



ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

PQI 3203 Fenômenos de Transporte I

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ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

Aula 14 – Caracterização de partícula

PQI 3203 Fenômenos de Transporte

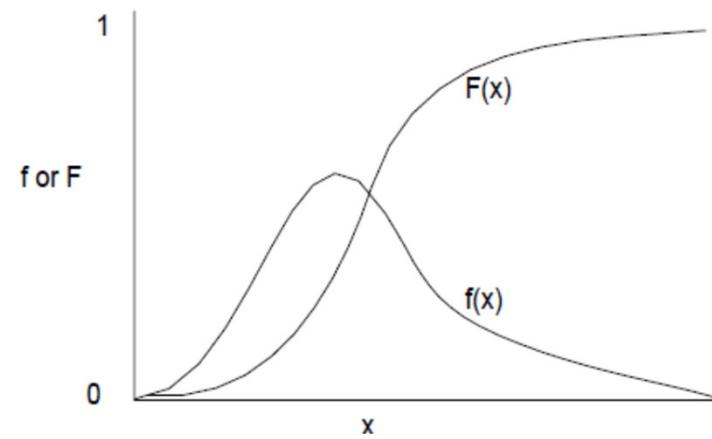
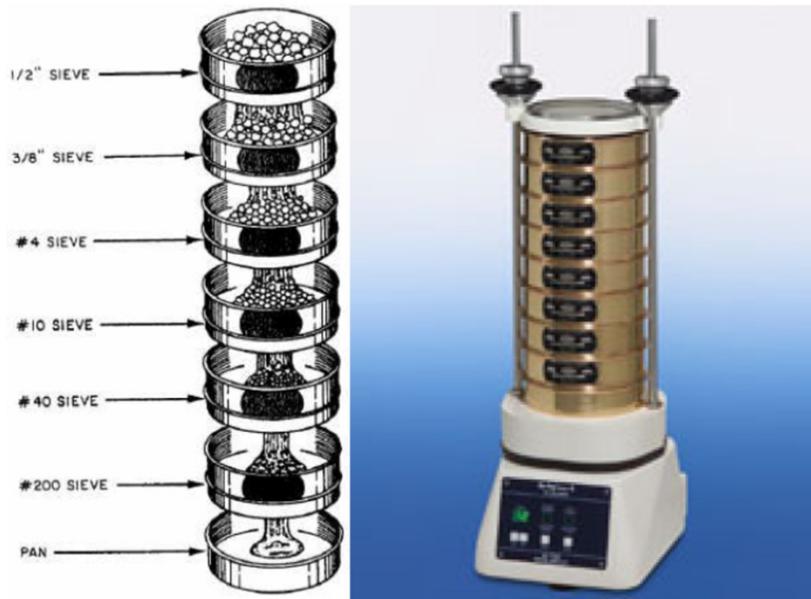


Roteiro

1. Caracterização de partícula por tamanho
2. Análise granulométrica
3. Microscopia
4. Permeametria
5. Pipeta de Andreasen
6. Difração a laser
7. Contador Coulter
8. Conclusão



