



ElectroStatic Detection Apparatus

ESDA

An instrument for the detection of indented writing documents

11th November 2020

Topics to be discussed

- Indented Writing
- Indentation Recovery Methods
- ElectroStatic Detection Apparatus (ESDA)
 - Basic Principles of ESDA and its components
 - Fundamental of Electrostatics
 - Variables Affecting the Results from ESDA
- Example of Questioned Document
- Appendix : Theoretical consideration

Indented Writing : The Origin



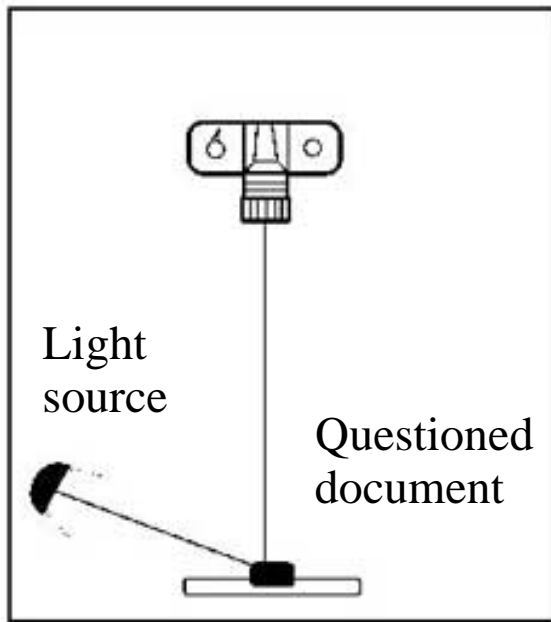
- If a document is written while resting atop other papers, impressions of the writing will be transferred to the underlying sheets.

<http://www.leelofland.com/wordpress/?p=4265>

The **Non-Destructive** Indentation Development Methods

- Indented writing is normally recovered by
 - photographically using oblique-angle light, or
 - using of an apparatus commonly referred to as **ESDA**, for **E**lectro**S**tatic **D**etection **A**pparatus.

Oblique Lighting :light shone at a shallow angle



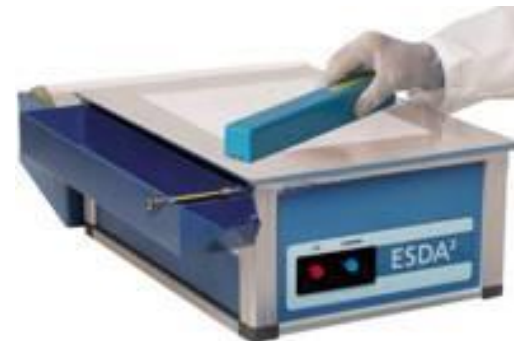
- Oblique-angle lighting casts shadows into the depressions in the paper.
- The record prints of the images are obtained by photographed.
- **The technique is time consuming and can recover only the deep impressions.**



