Strengths and Weaknesses of Access Control Systems

Eric Schmiedl and Mike Spindel

Choosing a System

- Error rate
- Environment
- Cost
- Physical Vulnerability
- Additional Constraints

Error Rate

- False Reject Rate (Type I error)
- False Accept Rate (Type II error)
- Equal Error Rate

Environment

- Does it have to handle inclement weather?
- Vandals?
- Extreme temperatures?

Cost

- You’re on a budget.

Physical Vulnerability

- Decreased resistance to forced and covert entry
  - Electromagnets can be bypassed with packing tape
  - Electric strikes can disable anti-loiding features on locksets
    - “Loiding”: from the celluloid strips originally used to slip latches. Credit cards can also be used.
  - Request to exit sensors can be defeated with balloons, long pieces of plastic, etc.

Additional Constraints

- What load does the system need to handle? How fast does it have to process users?
- Do you need different levels of access for different users? An audit trail?
- Does the system have to talk to a separate alarm system?
- Will it detect or resist physical attacks?

From DOD UG-2045-SHR

How to improve the security of any access control system

Stacking

What you have + What you know + What you are

- Improve either FAR or FRR (in the most common configuration)
- Can reduce security
    - e.g. mechanical key bypass

Centralized systems

- Terminals
- Communication lines
- Servers

Categories of Systems

- Guard
- Token
- Knowledge
- Biometric

Guard Checks Photo ID

- Good:
  - Simple
  - Low initial cost
  - Fast
  - Not affected by the environment.

Guard Checks Photo ID

- Bad:
  - Easy to counterfeit ID cards
  - Cards can be stolen
  - People get complacent
  - Guards have salaries, not a one-time purchase cost.

Guard Checks Photo ID

Source: www.african-safari-pictures.com

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  - 50% false accept rate

Source: www.african-safari-pictures.com

Guard Checks Photo ID

- Ugly:
  - 32.6% error overall
  - Paranoid: 3/6 cashiers rejected a recent, accurate photo at least once
  - 34.09% of the time a blatantly wrong photo was accepted
  - 50% false accept rate
  - 63.64% FAR for a similar-looking photo

Source: www.african-safari-pictures.com

Tokens

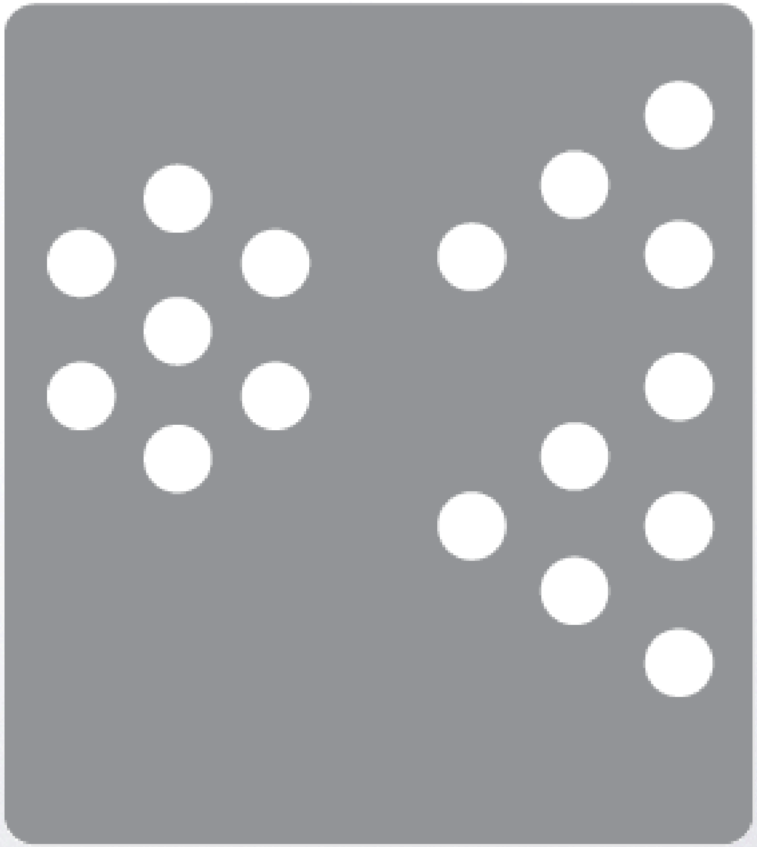
- Mechanical key locks
- Magnetic cards
- Barcodes
- Proximity / RFID
- Smart cards / CPU tokens
- BFV and Wiegand Wire
- VingCard

Mechanical key locks

- Very reliable and need no power supply
- No audit trail
- Lots of security issues
    - Picking
    - Bumping
    - Decoding
- Attacking the master key
- Many different mechanical lock technologies

VingCard

- Mechanical keycards
- Quick to rekey
- Easy to copy
  - Hotel thieves example
- Electronic lock decoding
- Low security



Magnetic Stripe cards

- Low vs. High Coercivity
- Reliable (as long as there's no magnet around)
- Audit trail limited by back-end
- Cheap
- Trivial to read, duplicate, and potentially modify

Barrium Ferrite Cards

- Preceded HiCo magstripe standard
- Embedded layer of Barium Ferrite
- Tough:
    - Weather-resistant
    - High Coercivity
- Easy to decode
- Last seen in an automated parking system

Wiegand Wire

- Processed magnetic alloy
- Single apparent domain wall
- Low coercivity core
- High coercivity shell

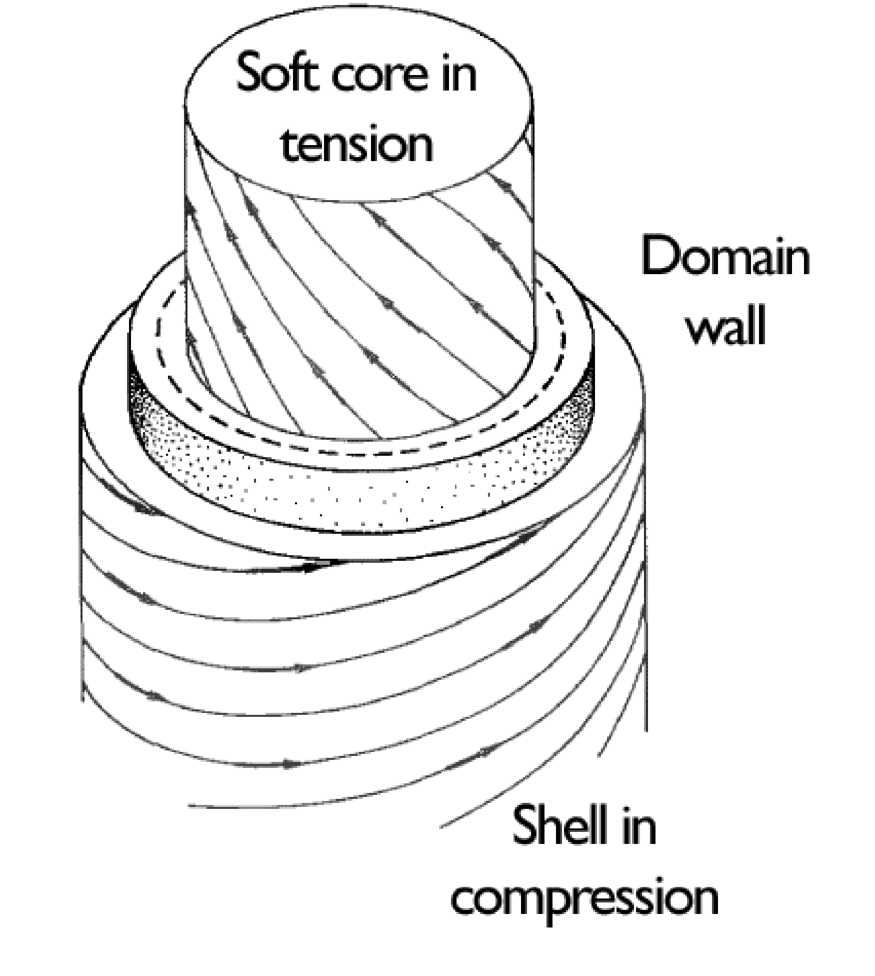


Image adapted from *Switching Behavior of Stressed Vicalloy Wire*, IEEE Transactions on Magnetics, 1979