1 Análise granulométrica (AG)



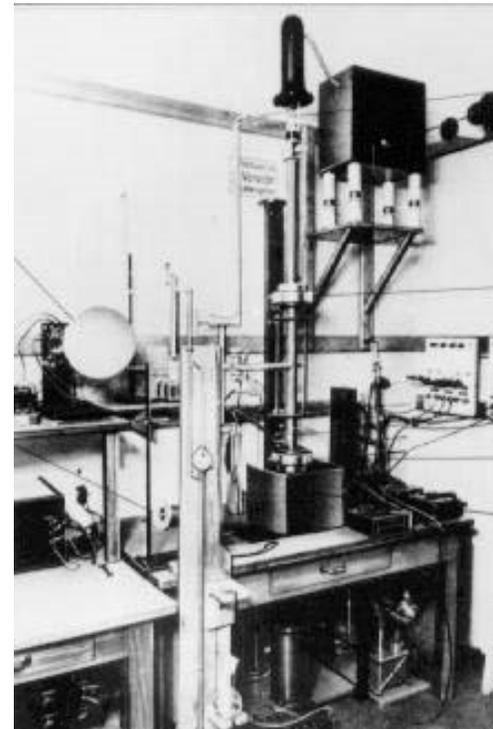
2 Microscópio ótico

- partículas de tamanhos entre 0,5 a 100 μm
- Resolução 0,25 μm

Dificuldades

- Difração
- Pequena profundidade
- Problemas com preparação de lâmina

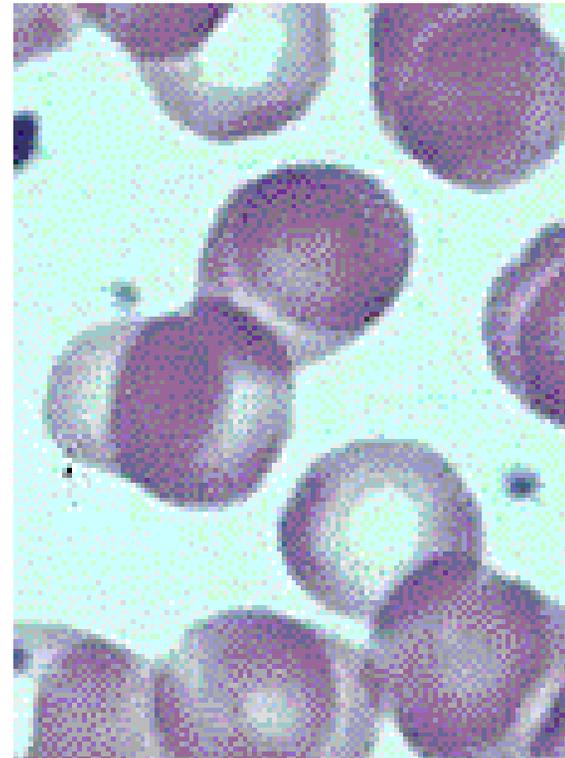
- 1° Microscópio ótico - 1938



2 Microscópio ótico



- hemácias



2 Microscópio ótico - medição

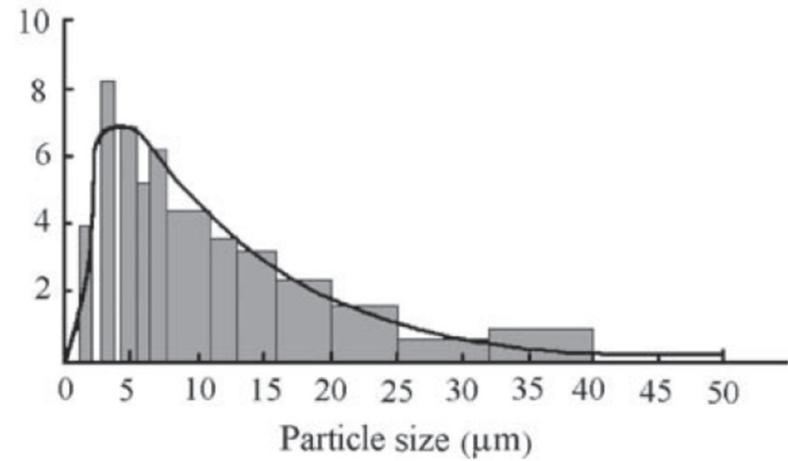
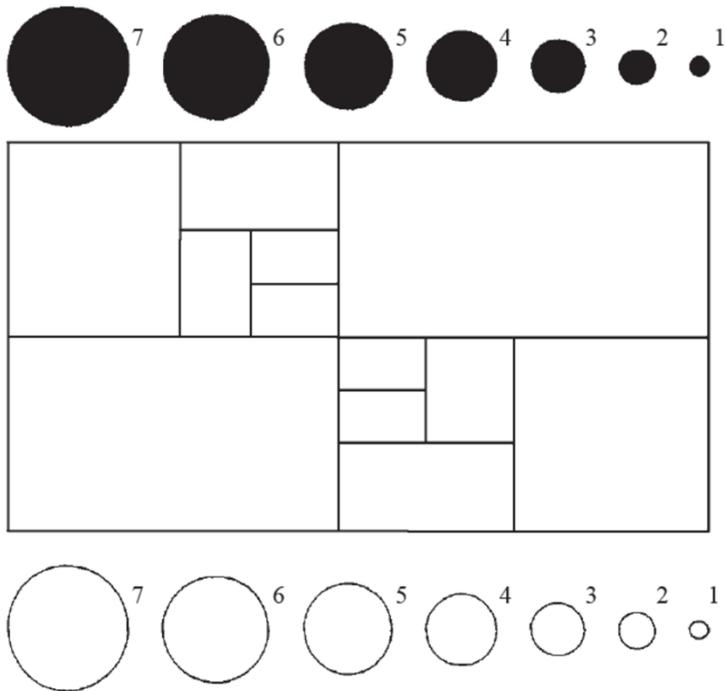


Figure 1.14 The British Standard eyepiece graticule for particle diameters measuring in optical microscope.



