

Convegno Internazionale  
International Congress



## LA MASSA E LA SUA MISURA

Storia, scienza, tecnica, legislazione e didattica

## MASS AND ITS MEASUREMENT

History, science, technology, legislation and didactics

Modena 15-16-17 Settembre 1993



## The early history of balances based on electromagnetic or electrodynamic force compensation

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### 1. Introduction

Today, the term «electronic balances» is used for a great variety of mass measuring instruments, based on different principles and used in various fields of application like commerce, manufacture, household techniques, and in laboratory. Indeed, the term «electronic balances» does not designate the weighing principle and is therefore misleading.<sup>1</sup>

Reminding the equal-armed lever balance, the steelyard with variable levers, the spring balance, and the inclination balance, for all these balances the notation is in accordance with its principle of working. This is not the case, however, for the so-called electronic balances, because a purely electronic weighing does not exist. Electrons per se are not capable to perform weighings. The electronic in modern balances is only able to control and to automatize the process of weighing, which is only based upon electromechanical principles; the representation of the measured value is done in digital manner. The same applies to the storage and the processing of the data by electronic techniques.

There is a considerable number of the so-called electronic balances, which work according to different weighing principles. Their function, however, is always based on electromechanical elements: a mechanical effect caused by the mass to be weighed, such as the increase of a certain length within the weighing cell, produces an electrical signal, for example the alteration of an electrical voltage or an electrical resistance. This means that these modern balances are based on weighing principles which are already known for long time<sup>2</sup>. As examples may be mentioned: balances with a magneto-elastic force transducer, balances with a capacitive force transducer, balances with an inductive force transducer, balances with a piezo-electric measuring probe, balances with strain transducers, balances with electromagnetic or electrodynamic force compensation.

In all these cases the weighing result is indicated via an electric signal. The application of such electrical procedures was accompanied with many difficulties and thus, in the beginning these methods were seldom transferred to weighing instruments of daily use. The development in electronics during the last decades made it possible to receive weak electric signals faster, the procedure was less expensive and in most cases also much more precise than the classical application of purely electrical methods.

The most precise weighing methods of all used today in the so-called «electronic balances» are the principles of electromagnetic and electrodynamic force compensation. Often no clear distinction between these two terms is made and they are commonly used as synonyms. Referring to the terms commonly used in physics, electromagnetic systems are understood as those where the force field of a permanent magnet interacts with that of an electric current flowing through a coil, and electrodynamic systems as those where electric currents flowing in two coils are interacting with each other.

Electromagnetic and electrodynamic balances were developed because of their high resolving power especially for the requirements of laboratories. The highest possible readability combined with very high absolute sensitivity are here the important criteria. Instruments which

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**Author** Jenemann, H.R.

**Title** **The early history of balances based on electromagnetic or electrodynamic force compensation**

**In** La massa e la sua misura; storia, scienza, tecnica, legislazione e didattica - Mass and its measurement; history, science, technology, legislation and didactics - Modena 15-16-17 Settembre 1993, pp. 9-20 (ed.: Lorella Grossi)

**Size** 12 pp., ill., 21 x 19.7 cm

**Publisher** Museo della bilancia / CLUEB (Cooperativa Libreria Universitaria Editrice Bologna).

**Place** Campogalliano / Bologna

**Year** 1995

**ISBN ISSN** 88-8091-222-4

**Abstract**

**Remarks**