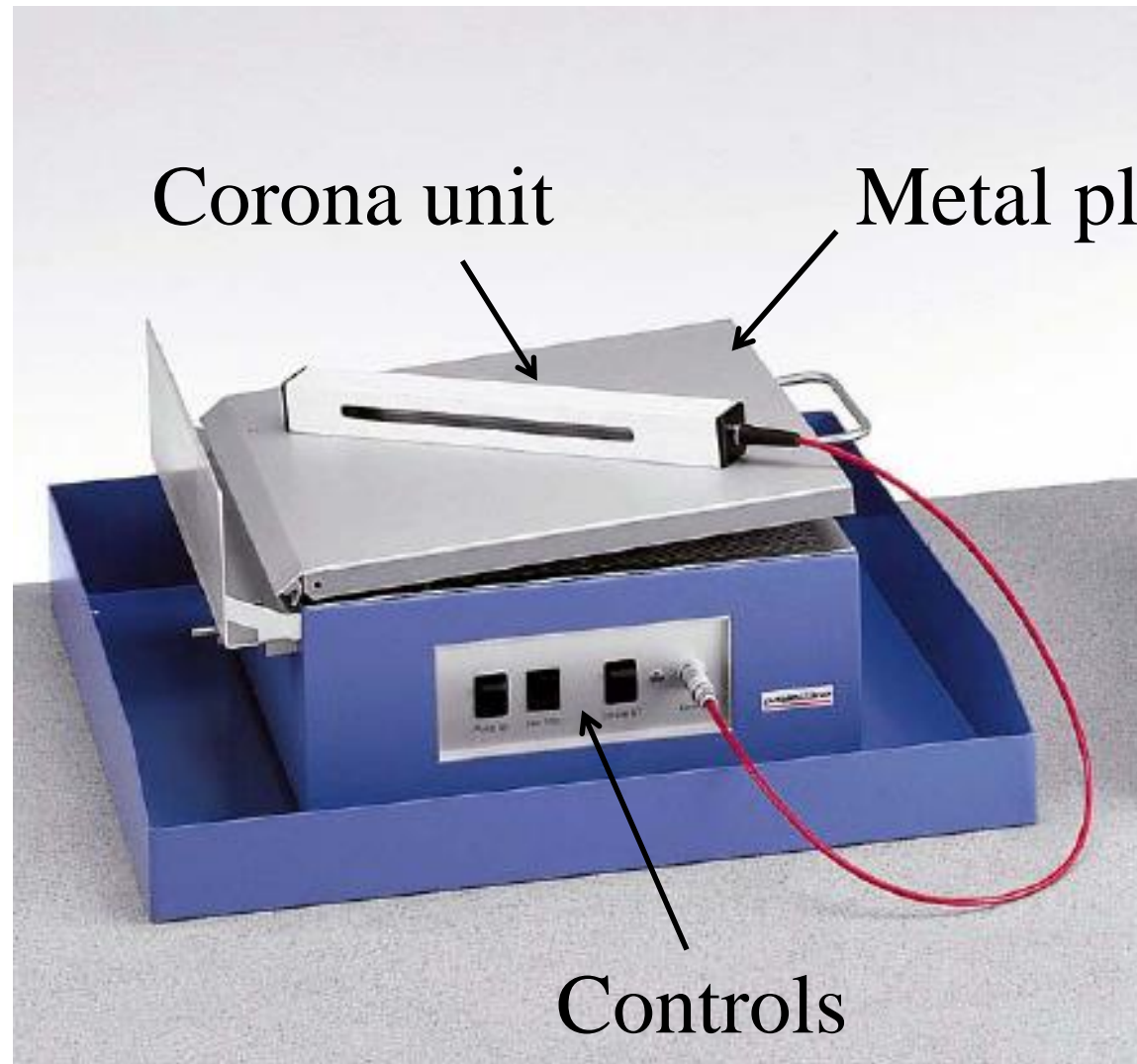
<http://www.staggspublishing.com/closeup.html>

ElectroStatic Detection Apparatus ESDA

- A more sensitive technique based on the electrostatic principle was proposed by D J Foster and D K Morantz in 1978.
- Weak latent writing impressions on the surface of a paper can be effectively detected and permanently recorded.



ESDA: Projectina Docustat DS-210



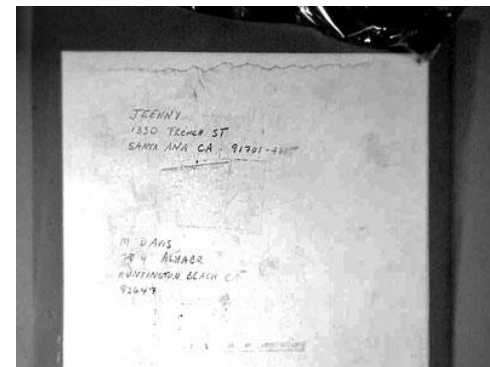
Corona unit

Metal plate

Controls

Basic ESDA Steps

- Humidify the document (optional)
- Place document on metal plate & turn on vacuum
- Pull imaging film over document & remove wrinkle
- Charge the imaging film with corona wire
- Turn off the vacuum and tilt the metal plate
- Apply developing powder
- Preserve the test results