3 Microscópio eletrônico

São instrumentos científicos que usam feixe de elétrons de alto energia para examinar amostras finas:

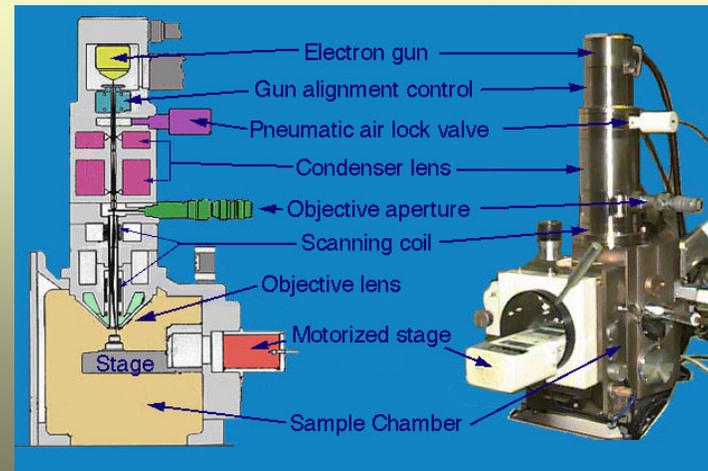
- Topografia
- Composição
- cristalografia



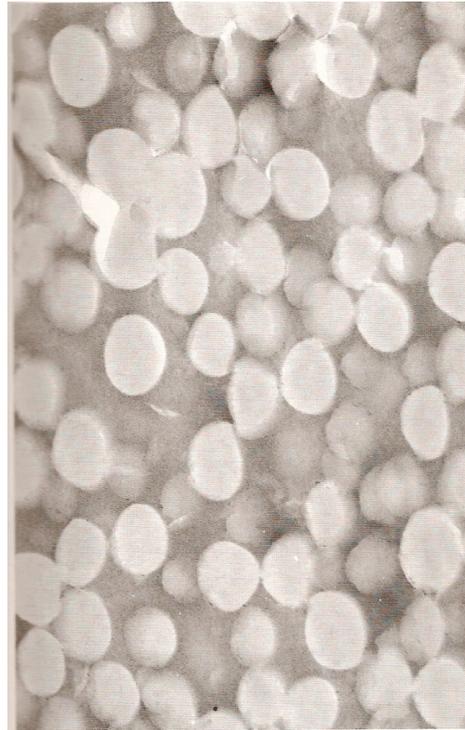
3.1 Microscópio Eletrônico de Transmissão (MET)