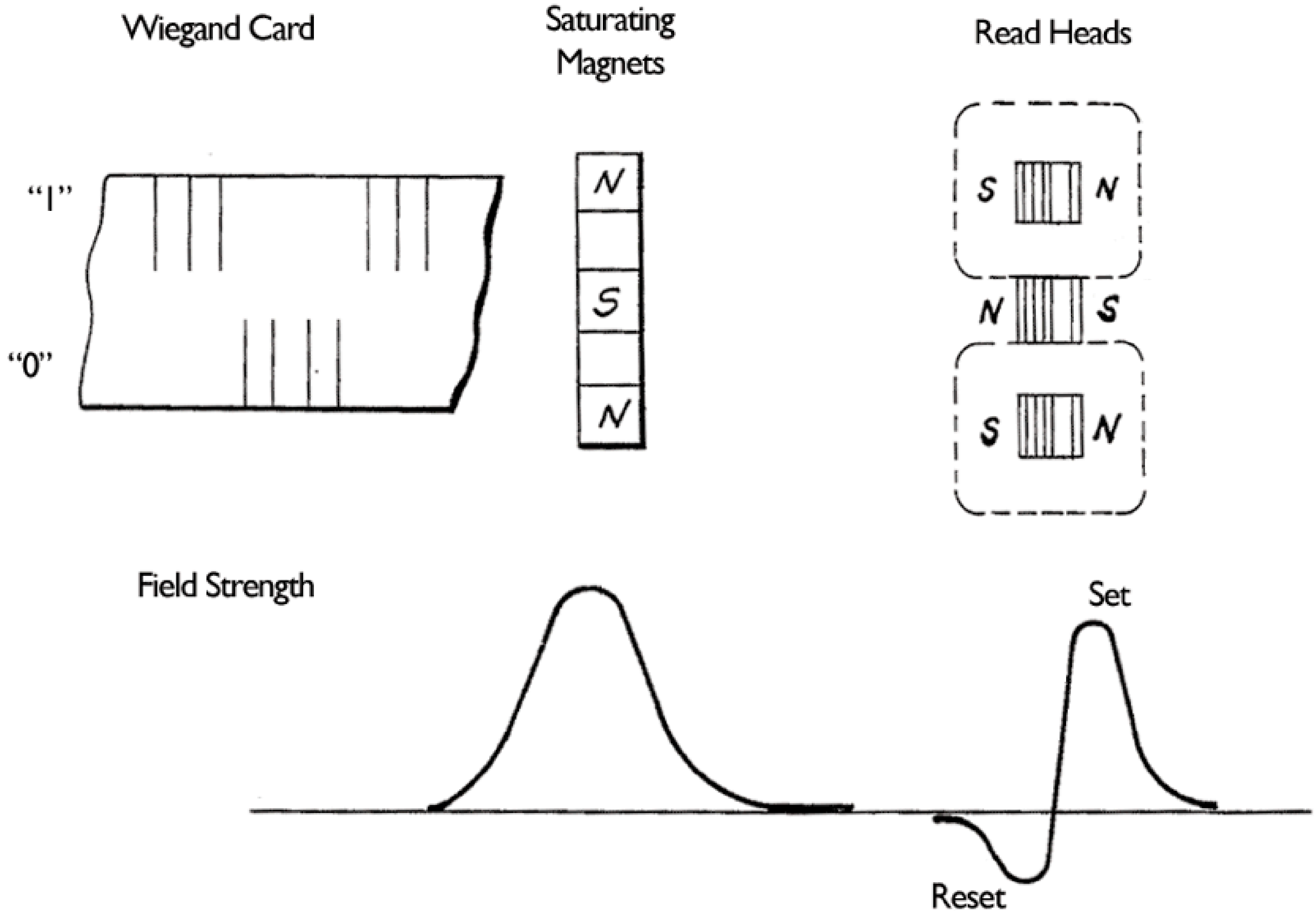
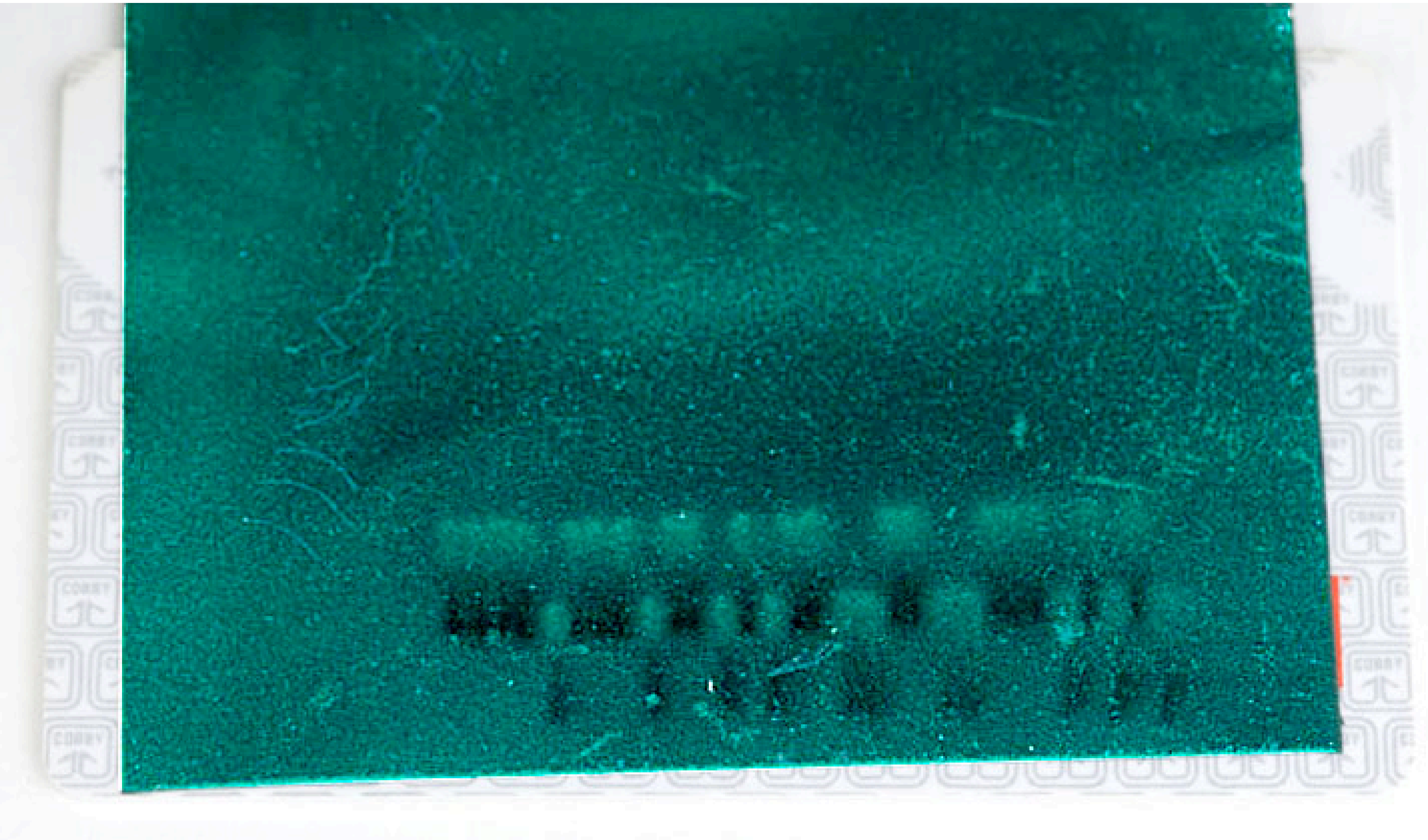


Image adapted from US patent 4,736,122

Wiegand



Wiegand Wire

- First attack published in 1996 on cypherpunks list:
  - Cut wires out of a card and rearrange
- Vulnerable to emulation style attacks

Barcodes

- Cheap, low security
- 1D and 2D versions
- Easy to duplicate
- Invisible barcodes

Prox / RFID

- Many well-known issues
- Cloning
- Hybrid RFID / Magstripe systems

http://web.mit.edu/keithw/Public/MIT-Card-Vulnerabilities-March31.pdf

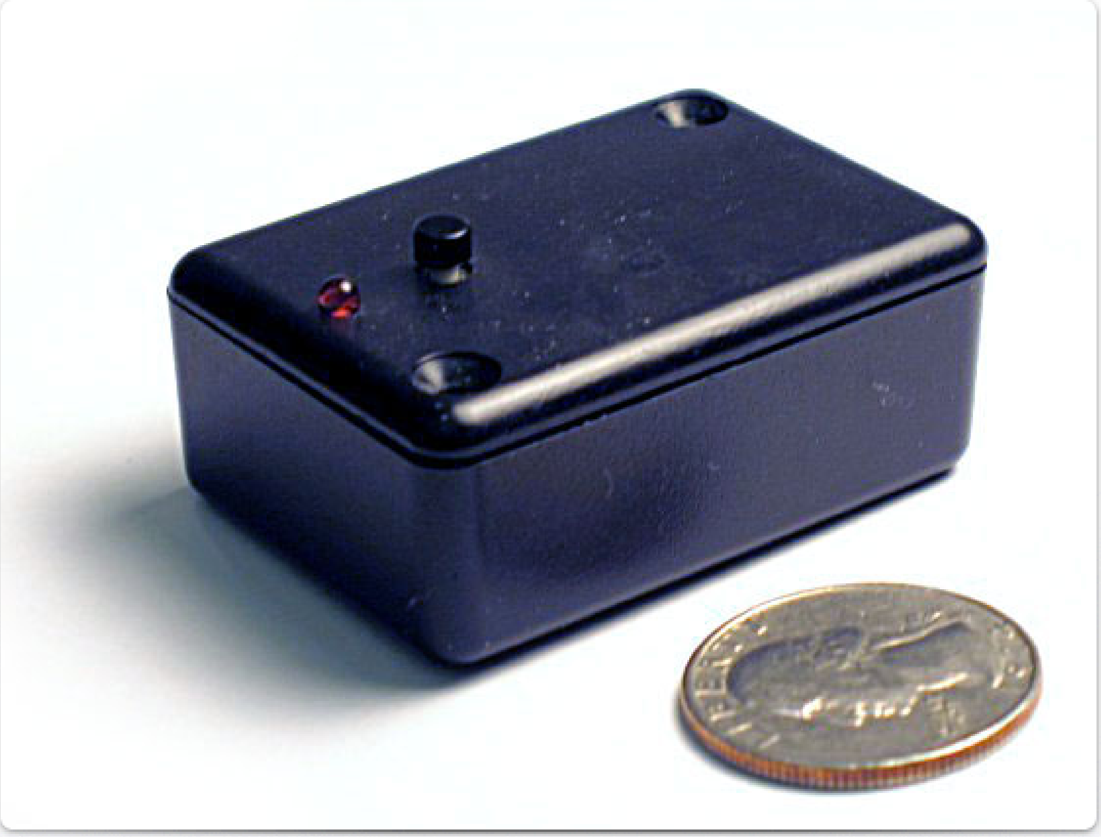


Image credit Austin Roach, Josh Mandel, and Keith Winstein of MIT

Richard M. Stallman’s Office Key

CPU Tokens

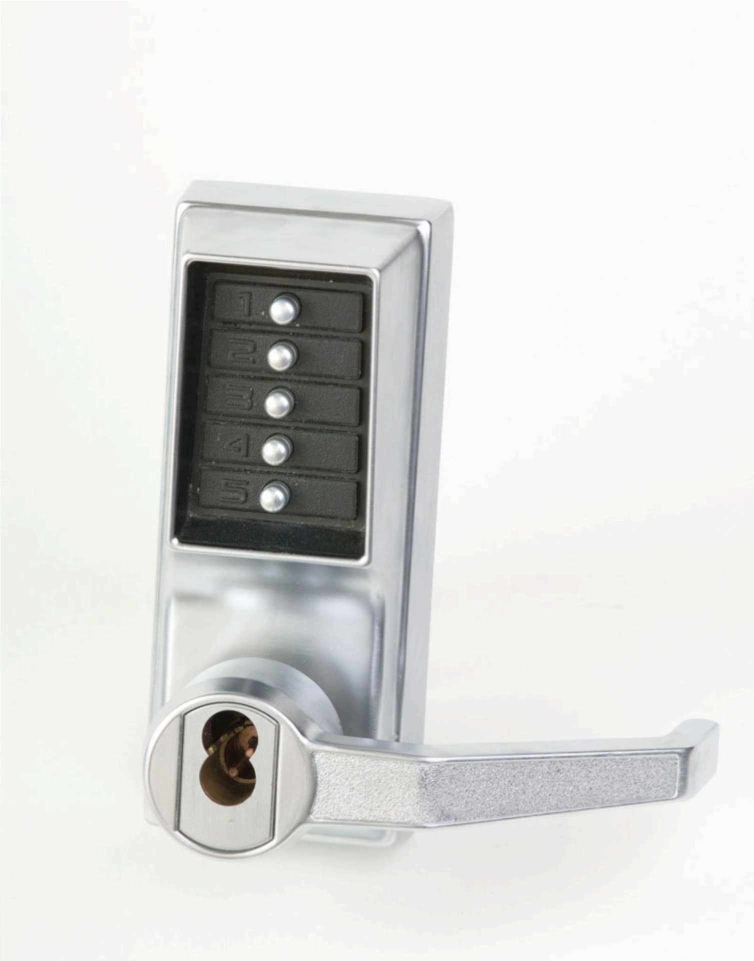
- Smart cards, iButtons
- It’s easy to make a ‘virtual’ token
- Cryptographic authentication is necessary for real security
- DirecTV vs. Hackers

