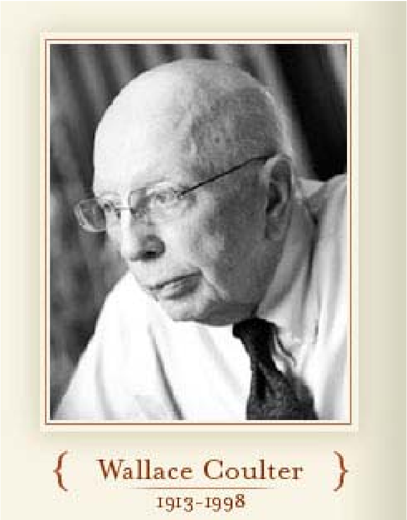
WHAT IS THE COULTER PRINCIPLE?

INTRODUCTION



While under contract with the United States Navy in the late 1940s, Wallace H. Coulter developed a technology for counting and sizing particles. The technology was principally developed to count blood cells quickly. Presently over 98% of automated cell counters incorporate the Coulter principle. In the past fifty years, the technology has also been utilized to characterize thousands of different industrial particulate materials as well. Any instrument utilizing this principle is commonly called a Coulter Counter. Coulter Counter is also a registered trademark. Drugs, pigments, fillers, toners, foods, abrasives, explosives, clay, minerals, construction materials, coating materials, metals, filter materials, and many others have all been analyzed by the Coulter principle. It can be used to measure any particulate material that can be suspended in an electrolyte. Particles as small as 0.4 μm and as large as 1200 μm in diameter can routinely be measured. Over the years, Coulter Counter has become the synonym for particle characterization technology in many fields. The technology is the subject of an ISO standard (ISO 13319) and many national standards. Over 8000 references to the uses of this technology have been documented.

DESCRIPTION OF THE TECHNOLOGY

In a Coulter counter, a tube with a small aperture on the wall is immersed into a beaker that contains particles suspended in a low concentration electrolyte. Two electrodes, one inside the aperture tube and one outside the aperture tube but inside the beaker, are used to provide a current path with the electrolyte when an electric field is applied (Figure 1). The impedance between the electrodes is then measured. The aperture creates what is called a “sensing zone." Particles in low concentration, suspended in the electrolyte, can be counted by passing them through the aperture. As a particle passes through the aperture, a volume of electrolyte equivalent to the immersed volume of the particle is displaced from the sensing zone. This causes a short-term change in the impedance across the aperture. This change can be measured as a voltage pulse or a current pulse. The pulse height is proportional to the volume of the sensed particle. If constant particle density is assumed, the pulse height is also proportional to the particle mass. This technology thus is also called aperture technology.

Using count and pulse height analyzer circuits, the number of particle and volume of each particle passing through the sensing zone can be measured. If the volume of liquid passing through the aperture can be precisely controlled and measured, the concentration of the sample can be determined. In modern Coulter Counters, such as Beckman Coulter’s MS 3 instruments, pulses are digitized and saved with several key parameters that describe each pulse such as pulse height, pulse width, time stamp, pulse area, etc. These parameters will allow instrument to better discriminate between noise and real pulses and between normal pulses and distorted pulses due to various reasons when particles transit through the aperture. The saved pulses can be also used to monitor sample changes over the measurement time period if pulses are arranged in time sequence. In practice, the particle volume is often represented in terms of equivalent spherical diameter. The measured particle volume (or size) can be then used to obtain particle size distribution.

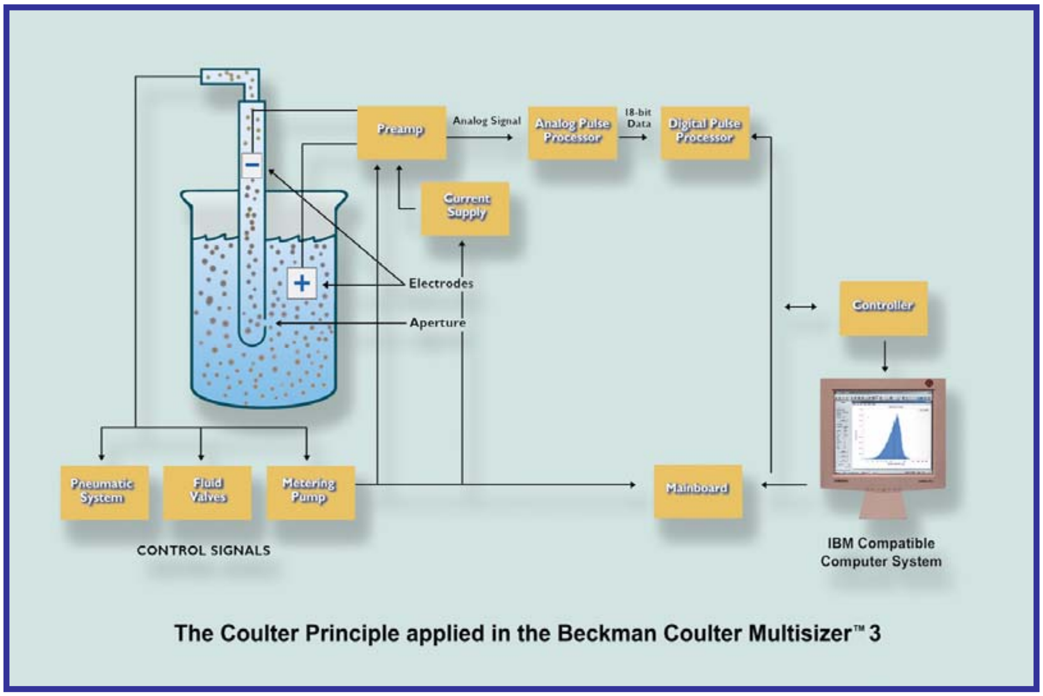


Figure 1. Schematic of a Coulter Counter

A typical measurement using Coulter Counter takes less than a minute as counting and sizing rates of up to 10,000 particles per second are possible. The accuracy of the size measurements can be better than 1%. Aperture size typically ranges from 15 µm to 2000 µm. Each aperture can be used to measure particles within a size range of 2% to 60% of its nominal diameter. Therefore, the overall particle size range of 0.4 µm to 1200 µm is possible. The ability of the technology to analyze particles is limited to those particles that can be suitably suspended in an electrolyte solution. The upper limit therefore may be 500 µm for sand but only 75 µm for tungsten carbide particles. The lower size limit is restricted by electronic noise generated mainly within the aperture itself. The selection of the most suitable aperture size is dependent upon the particles to be measured. If the sample to be measured is composed of particles largely within a 30:1 diameter size range, the most suitable aperture can be chosen. For example, a 30 µm aperture can measure particles from about 0.6 to 18 µm in diameter. A 140 µm aperture can measure particles from about 2.8 to 84 µm. If the particles to be measured cover a wider range than a single aperture can measure, two or more apertures have to be used and the test results can be overlapped to provide a complete particle size distribution.