- partículas de tamanhos entre 0,001 a 5 μm
- Resolução 2 a 100 nm
- fotografia

Microscopia Eletrônica de Transmissão

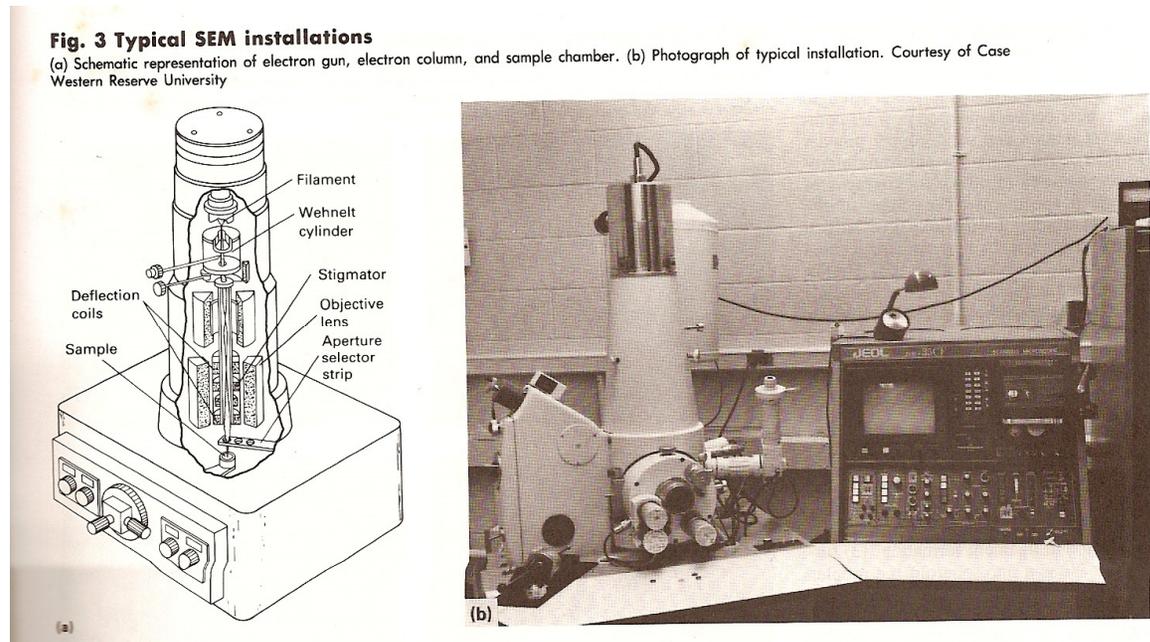


3.1 MET látex de estireno e butadieno 100 μm



3.2 Microscópio Eletrônico de Varredura (MEV)

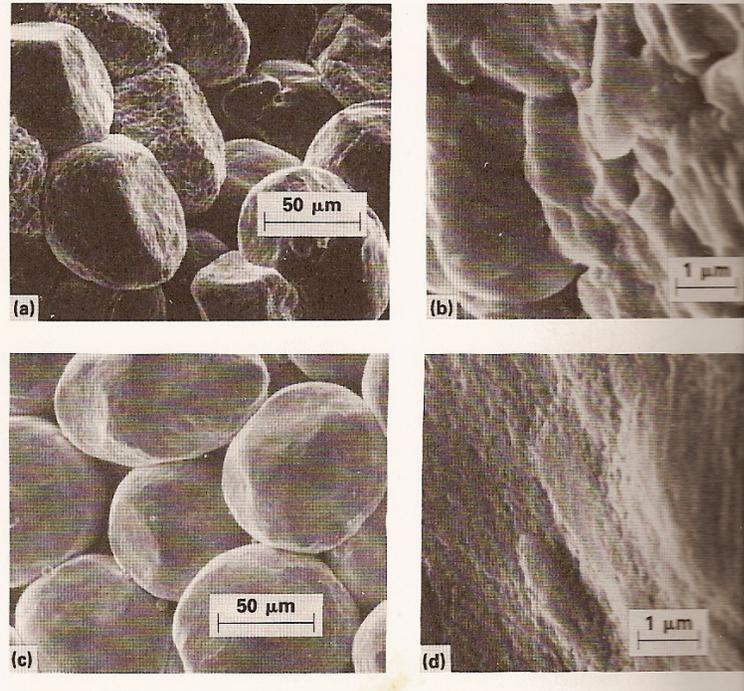
- partículas de tamanhos entre 1 μm a 1 mm
- Resolução 10 nm
- Fotografia
- Varredura



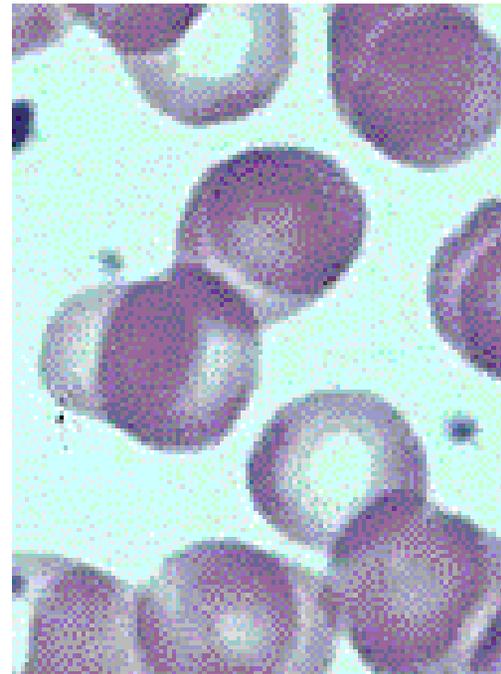
3.2 Microscópio Eletrônico de Varredura (MEV)

Fig. 5 Scanning electron micrographs of pressed copper powder

Porous copper particles at lower (a) and higher (b) magnifications. Solid copper particles at lower (c) and higher (d) magnifications. Lower magnifications reveal greater contact area of the individual particles. Higher magnifications show surface penetration effect, which further increases the contact area, resulting in enhanced green strength of the porous powder.