Image from CA Technology Inc. / Keylessdepot.com

Knowledge

- Mechanical combination locks
- Electronic keypads
- Safe-type electronic locks

Mechanical combination locks



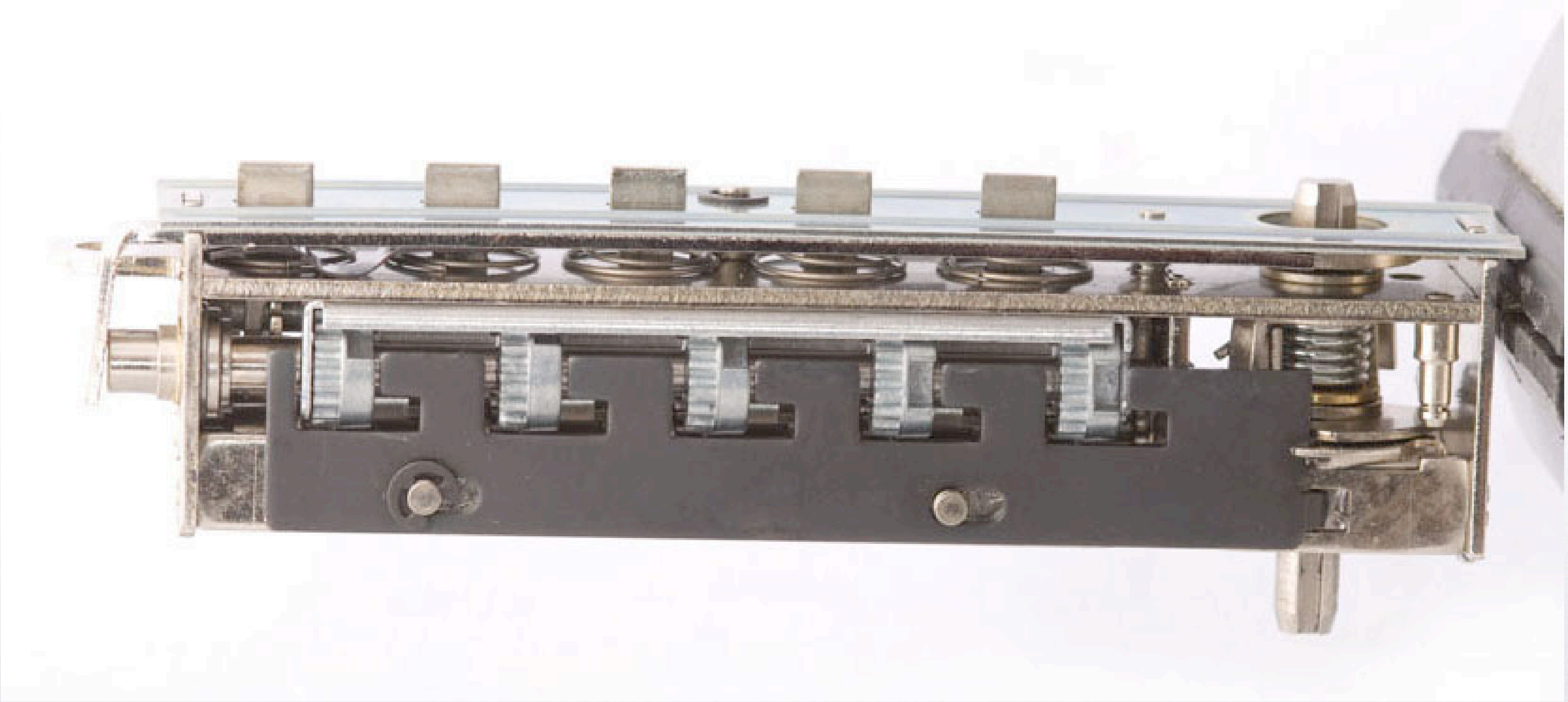
Mechanical combination locks

- Good:
  - Simple, reliable, and no power necessary

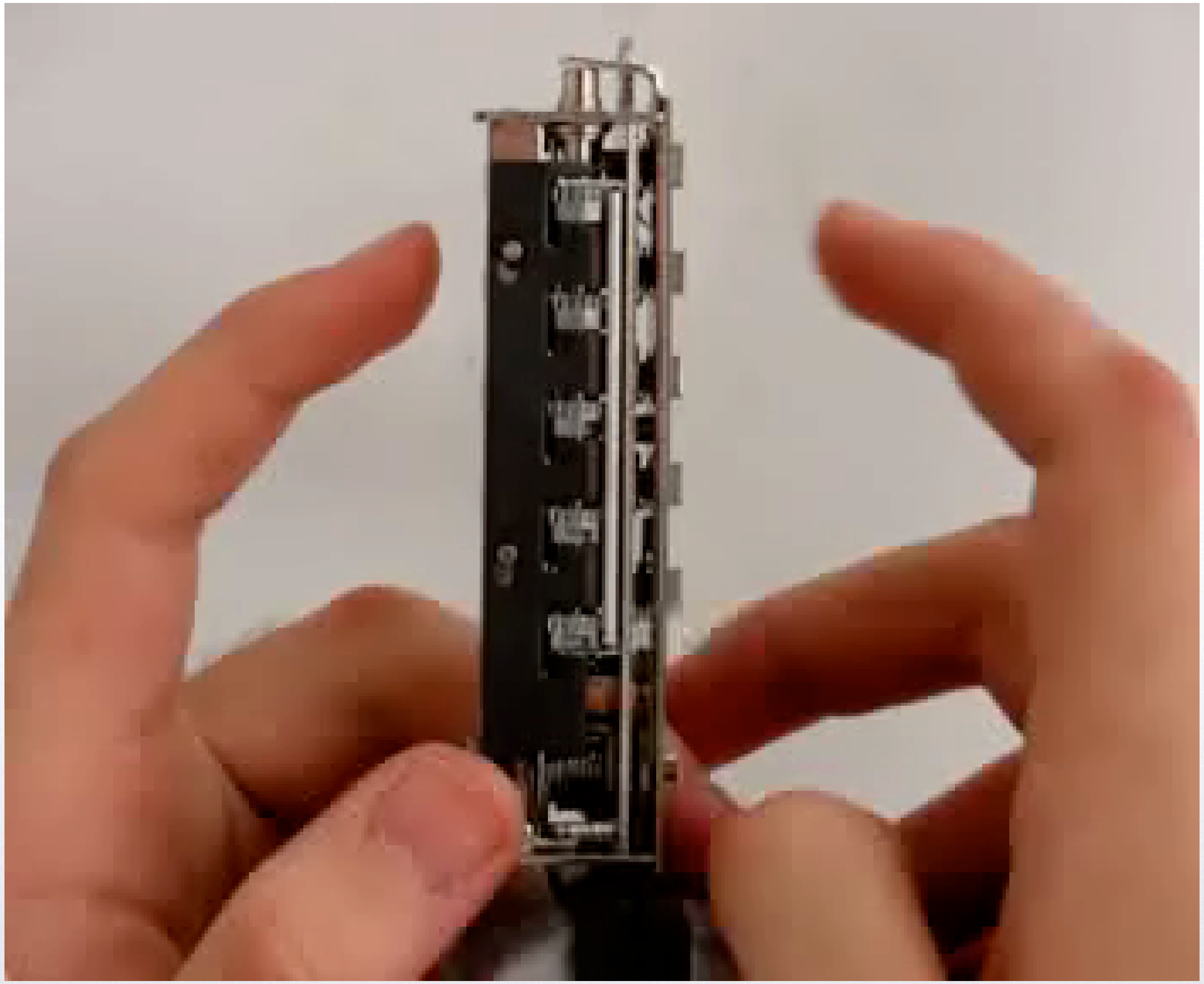
Mechanical combination locks

- Good:
  - Simple, reliable, and no power necessary
- Bad:
  - No audit trail
  - Can be manipulated (usually)
  - Brute force attack
    - http://www.cs.berkeley.edu/~bh/v3ch2/math.html
    - http://www.tech-faq.com/simplex-lock-combinations.shtml