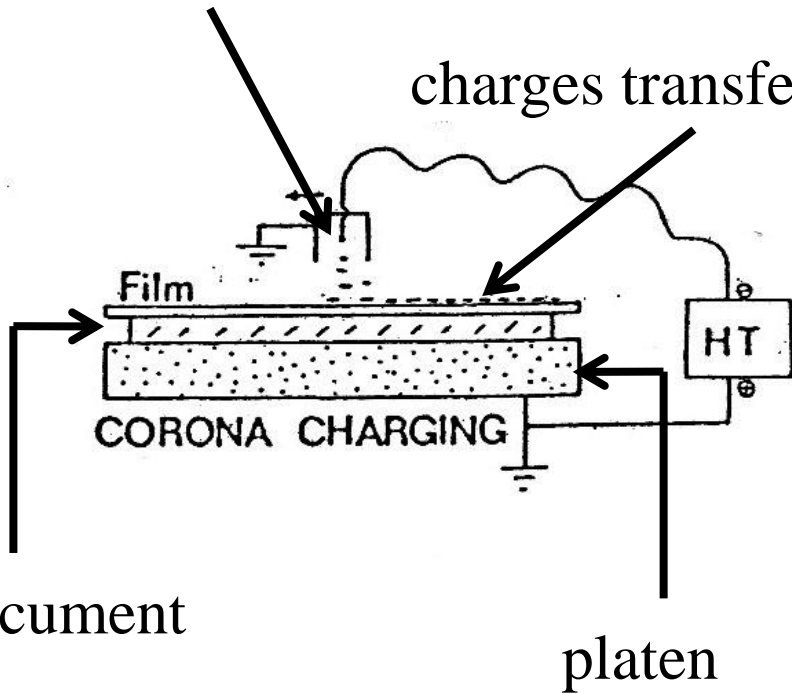
- [ESDA.mp4](#)



Electrostatic Methods of ESDA (1)

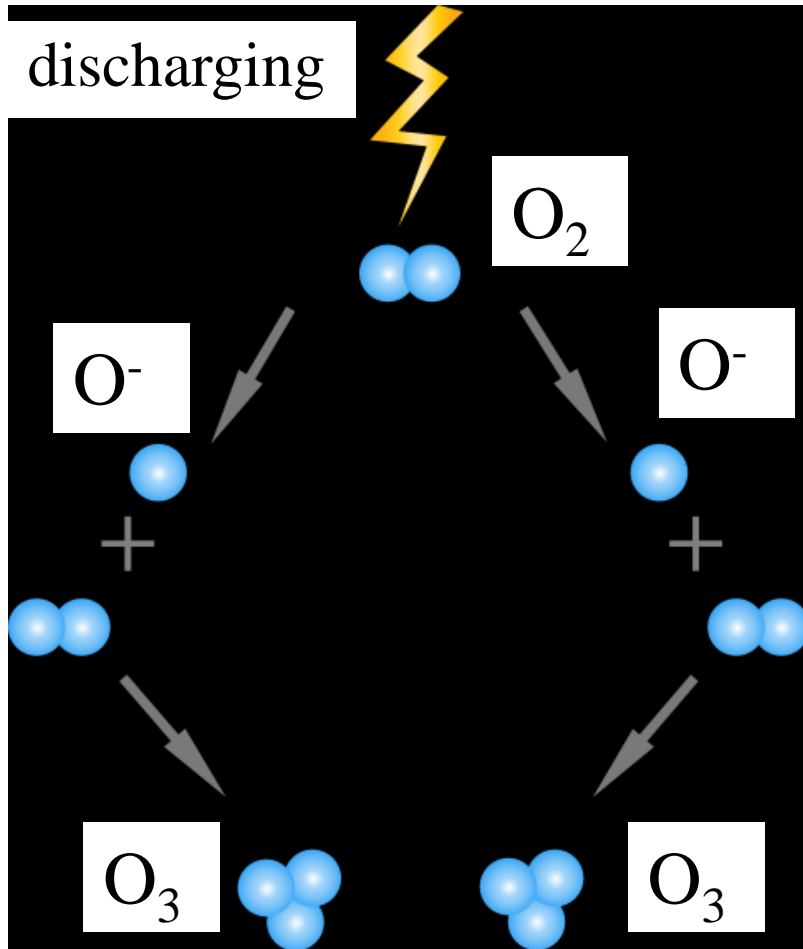
corona wire (inside a metal case)

charges transferred



- Corona wire inside the corona unit is charged at a high negative voltage of 5kV.
- Subsequently, the **negative charges** are transferred to the imaging film.