3.2 MEV e óptico - hemácias



4 Permeâmetro ($D_p > 1 \mu\text{m}$)

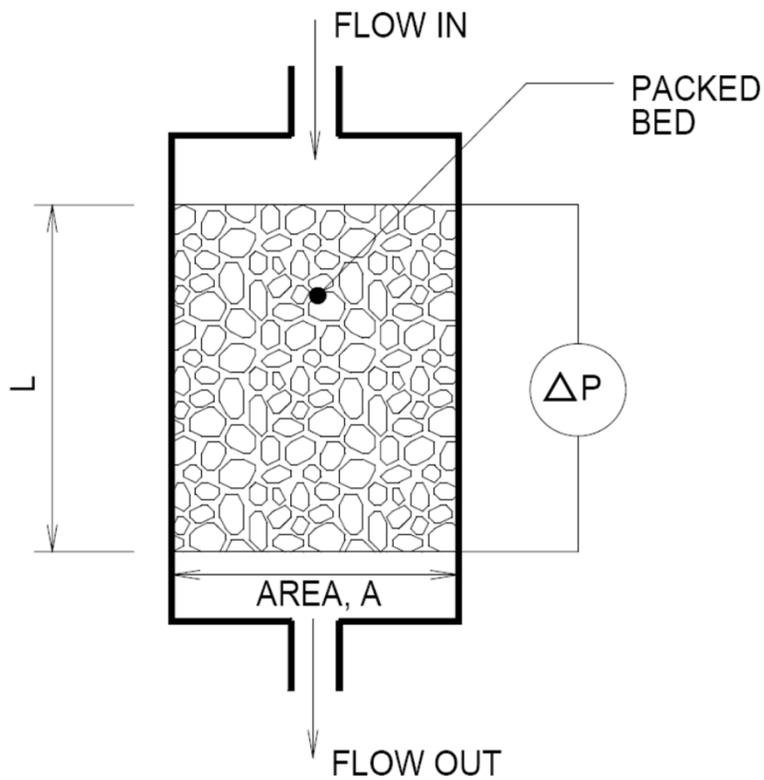


Figure 4-10. Typical Packed Bed.