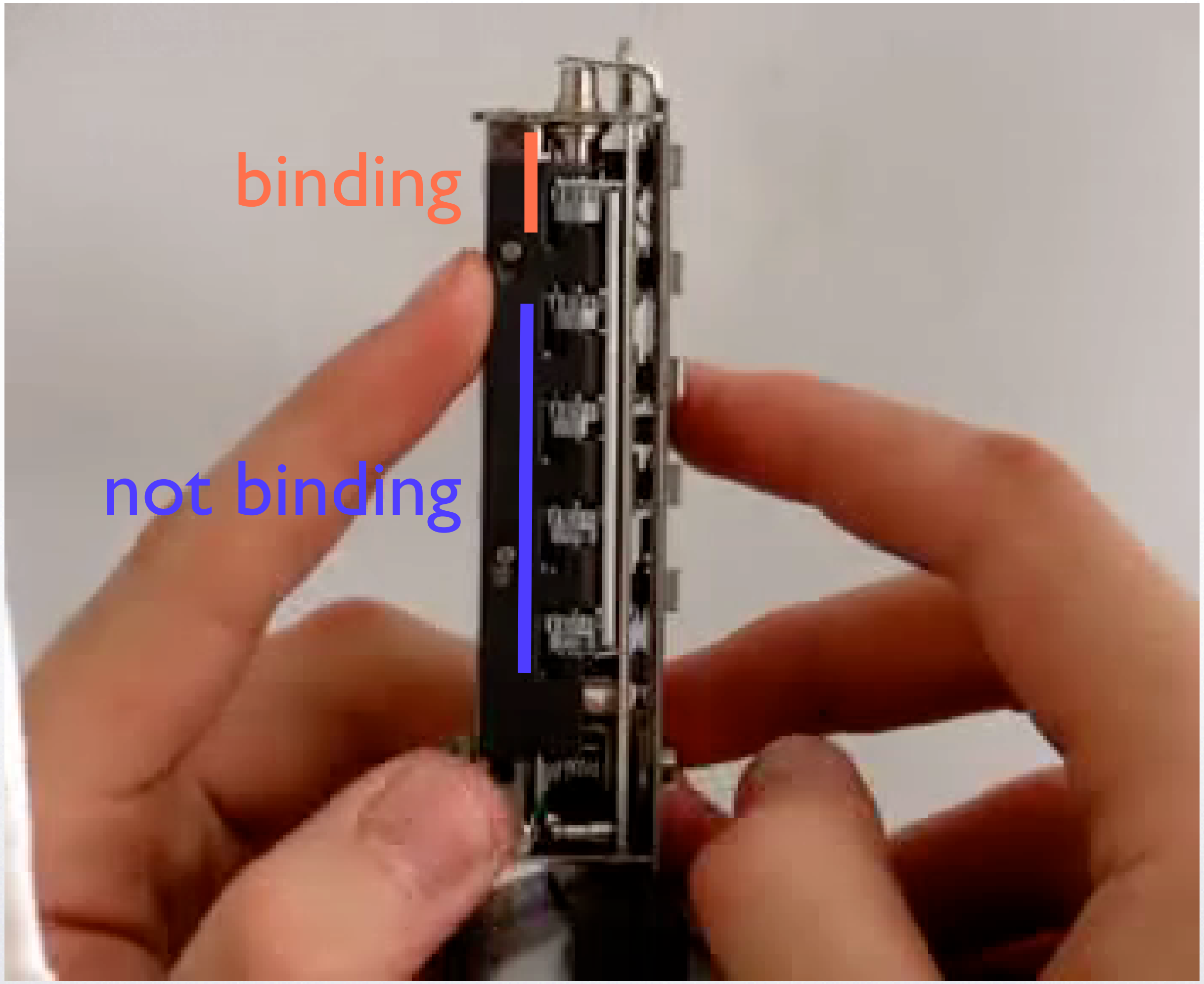
Simplex operation



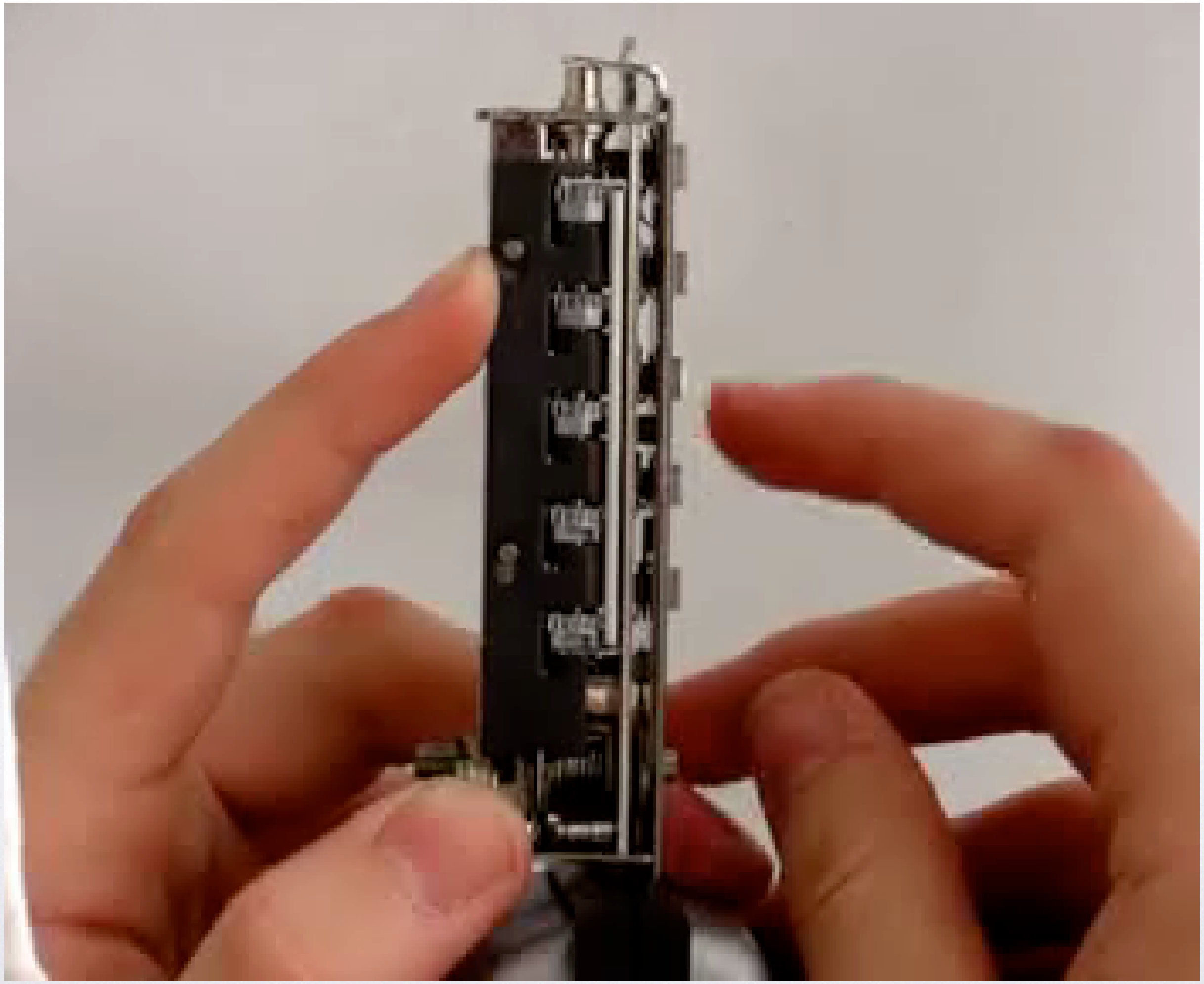
Opening Procedure



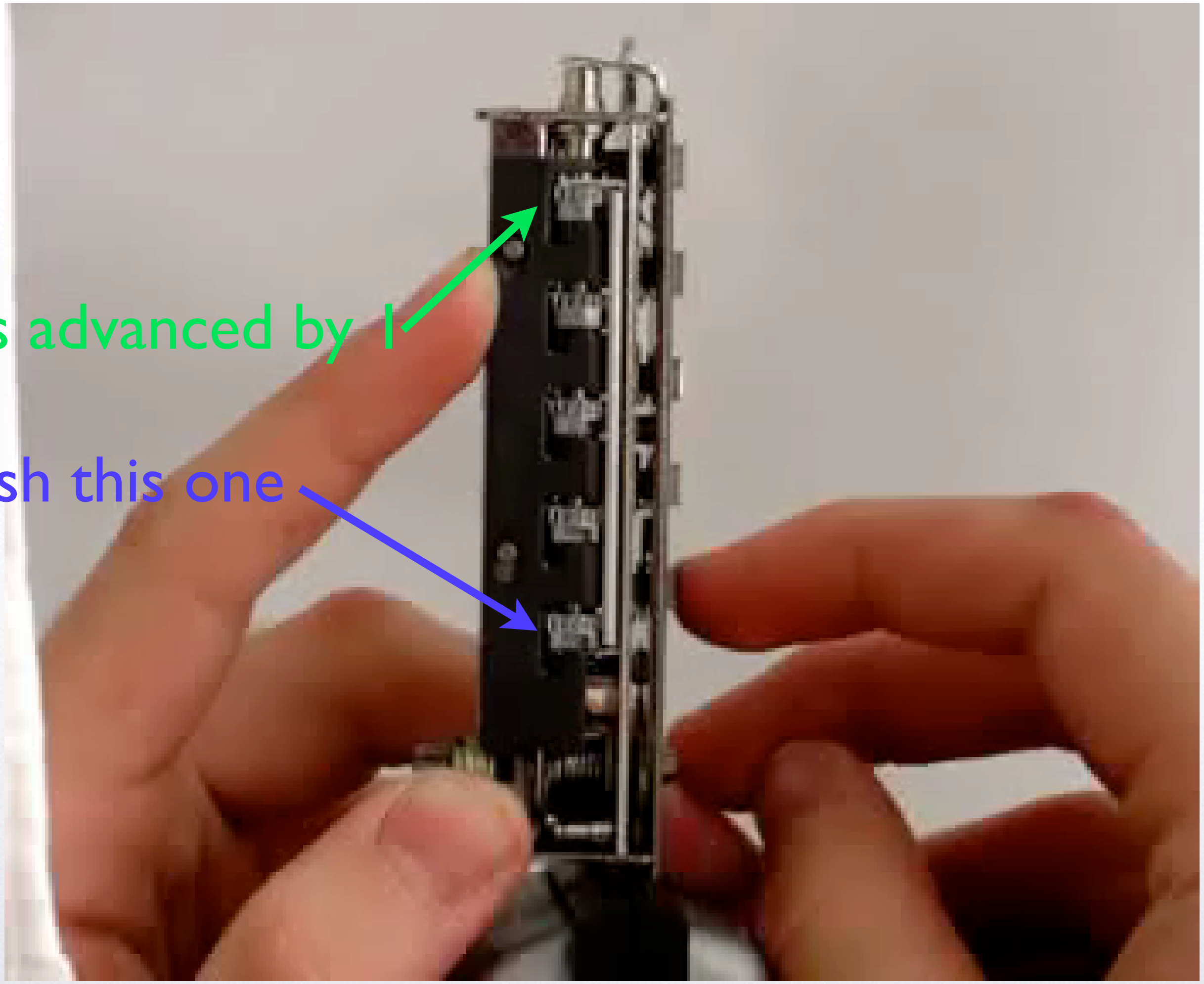
Which tumbler is binding?



Push 1. Is a new tumbler binding?



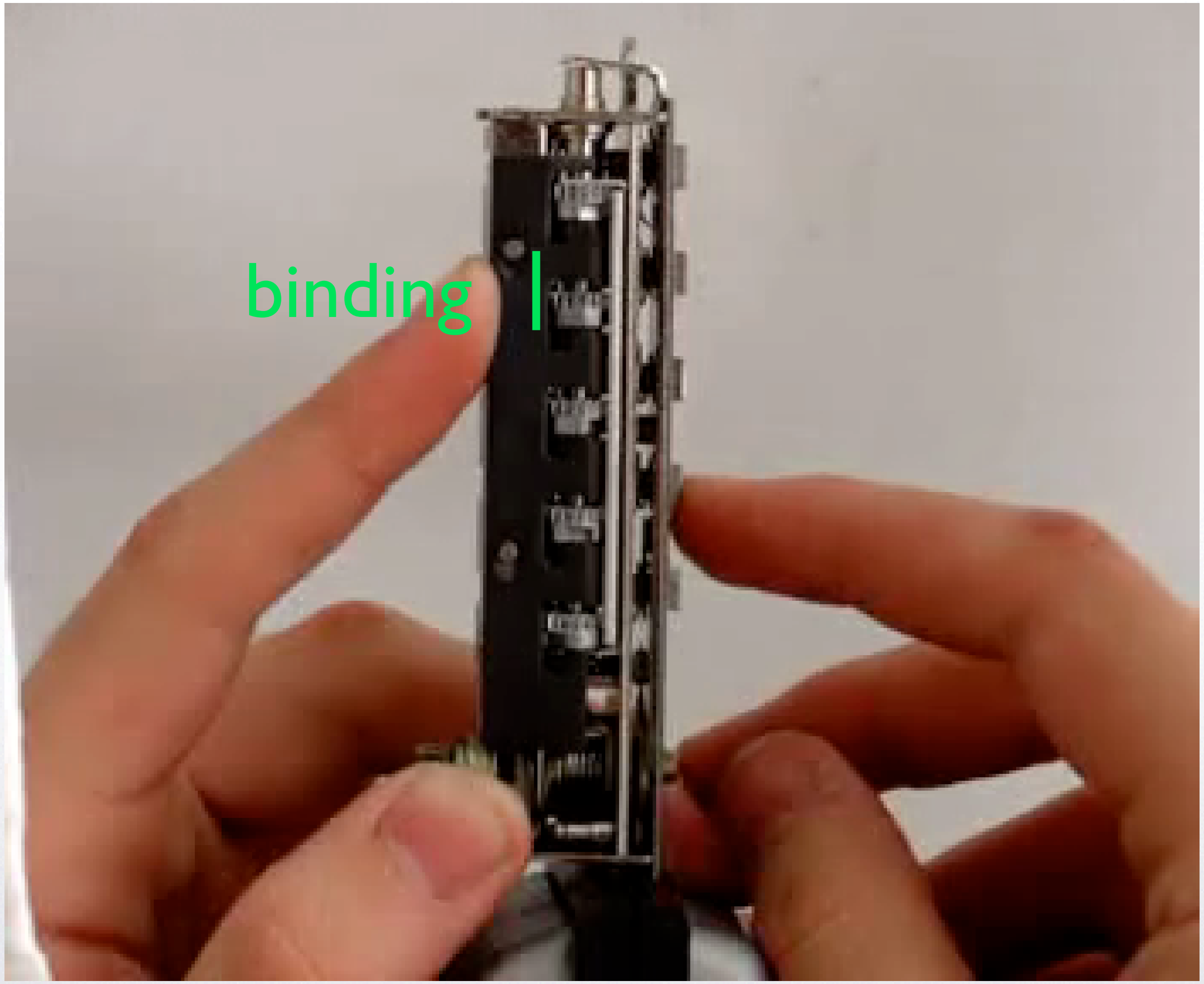
Advance tumbler 1 by pushing a "throwaway" button -- here, number 5 -- and check if another tumbler is binding



