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THE MEASURE OF STIMULATING THRESHOLD OF NEURO-MUSCOLAR TISSUES: INTRUMENTATION AND APPLICATION IN CARDIAC STIMULATION

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L77-33

Estratto da: First Mediterranean Conference on Medical and Biological Engineering, Sorrento(Napoli) ITALY, - 12-17 September 1977.

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Introduction

The measure of the stimulating threshold of neuro-muscolar tissues is currently done refering to voltage or current [1,2]. However the tissues are tipically non linear systems so that the stimulating threshold is not well defined only on the basis of the voltage or current. Some authors [3,4] have succesfully suggested to measure the stimulating threshold as the energy required to obtain a response.

The problem is particularly important in the stimulation of the myocardium by cardiac pacemaker, where the energy consumption must be kept to a minimum in order to achieve a long life-time of the prosthesis. An energy saving has been up to now obtained by reducing the electrode size [5,6] and by a proper choice of the duration of the stimulating pulse [2]. Further saving can be achieved only by a close investigation of the electrode-myocardium system [7].
For this purpose we have developed an instrument for the direct reading of the stimulating energy associated with different pulse shapes.

The myocardium excitation energy meter (MEEM)+

The instrument we have developed (MEEM) provide a reading of the stimulating energy on a calibrated scale and, at the same time, gives two output waveforms one proportional to the applied voltage and the other to the current.
The energy is measured by calculating the integral of the product voltage current over the interval during which the current is supplied to the system. The block diagram of the MEEM is shown in fig. 1. The internal generator is capable to supply the system under investigation with two different shaped pulse: one is a typical pulse as generated by conventional pacemakers (fig. 2a) the other is a filtered pulse (fig. 2b) much more close in shape to the pulses of physiological origin.

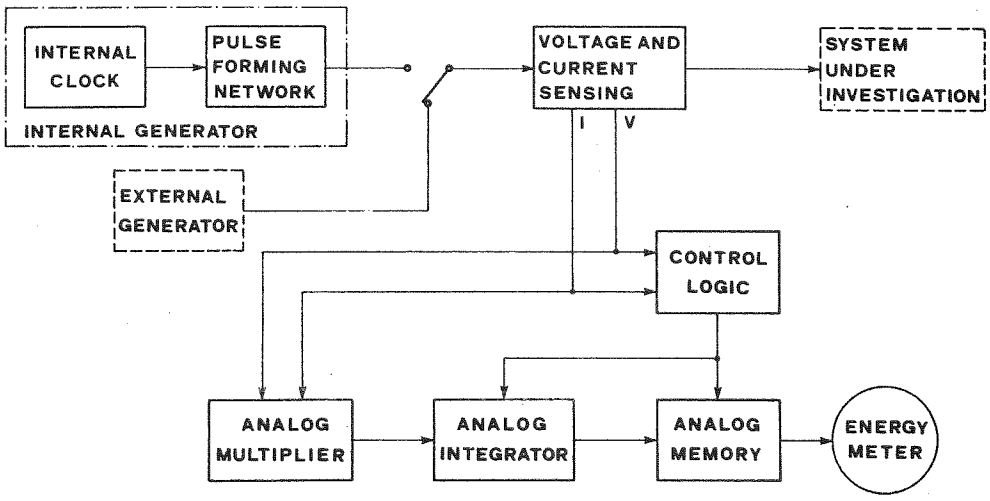

Fig. 1 Block Diagram of the MEEM

+ Patent n. 965757, Italy

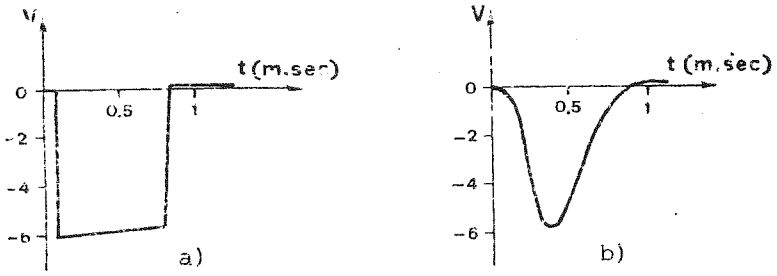

Fig. 2 Internal generator pulses: a) standard pacemaker pulse; b) pulse filtered by a second order system.

The instrument is provided with an external input for experimenting with any other pulse shape.
The repetition frequency, amplitude and duration of the pulses generated by the internal generator are manually adjustable over a wide range (table 1). The MEEM is capable of measuring energies from 2,5 μj to 100 μj full scale, divided in 6 ranges (2,5; 5; 10; 25; 50; 100 μj f.s.). The reading of the measure is stabilized between successive measurement by an analog memory.
The safety of the patient against shock hazard is ensured by battery or high isolation power supply.

Table 1: Internal generator characteristics

Rep. Freq.	:	50÷150 pulses/min
Duration	:	0.4÷ 5 msec
Amplitude	:	0÷6.8 Volt

Experimental results

The MEEM has been succesfully utilized by the medical equipe involved in pacemaker implantation and control at the Istituto di Patologia Medica - PISA.
Typical applications of the instrument have been:

a) positioning of the stimulating electrod at the implantation; the direct reading of the stimulating energy enables the physician to localize easily the most excitable area; the corresponding threshold is measured by suppling stimulating pulses with decreasing amplitude.

b) investigation of the electrode-myocardium system; by using the current and voltage outputs of the MEEM when stimulating with variously shaped pulses, it is possible to study the electrical properties of the system; an interesting approach may be based on the identification of an electrode-myocardium model.

c) evaluation of the stimulation effectivness of different pulse shapes; an interesting result has been obtained by using the filtered pulse (fig. 2b) instead of the conventional pulse (fig. 2a): our results in 230 patients have shown a mean threshold energy reduction of 20% when operating with the filtered pulse.

The MEEM is also currently applied for measuring at the implantation, for following up the patient's stimulating threshold, and for evaluating the stimulating effectivness of electrodes with various surfaces and shapes.
The medical people using the MEEM have never met with any difficulties either technical or clinical.

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