Ozone Generation from ESDA

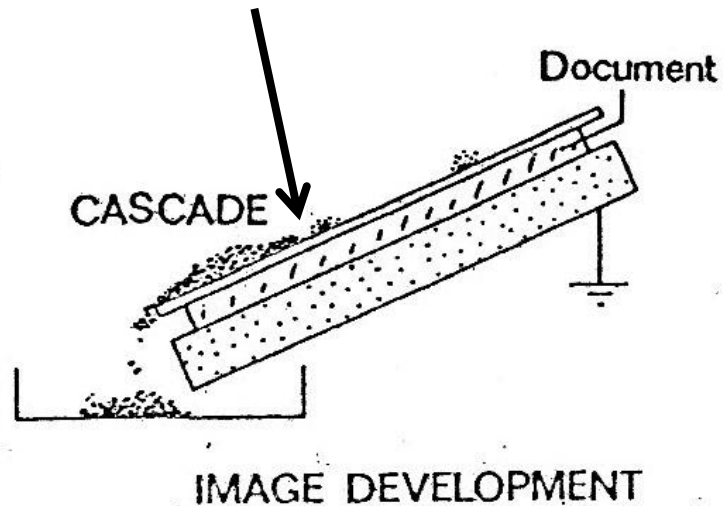


- When the corona wand is used, the electric filament generates ozone gas.
- The ozone gas is generated from the corona discharging.
- Ozone can cause respiratory irritation and breathing difficulty.

http://www.ozoneapplications.com/info/cd_vs_uv.htm

Electrostatic Methods of ESDA (2)

charged pigmented toner powder



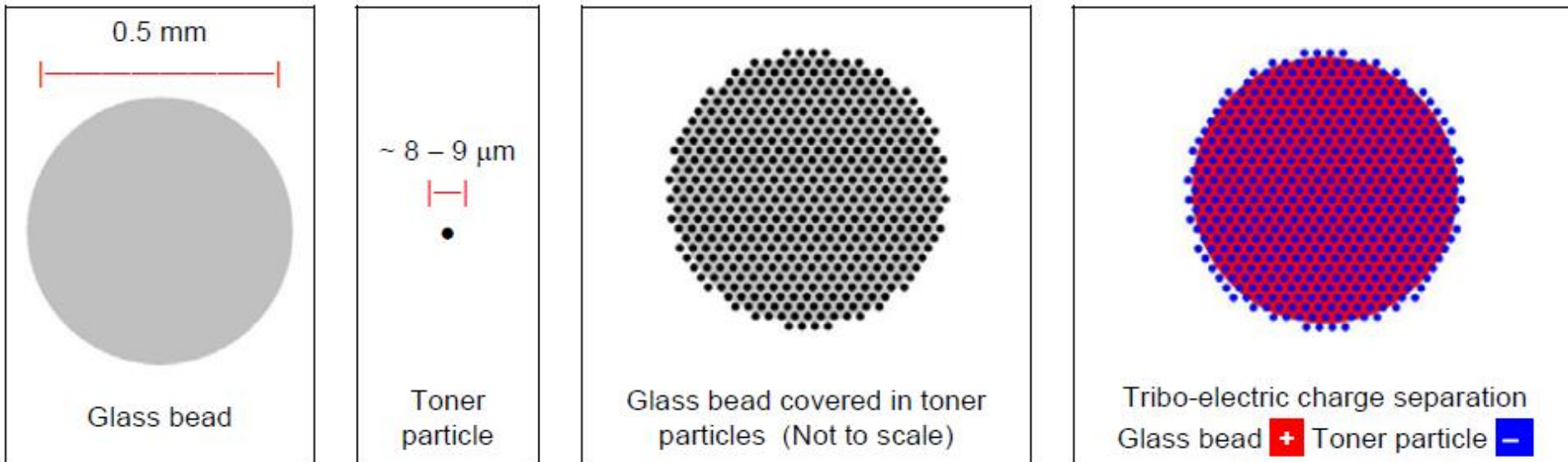
- Toner is cascaded across the film while the platen is raised.
- Variables include :
 - Angle of platen
 - Position of paper and platen
 - Rate of flow, and
 - Amount of toner deposited
- Alternatively, a fine powder may be sprayed from a nozzle.

Imaging Film

- The insulating imaging film has a polyester base manufactured under the trade name Mylar.
- The thickness of film is roughly 5 to 10 microns.
- Important roles of the film include
 - protect the document from the developing powder, and
 - act as a dielectric or insulating, charge-trapping material.