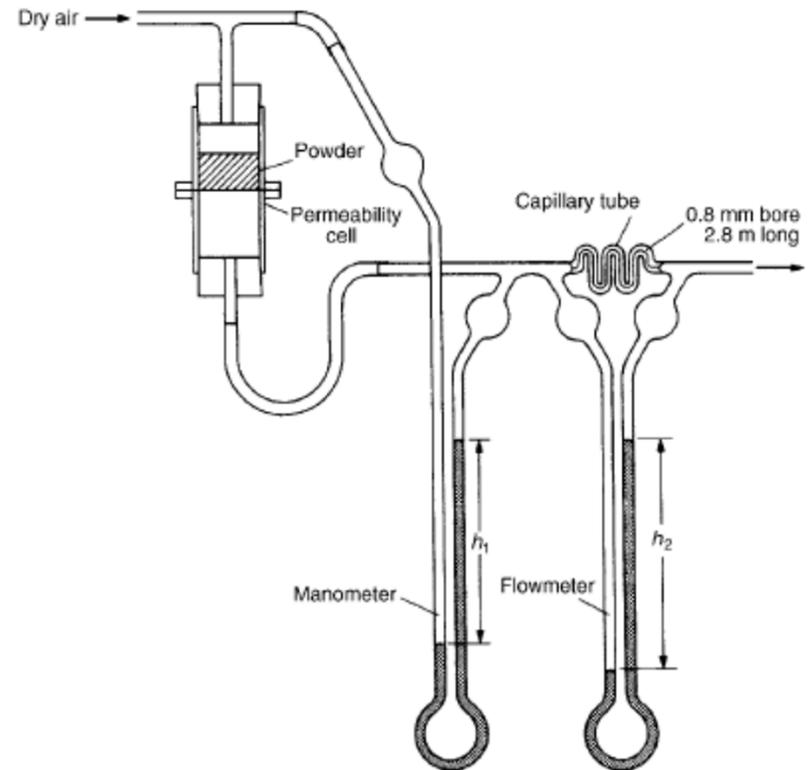
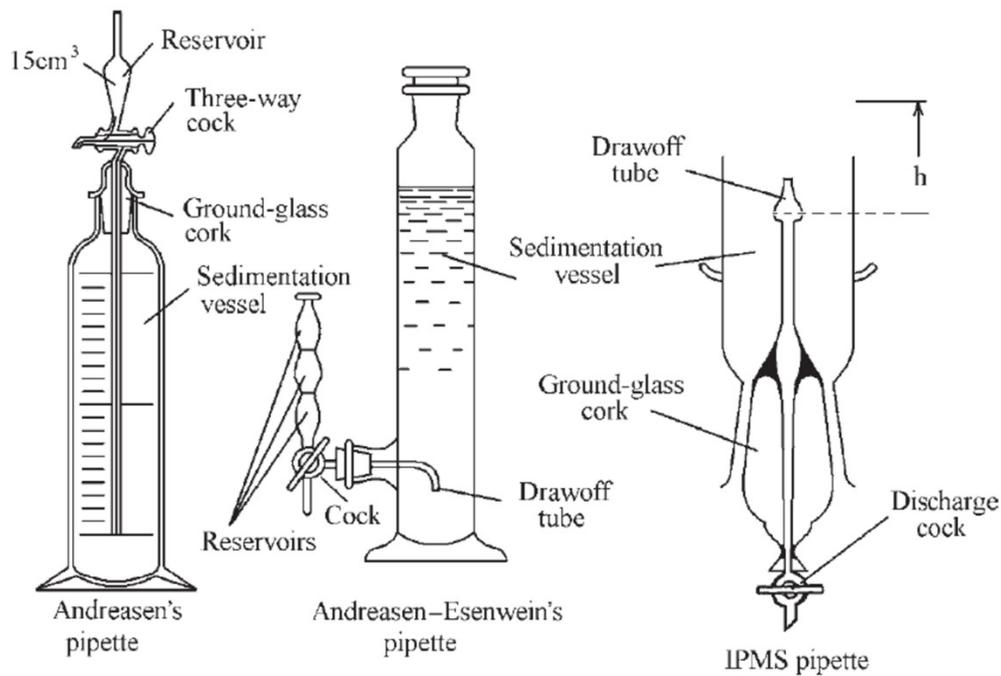


Figure 4.4. The permeability apparatus of LEA and NURSE⁽²²⁾



5 Pipeta de Andreasen

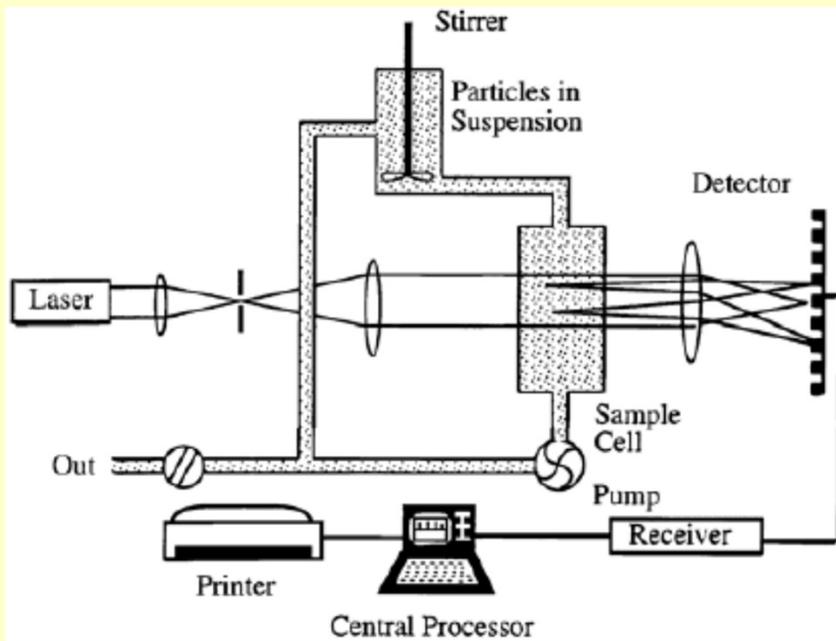


- $d_{st} = \sqrt{\frac{18 \eta u}{(\rho_s - \rho_f) g}}$
- $5 \mu\text{m} < D_p < 100 \mu\text{m}$

