied to a contact system consisting on one side of the writing electrode 1 and on the other side of the conducting surface of the paper transport mechanism 2. Between the contacts 1 and 2 moves a slightly moistened paper tape preimpregnated with electrically conducting chemical reagents. Electrolysis of the reagent at the point of contact is associated with formation of dyes. If the writing electrode travels across the paper it will produce a trace. Depending on the type of electrochemical recording, the trace image appears either instantaneously or after 1-2 seconds. The recording paper is premoistened (to 35-40%) and stored in a closed paper holder 3.

There are many different kinds of electrochemical recording. A study proved that the most widely used methods are based either on the injection of ions from the writing electrode into paper impregnated with a special chemical compound, or on a change in the hydrogen ion concentration at the point of contact of the writing electrode and electrolyte-impregnated paper. These methods of electrochemical recording are also the ones most suitable for use in medical recording instruments.

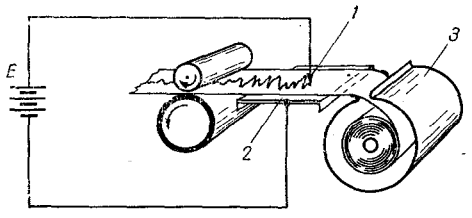

Fig. 1. Electrochemical recording circuit.

Recording by ion injection is based on the fact that metal ions from the writing electrode reacting with the chemical substance on the paper surface produce dark-brown, dark-blue, or light-blue colored stains. This process of dye formation requires a relatively prolonged current flow thus limiting the recording speed. The second method is based on changes taking place in the solution pH, i.e., in the concentration of hydrogen

All-Union Scientific-Research Institute of Medical Instrument Design, Moscow. Translated from Meditsinskaya Tekhnika, No. 2, pp. 8-13, March-April, 1972. Original article submitted November 16, 1970.

TABLE 1. Comparative Characteristics of Contact Recording Methods

Recording method	Acceptable linear speed, m/sec	Line thickness, mm	Cost of 30 m × 35 mm paper roll, kop.	Distinctive features
Ink	0.2-0.5	0.1-1	5-10	Special inks are required; pen clogging and ink sputtering occur frequently
Electromechanical	2.0-3.0*	0.3-0.5	10-20	Carbon paper and a means for its transport are required
Electrothermal	2.0-3.0†	0.2-0.25	50-70	Special paper as well as a pen power supply are needed; causes interference and dust
Heat	0.5-1.0	0.2-0.25	200-300	Special paper and pen heating circuit are required
Electrochemical	3.0-4.5	0.2-0.3	10-20	Requires special impregnated paper and pen current supply

*Linear speed limited by inertia of the carbon paper pressure mechanism.
†Limitations imposed by the rate of burning out of the paper layer.

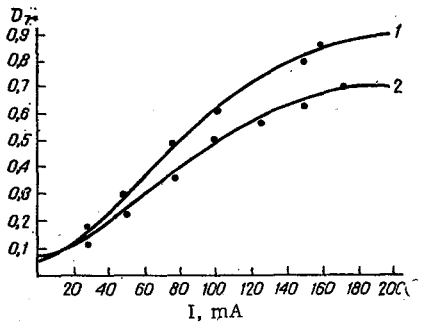

Fig. 2

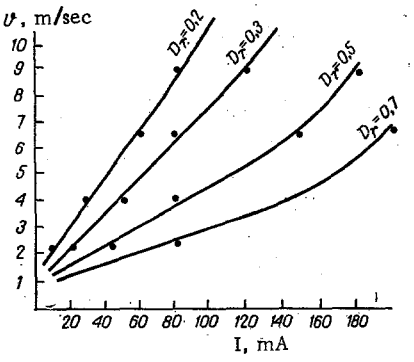

Fig. 3

Fig. 2. Optical density D_r as a function of current I passing through the paper: 1) alkali recording; 2) acid recording.

Fig. 3. Recording current I as a function of linear recording speed v for different image optical densities D_r.

ions, at the point of contact of the writing electrode and paper. The electrolyte includes substances that under the influence of pH changes form stable dark-brown, blue, black, or red-yellow dyes. The process is very sensitive to current so that the recording speed can be high.

Electrochemical recording based on pH changes can be either anodic (alkali) or cathodic (acid).

In anodic recording the positive pole of the current source is applied to the writing electrode. The paper is impregnated with an electrolyte containing aromatic amines, sodium nitrite, staining agents, and other components that in response to pH changes produce stable black dyes.

In cathodic recording the negative pole of the current source is applied to the writing electrode. The paper is impregnated with an electrolyte containing disonium salts, staining reagents, and acid. The change in hydrogen ion concentration (but in a direction opposite to that in anodic recording) results in formation of dark-brown, blue, or red-yellow dyes. Acid recording produces a sharper and more stable trace that alkali recording but its technology, which requires protection of the recording paper from light and strong illumination for image formation, limits its application to high-quality phototelegraphy producing images with a wide range of contrast and colors. In alkali recording the technology of image formation is much simpler but the images are less sharp (especially in halftones) and, in addition, results in a somewhat darker background. In phototelegraphy alkali recording is used chiefly for transmission of black and white images (synoptic and topographic charts, drafts, texts, etc.,).