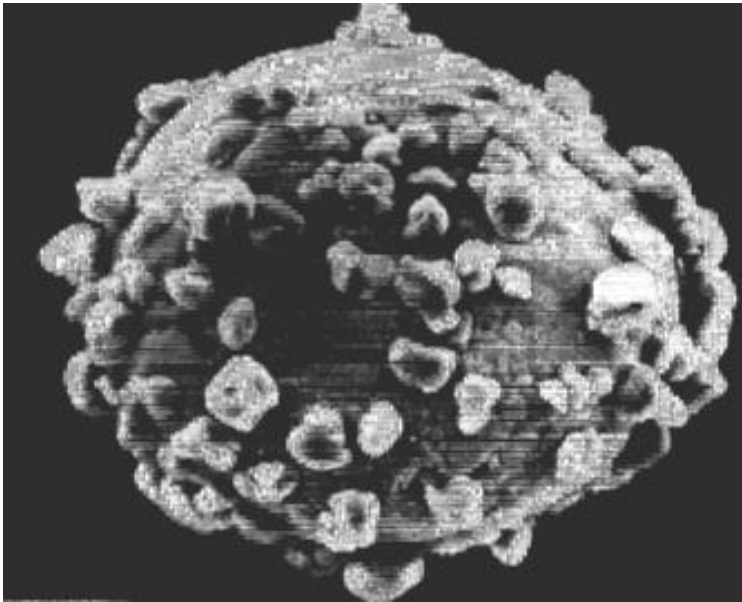


Cascade developer



- Cascade developer is a mixture of **glass beads** and **ESDA toner**.
- The tribo-electric properties of the two materials are carefully selected so that the glass naturally loses electrons to the toner material, causing the beads to **charge positively** and the **toner particles negatively**.
- The constituents interact and the beads become coated with toner particles.

Toner



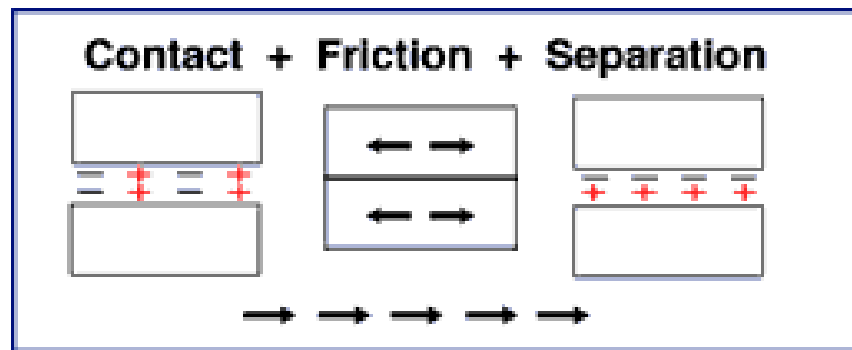
A small glass bead coated with particles of toner

- Toner is a fine, negatively charged, black powder similar to that used in photocopying machines and laser printers.
- Toner powder becomes **tribo-electronically** charged when in contact with glass beads.