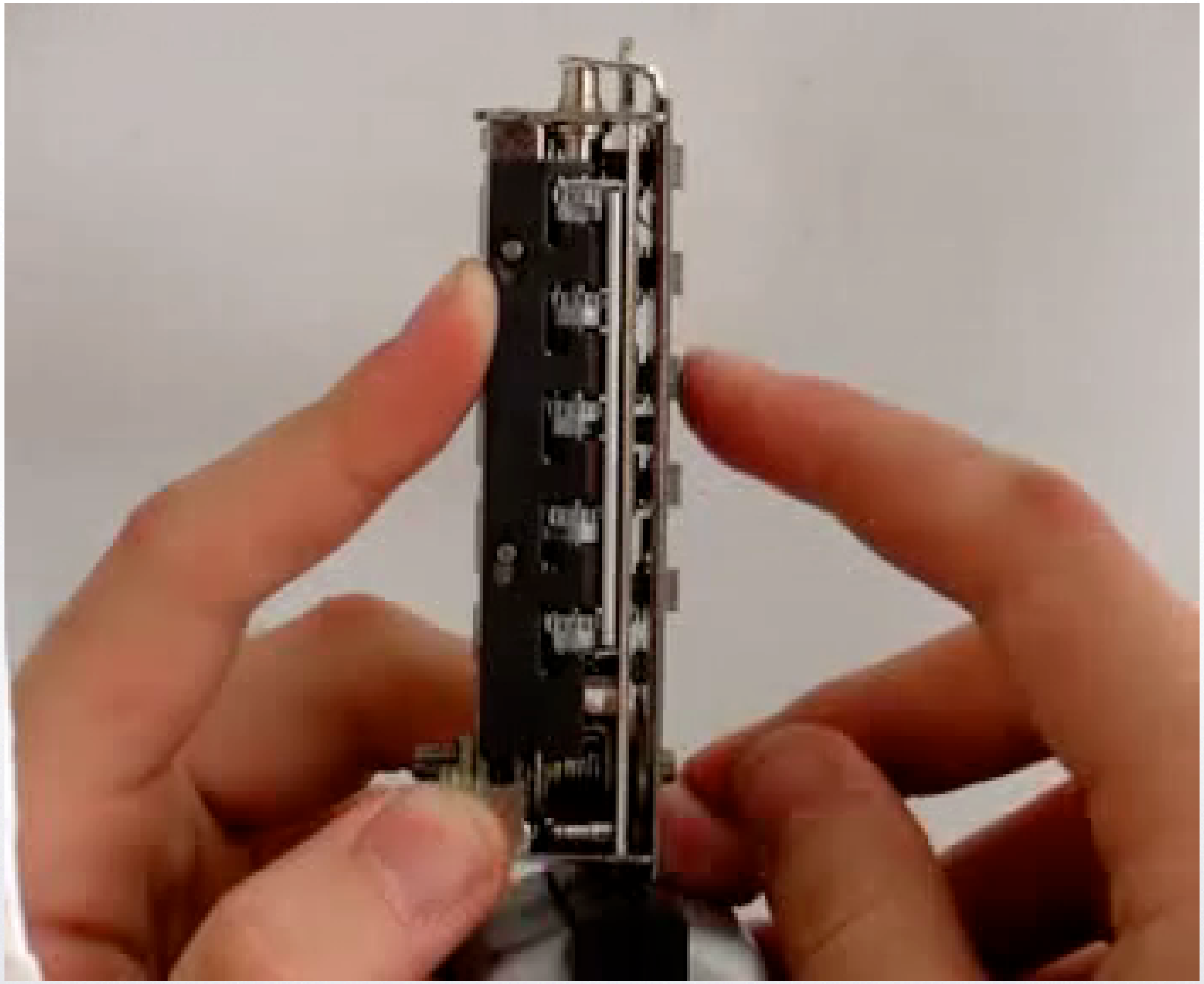
This tumbler is advanced by 1

when I push this one

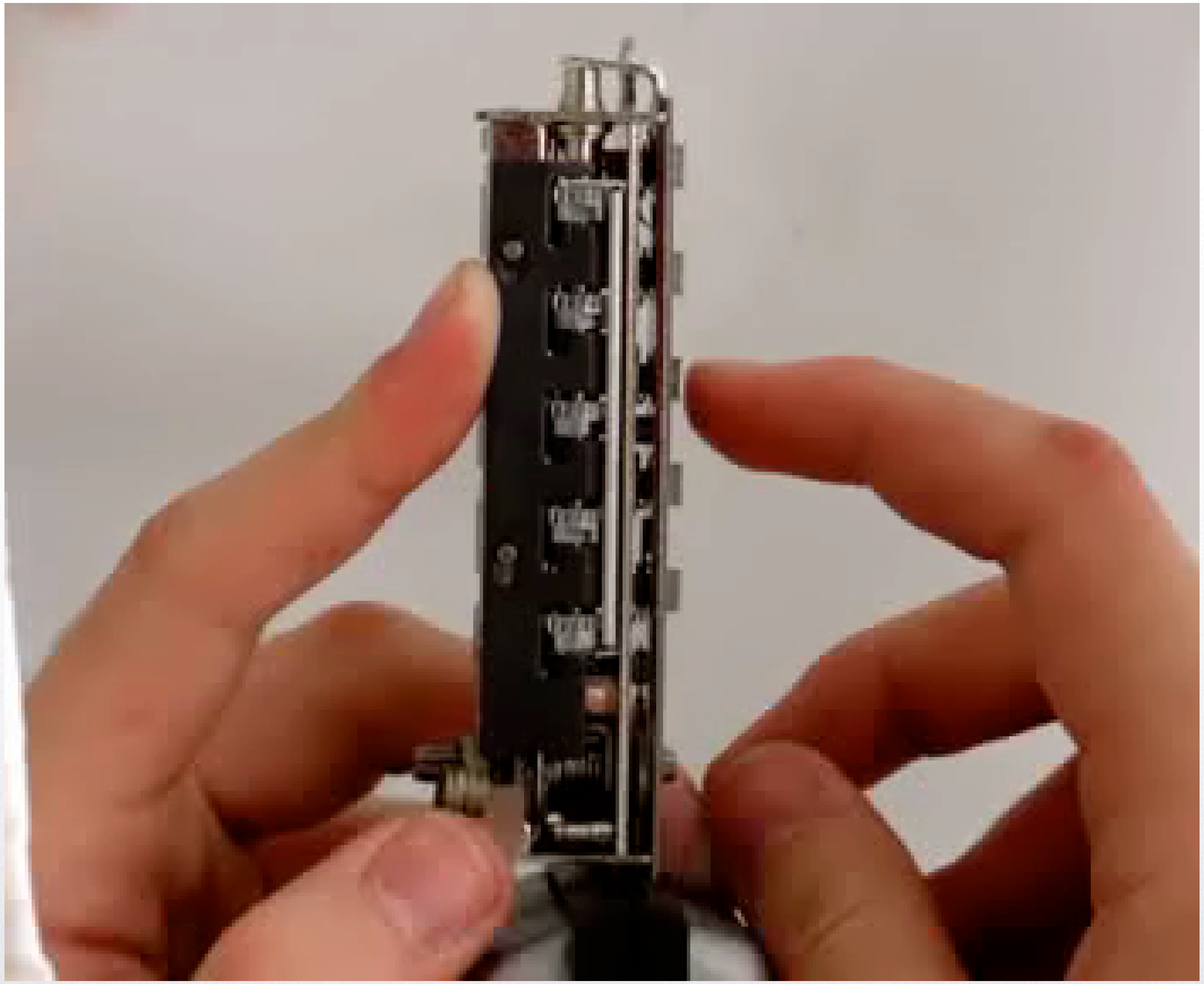
Try pushing another throwaway button -- 4 -- and check for binding