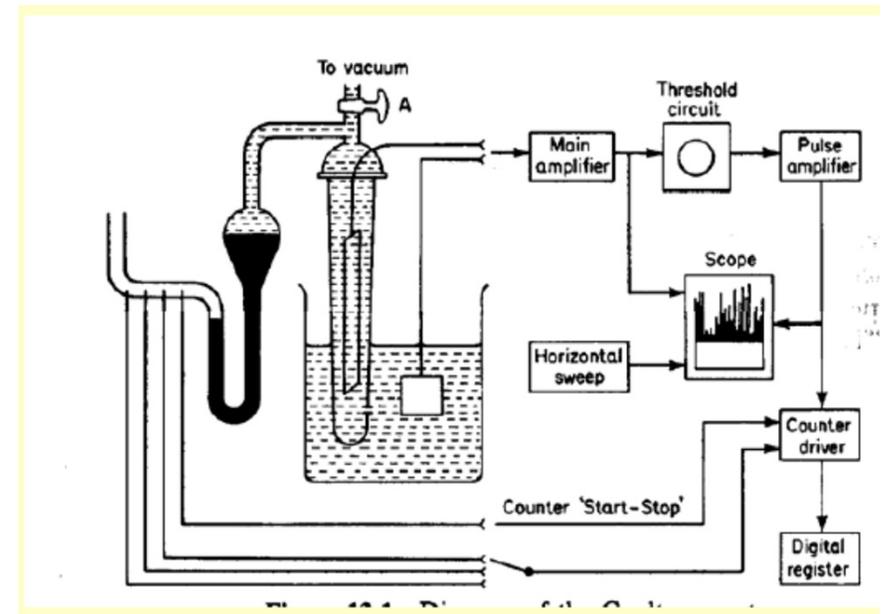
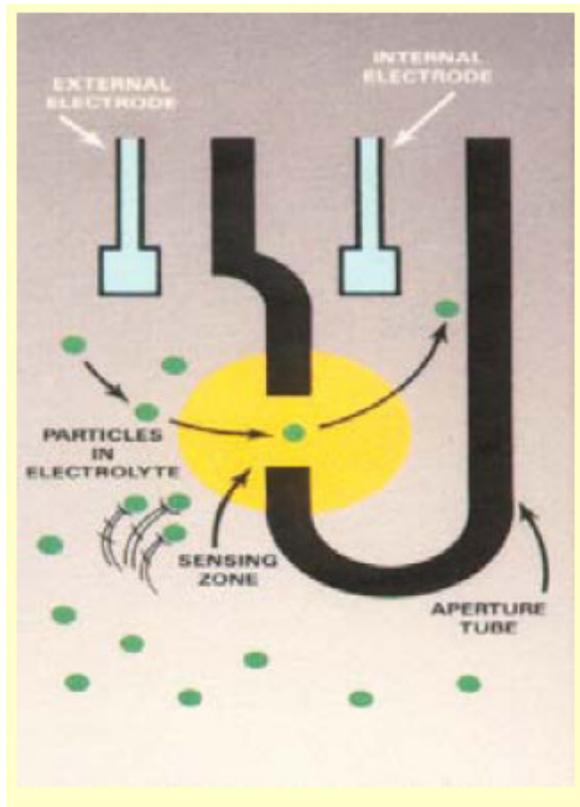


6 Difração a laser

Malvern Laser Diffraction



7 ELECTROSENSING ZONE-COULTER PRINCIPLE



7 Contador COULTER



8 Conclusões

- Tamanho de partícula
- Princípios físicos diferentes
- Valores diferentes
- Custo x benefício



Bibliografia

- ALLEN, T. **Particle size measurement**. Springer, 2013.
- JM Coulson, JF Richardson, JR Backhurst, JH Harker, **Chemical Engineering: Vol. 2. Particle Technology and Separation Processes**, 6th ed., Butterworth-Heinemann, 2019.
- NEIKOV, Oleg D.; LOTSKO, Dina V.; GOPIENKO, Victor G. Powder characterization and testing. **Handbook of Non-Ferrous Metal Powders: Technologies and Applications**. Oxford: Elsevier, 2009.