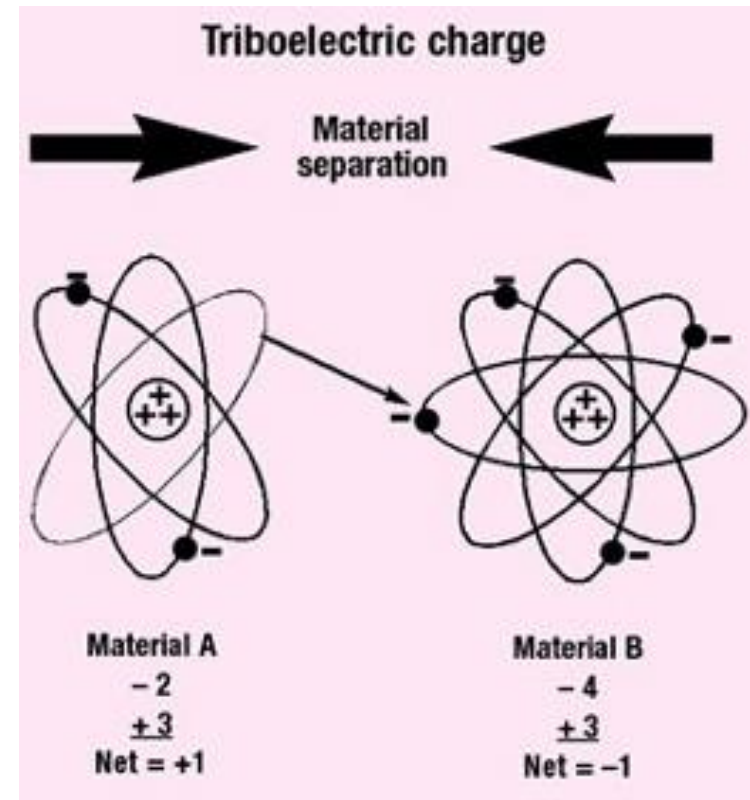
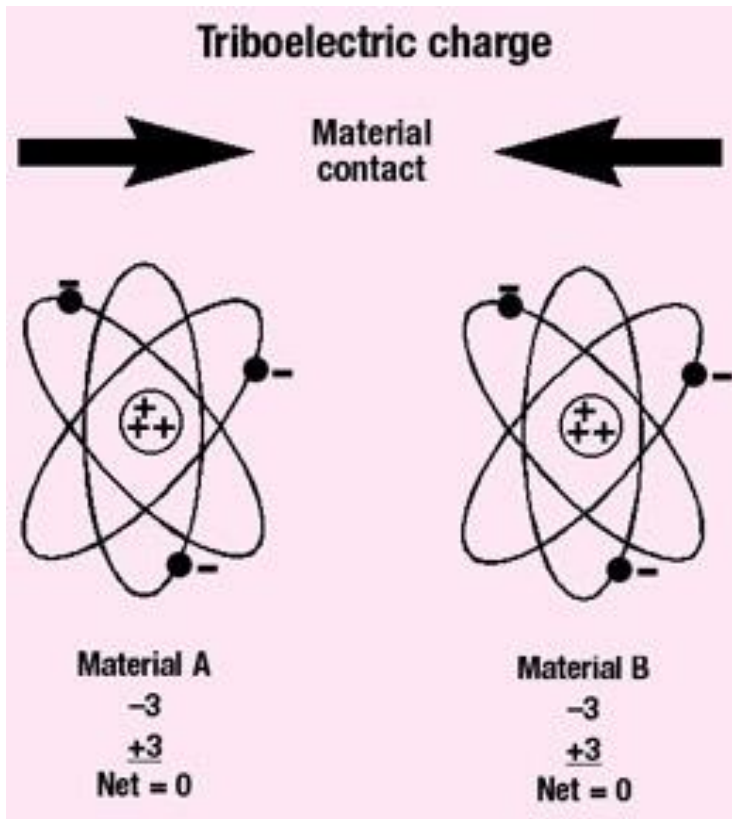
<http://home.howstuffworks.com/photocopier.htm>

Triboelectric Effect

- The **triboelectric effect** is also known as *triboelectric charging*.
- The process of triboelectric charging results in one object gaining electrons on its surface, and becoming negatively charged, and another object losing electrons from its surface, and becoming positively charged.



Triboelectric Charging



(1) Before contact, both materials are electrically neutral.

(2) After contact, both materials are differently charged.



POSITIVE CHARGE

Air
Human body
Glass
Human hair
Nylon
Wool
Silk
Aluminium
Paper
Cotton

Iron

Wood
Hard rubber
Nickel Copper
Brass silver
Gold Platinum
Artificial silk
Polystyrene
Polyester
Polyurethane
Polyethylene
Polypropylene
PVC (vinyl)
Silicon