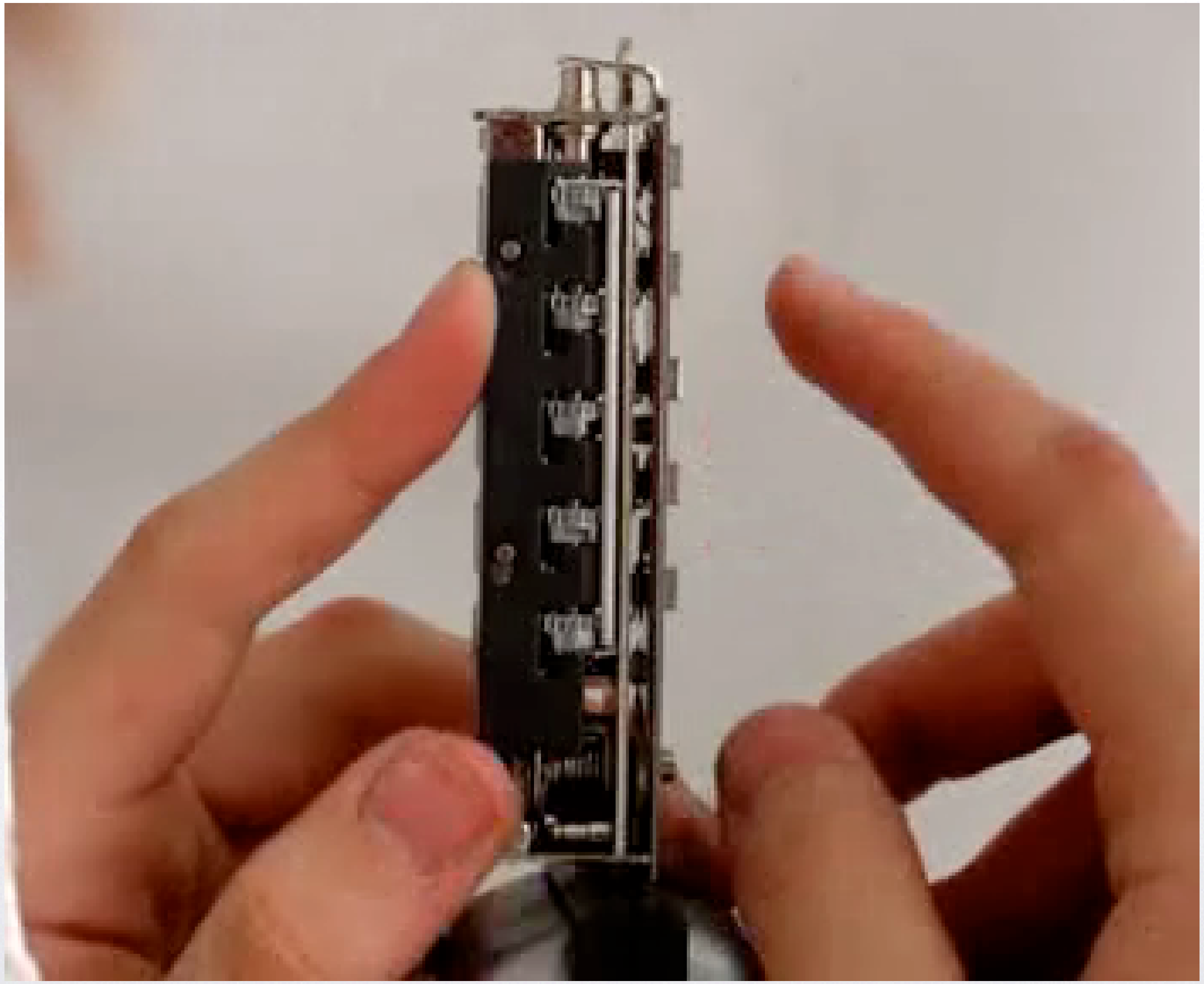
Reset, and try the combination 152



Check if any new tumblers are binding now



Reset, and try the combination 125



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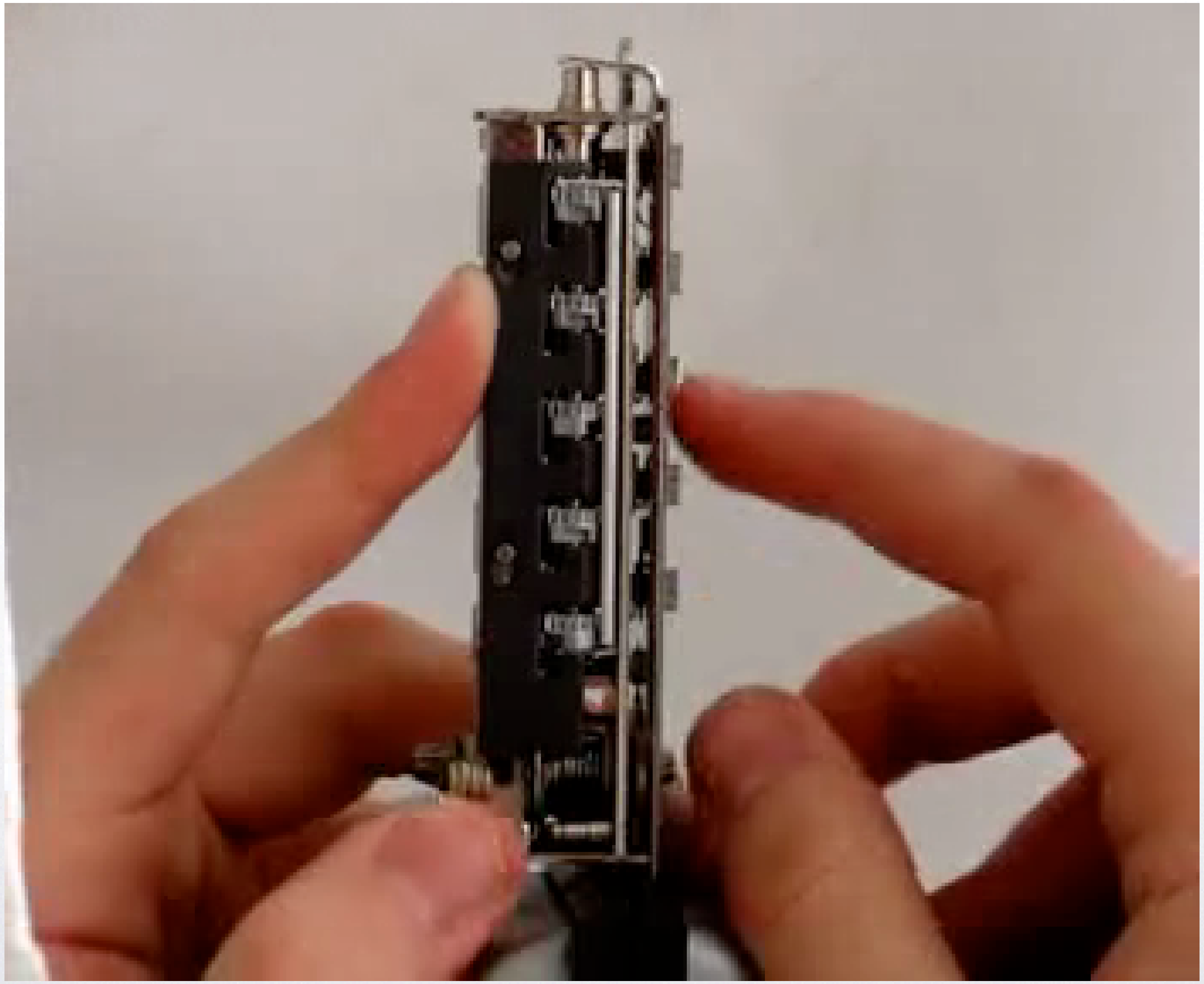
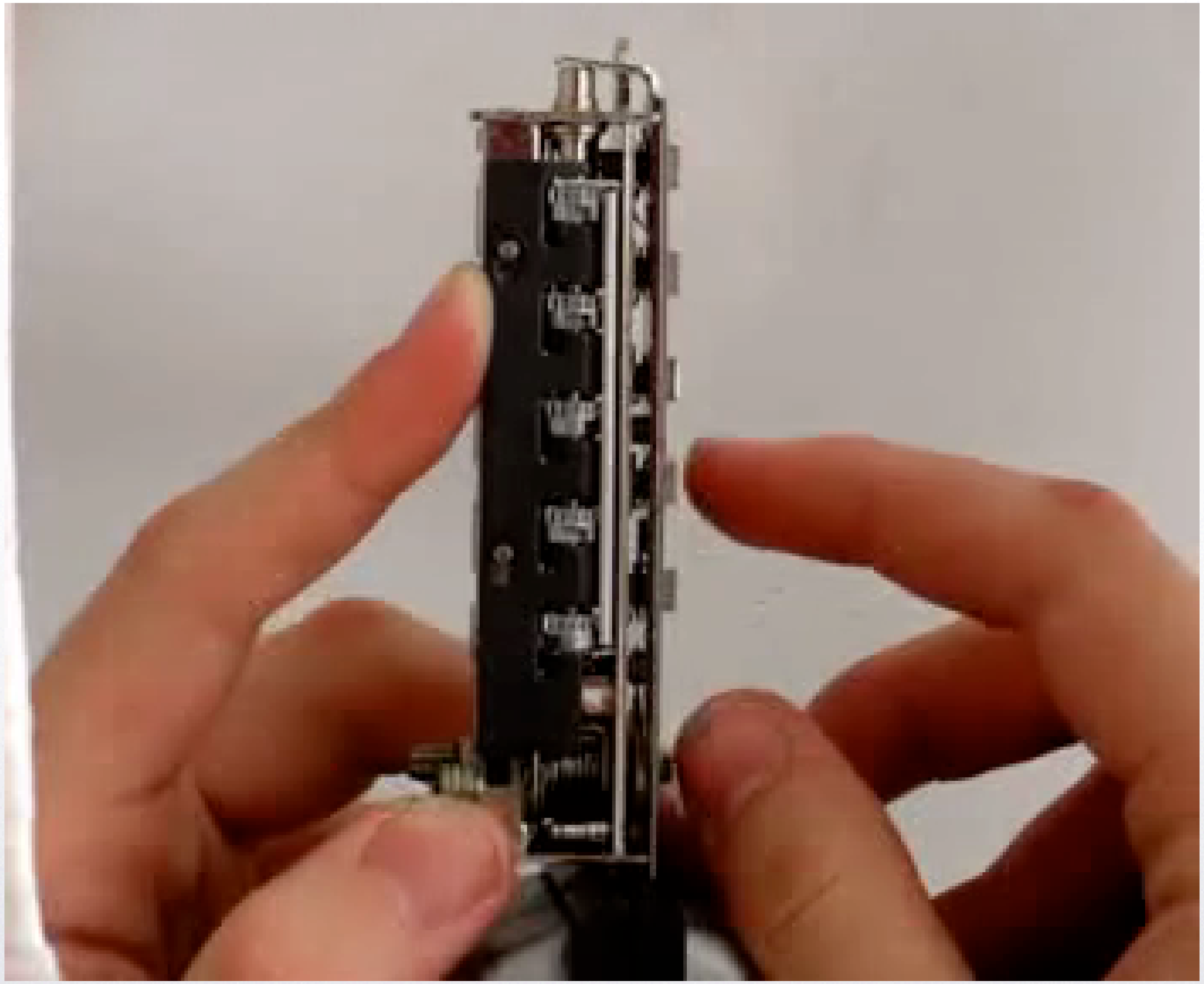


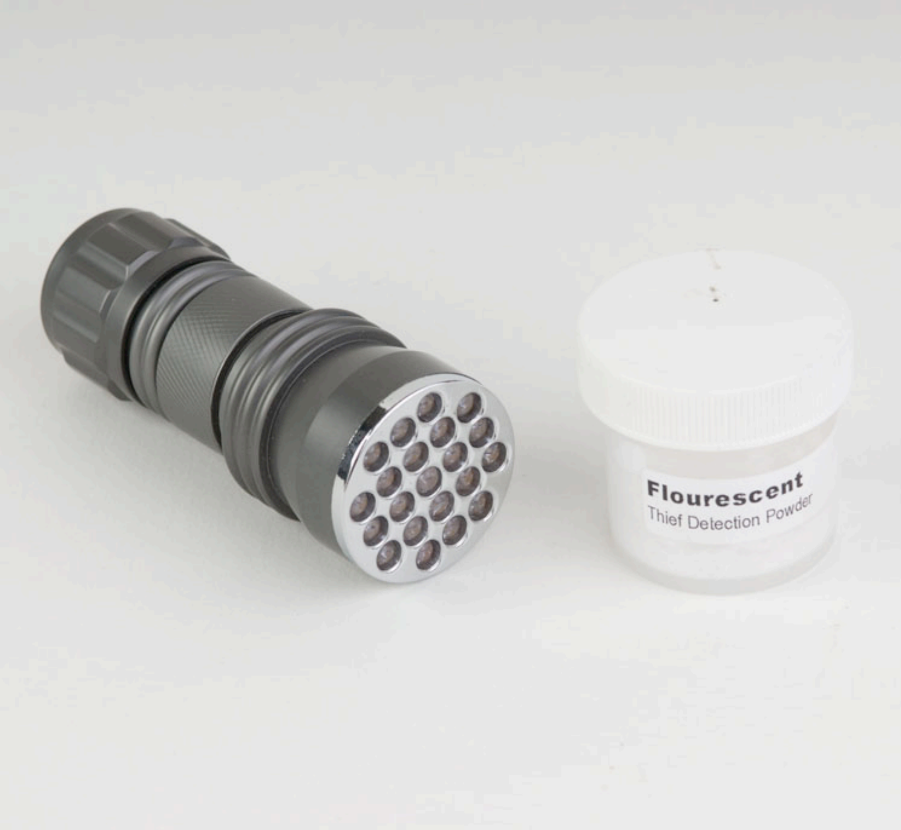
Reset and try the combination 123



Electronic keypads

Electronic keypads

- Attacks



Electronic keypads

- Attacks
- The UV powder trick
  - Attacker needs to enter very many combinations
  - So use a highlighter

Electronic keypads

- Attacks
- The UV powder trick
  - Attacker needs to enter very many combinations
  - So use a highlighter
- Shoulder surfing and hidden cameras