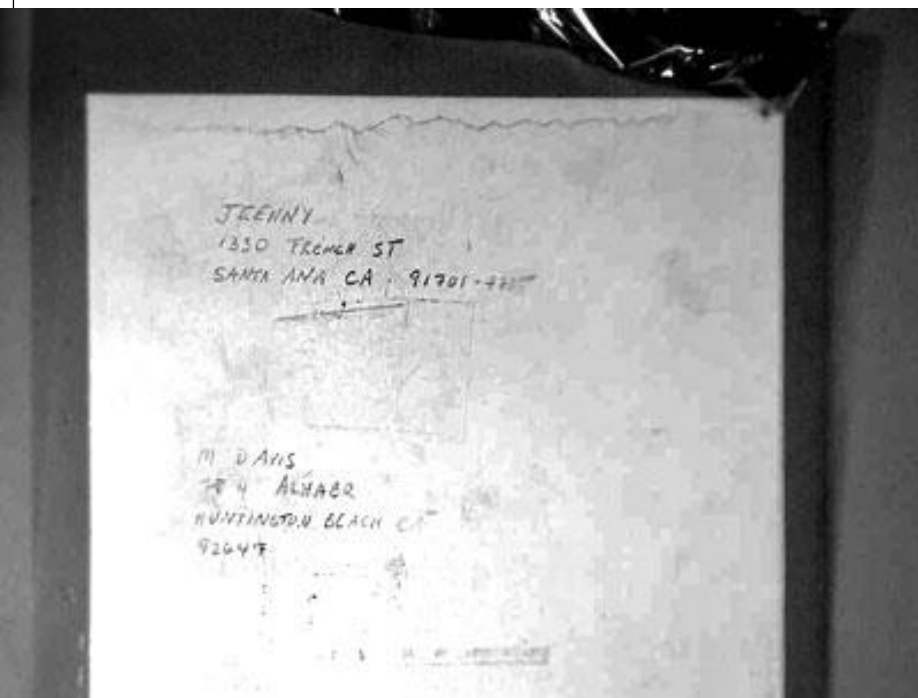
NEGATIVE CHARGE

Troboelectric Series

- a triboelectric series shows a ranking of materials' ability to hold or give up electrons.

<http://www.simco.nl/info/about-simco/introduction-to-static/>

Charging Distribution on the Imaging Film



ESDA lift off impression

- Variations on the surface of the document cause correspondent distribution of toner on the document.
- The deeper the indentation, the more toner adheres to the spot.
- Images of indentation are developed as black lines on a lighter background.
- The image may be recorded photographically or preserved with a protective transparent adhesive covering.

Questioned Document Example

Original questioned medical record suspected of being changed.