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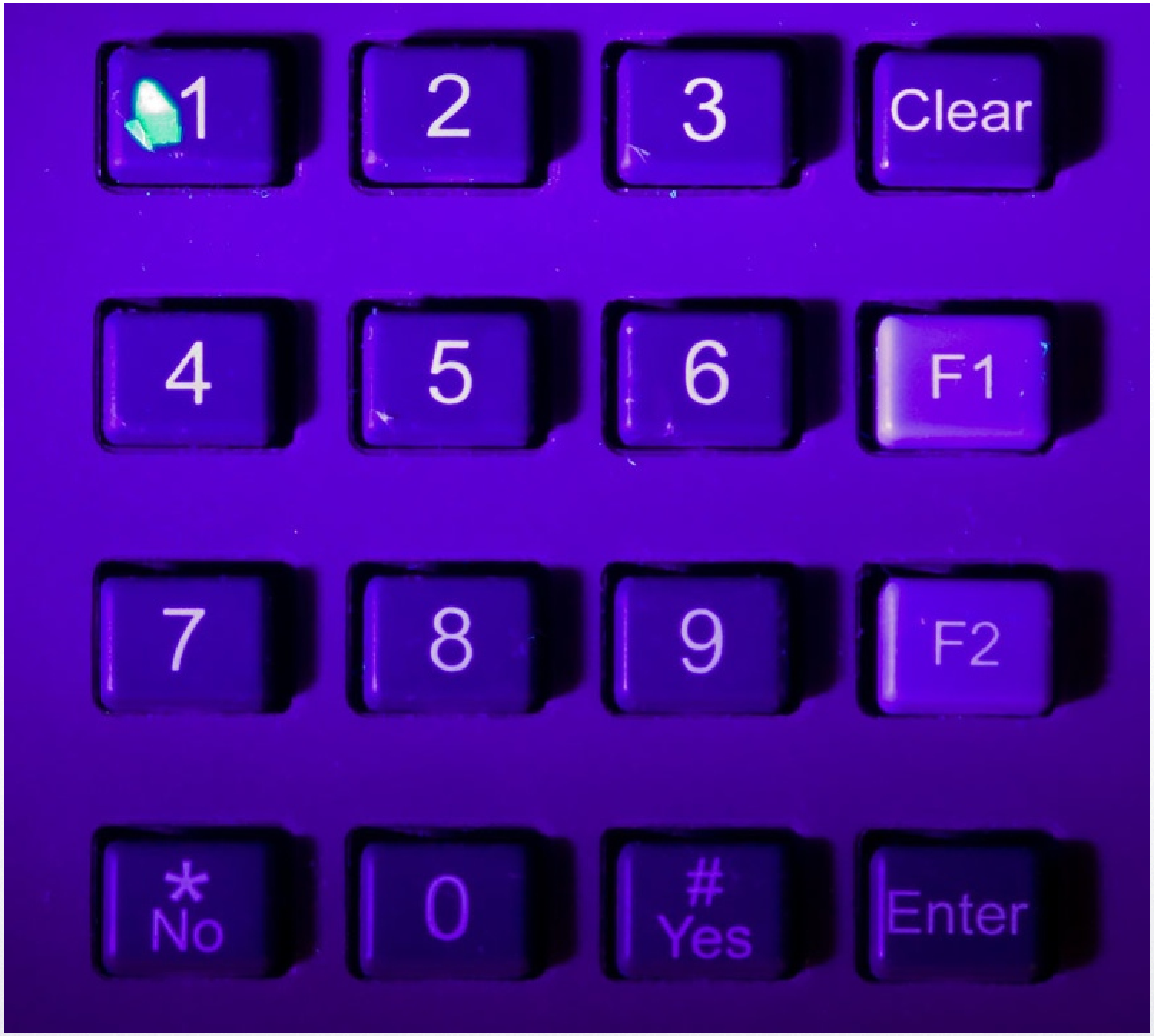
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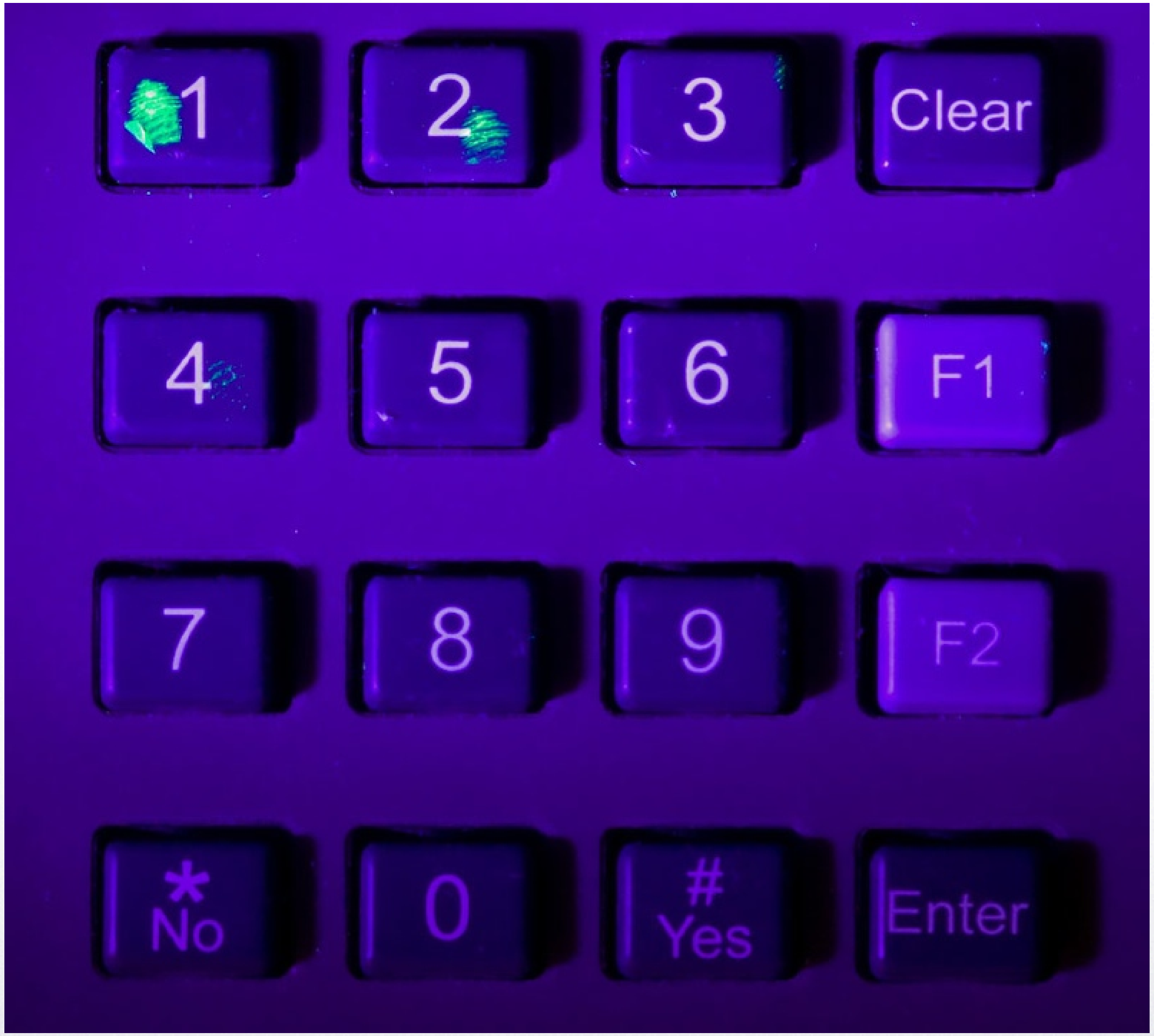
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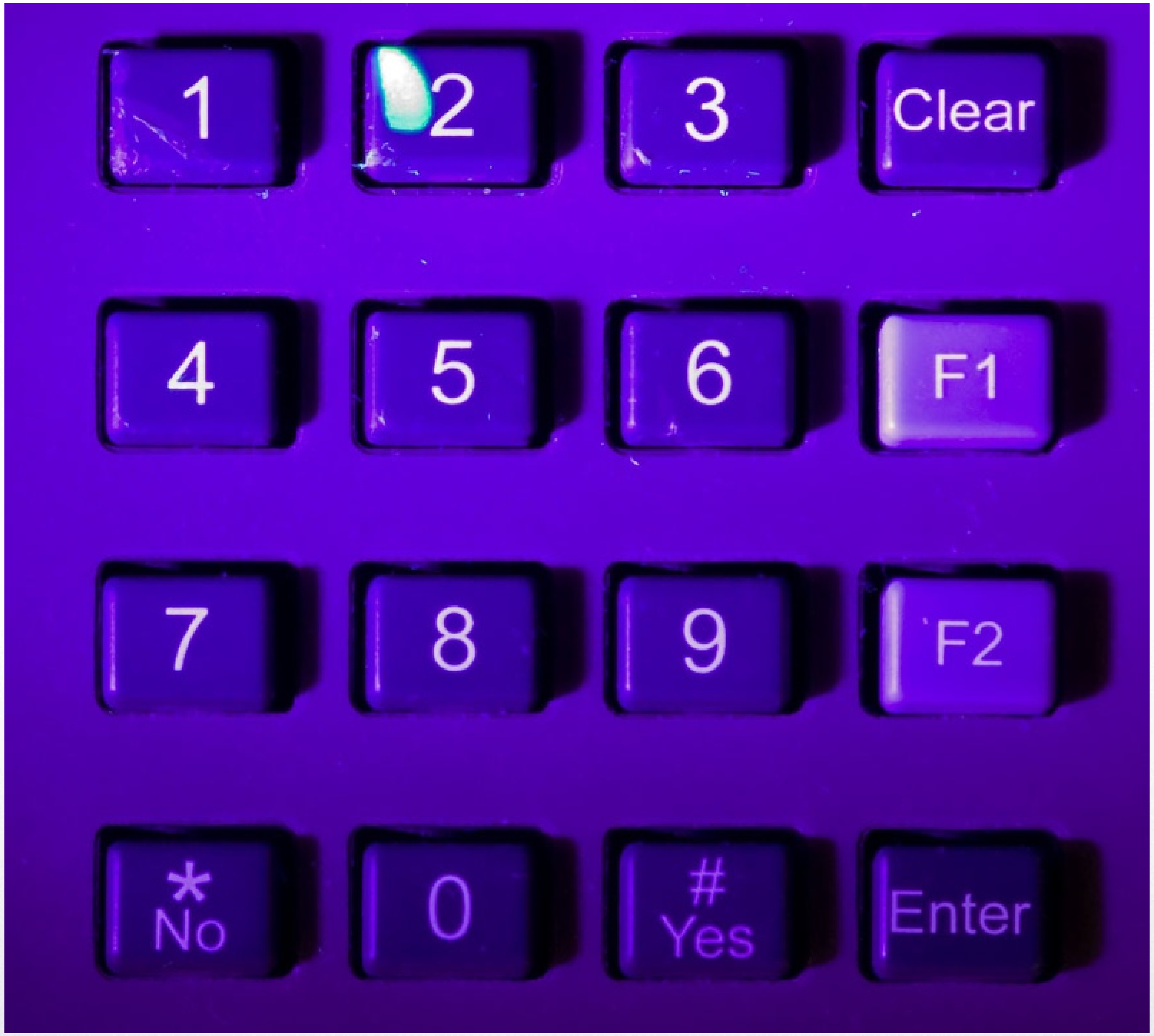