FBN MEDICAL CENTER

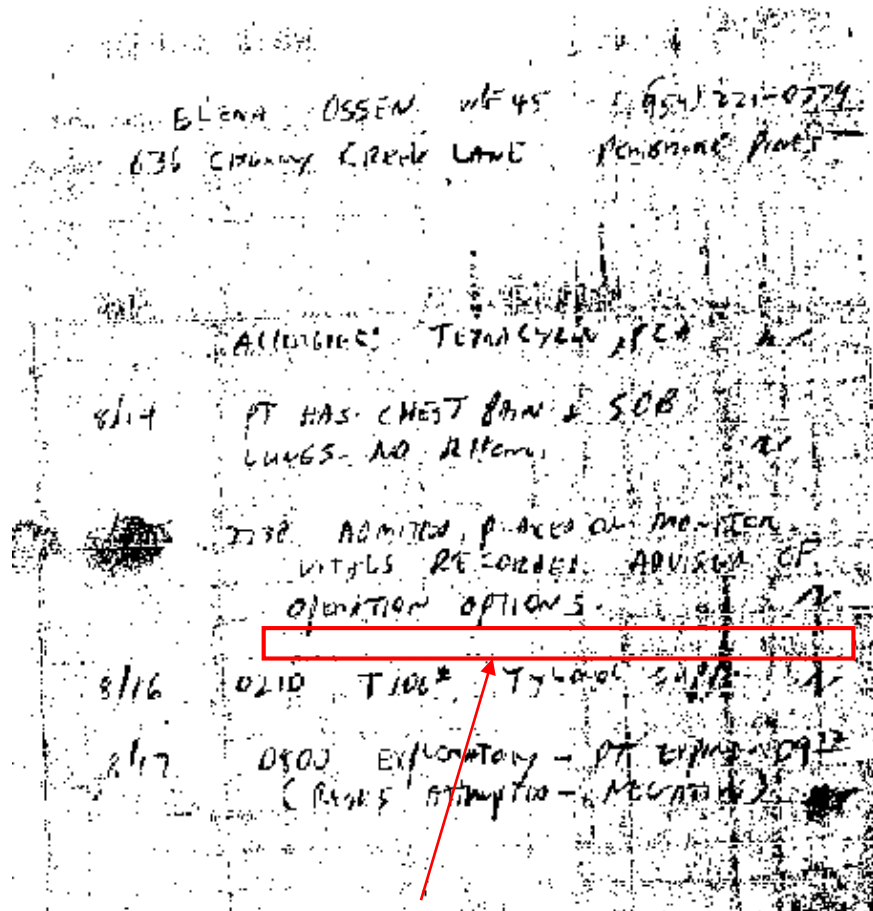
Patient Number 96-0224

Patient's Name ELENA OSSEN W/F 45 Phone (54) 221-0779

Address 636 CHERRY CREEK LANE PEMBROKE PINES

DATE	PROGRESS NOTES
	ALLERGIES: TETRAALYLIN, PCA N
8/14	PT HAS CHEST PAIN + SOB LUNGS- NO R.HORN, N
8/15	2030 ADMISSION, PLACED ON MONITOR. VITALS RECORDED. ADVISED OF OPERATION OPTIONS. N
8/16	0210 T100# TYLOL SUFF. N
8/17	0800 EXPLANATORY - PT EXHIBITS O ₂ ↑ (RESUS ATTEMPTED - NEGATIVE) N

ESDA recovered indented writing from the following page in the medical records



Missing messages in original record

*Peter E. Baier*¹

Application of Experimental Variables to the Use of the Electrostatic Detection Apparatus

REFERENCE: Baier, P. E., “**Application of Experimental Variables to the Use of the Electrostatic Detection Apparatus,**” *Journal of Forensic Sciences*. JFSCA, Vol. 28, No. 4, Oct. 1983, pp. 901-910.

ABSTRACT: The article discusses the theory of the electrostatic detection process and its application to the investigation of questioned documents. A special device for this purpose was developed and introduced to the market in 1978. An experimental design offers a system to determine the quality of the detection process as a function of different technical and environmental factors. Working hypotheses were tested under empirical conditions and gave satisfying results.

KEYWORDS: questioned documents, electrostatic detection apparatus, impressions

Variables affecting the results of **ESDA**

- **Paper types and quality** : poor results from shiny paper, thin newspaper and severely crumpled paper.
- **Writing instrument** : good results from ball point pens
- **Level of impression** : number of layers affecting the quality of the reproduction quality.
- **Humidity and temperature** : humidified documents recommended for better contrast.
- **Development method** : cascade development method is better for weaker indentations.
- **Flexibility of the polymer films** : poor elastic films may not follow the relatively deep grooves of some indented writing.

Use caution when operating ESDA

The examiner using ESDA should exercise caution since

- extreme voltages are part of the application ($\approx 5\text{kV}$) and
- the quantities of ozones produced by the wand are far in excess of the safe exposure rates which should be considered a health hazard.

Summary

- The electrostatic detection apparatus (ESDA) is a technique most commonly used for the visualization of indented impression on questioned documents.
- The function of ESDA is based on the change in the dielectric properties of the paper due to some form of microscopic damage sustained by the paper fibers during the formation of indented writing.

References

1. D J Foster and D J Morantz, “An Electrostatic Imaging Technique For The Detection Of Indented Impressions In Documents”, *Forensic Science International*, 13, 51-54 (1979).
2. D M Ellen, D J Foster and D J Morantz, “The Use Of Electrostatic Imaging in the Detection Of Indented Impressions”, *Forensic Science International*, 15, 53-60 (1980).
3. P E Baier, “Application of experimental variables to the use of the electrostatic detection apparatus”, *Journal of Forensic sciences*, 28, 901-910 (1983).
4. N N Daeid, K Hayes and M Allen, “Investigations Into Factors Affecting the cascade developer used in ESDA- A review”, *Forensic Science International*, 181, 1-9 (2008).

Appendix : Thickness variation theory

Theoretical Explanation (1)

Preliminary consideration

- The indented writing is visualized as the change in the dielectric properties of the paper due to some form of microscopic damage sustained by the paper fibers; i.e. indented impressions.
- The potential difference on the surface of the imaging film is created by the application of the electric charge through the corona wire.
- The metal plate and film constitute a capacitor and the paper document is considered as an insulator (or dielectric) between the two.

Theoretical Explanation (2)

Mechanisms

- The capacitive arrangement is a key to describe the electrostatic phenomenon.
- At the place where the thickness of the paper decreases (the point of indentation), the dielectric constant of the paper increases and results in a **decrease of the surface potential**.
- This leads to a difference in potential across the paper.
- The negatively charged toners, being repelled from the high negatively charged background, **adhere preferentially to those lower potential areas which corresponds to the indented writing**.
- This is assumed that the impressions could be developed because of a reduction in the thickness of the paper.