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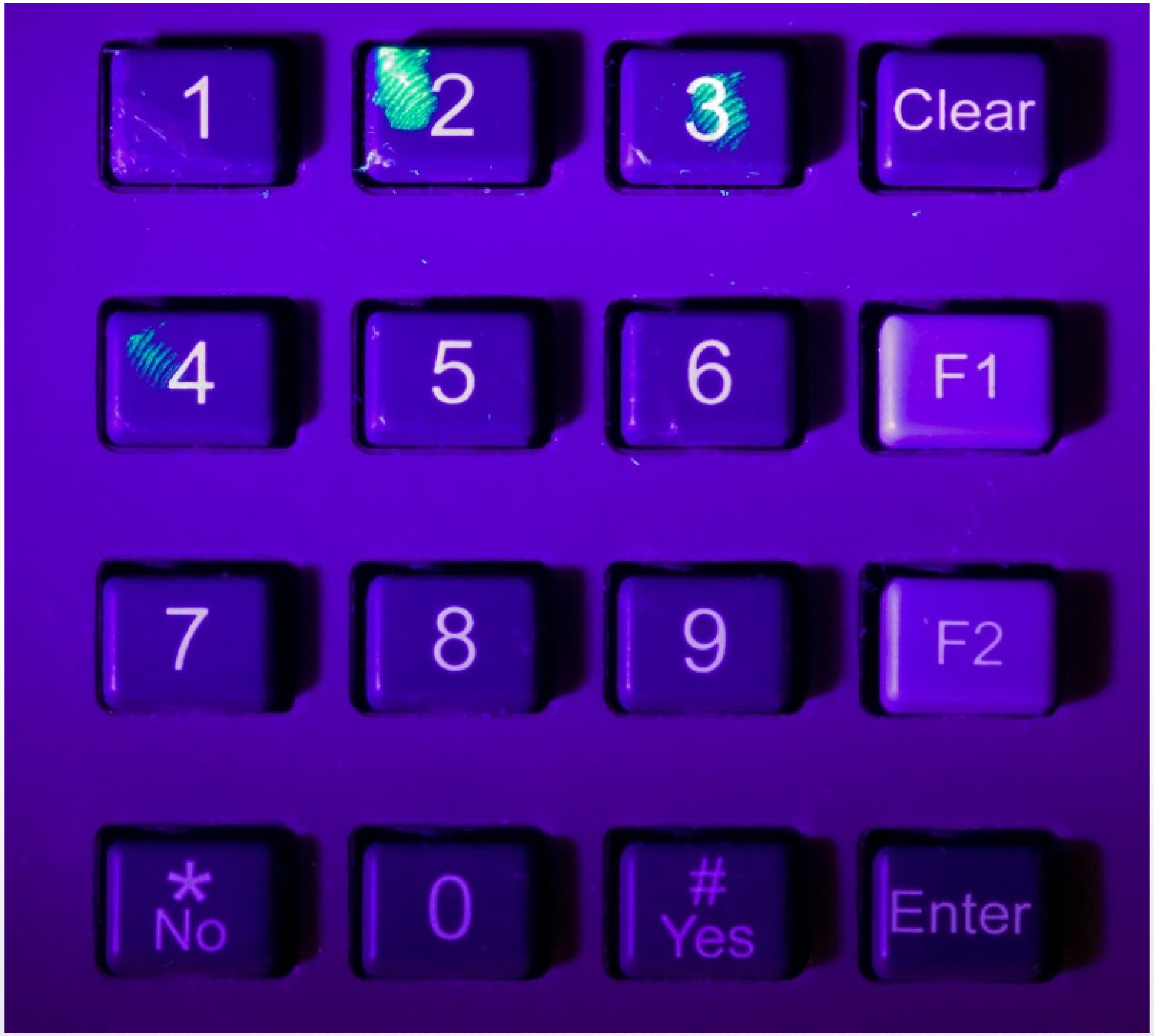
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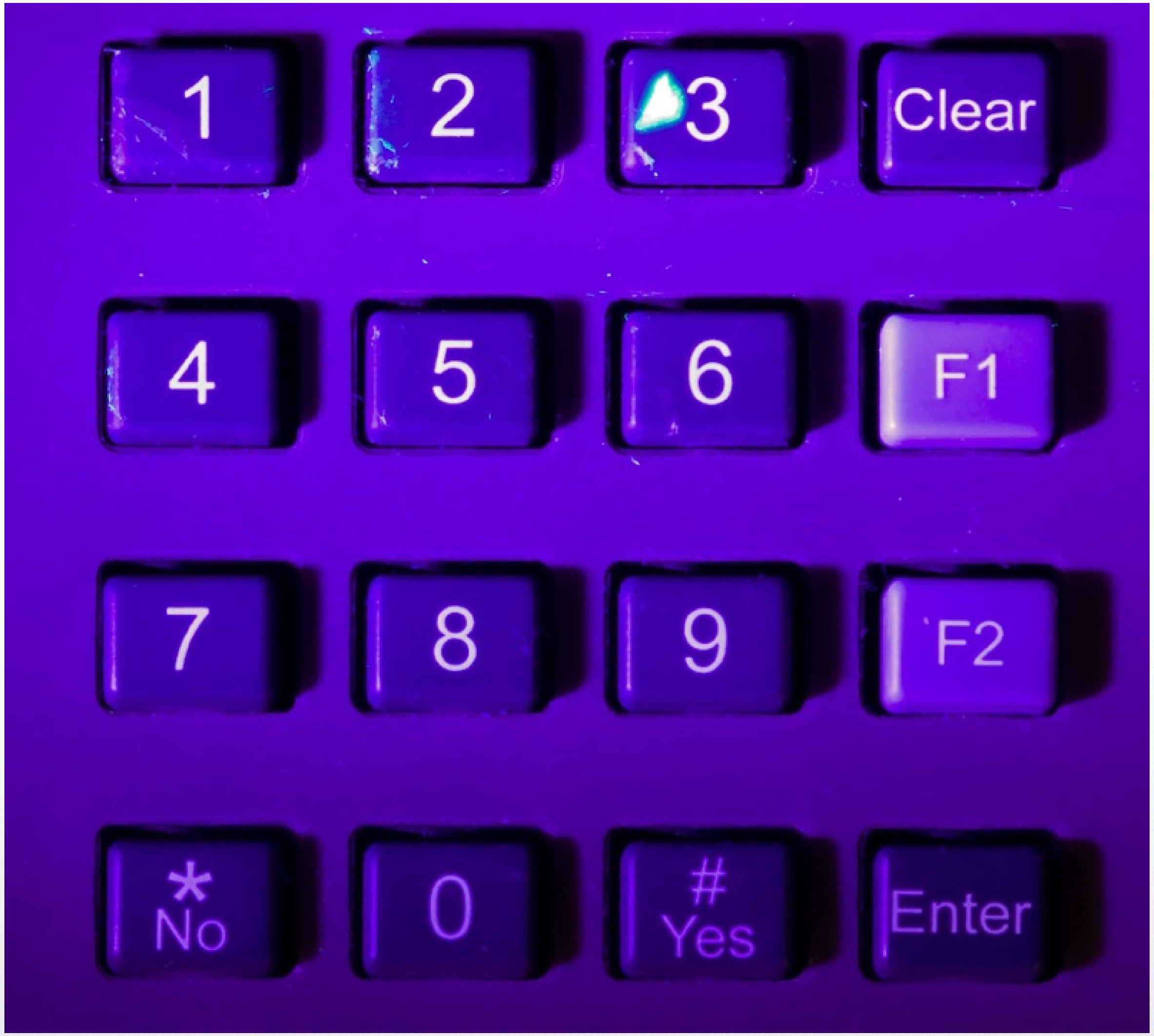
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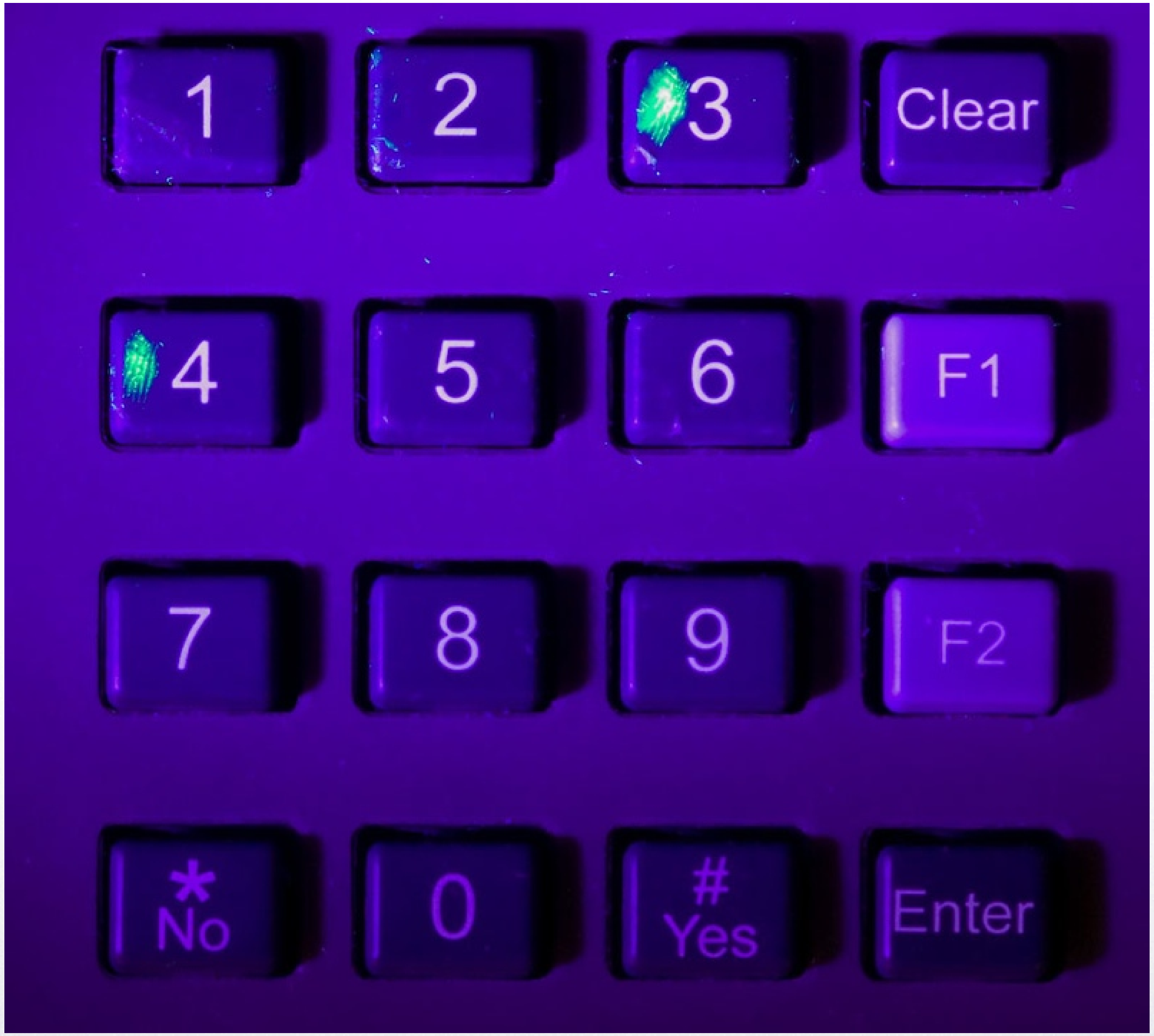
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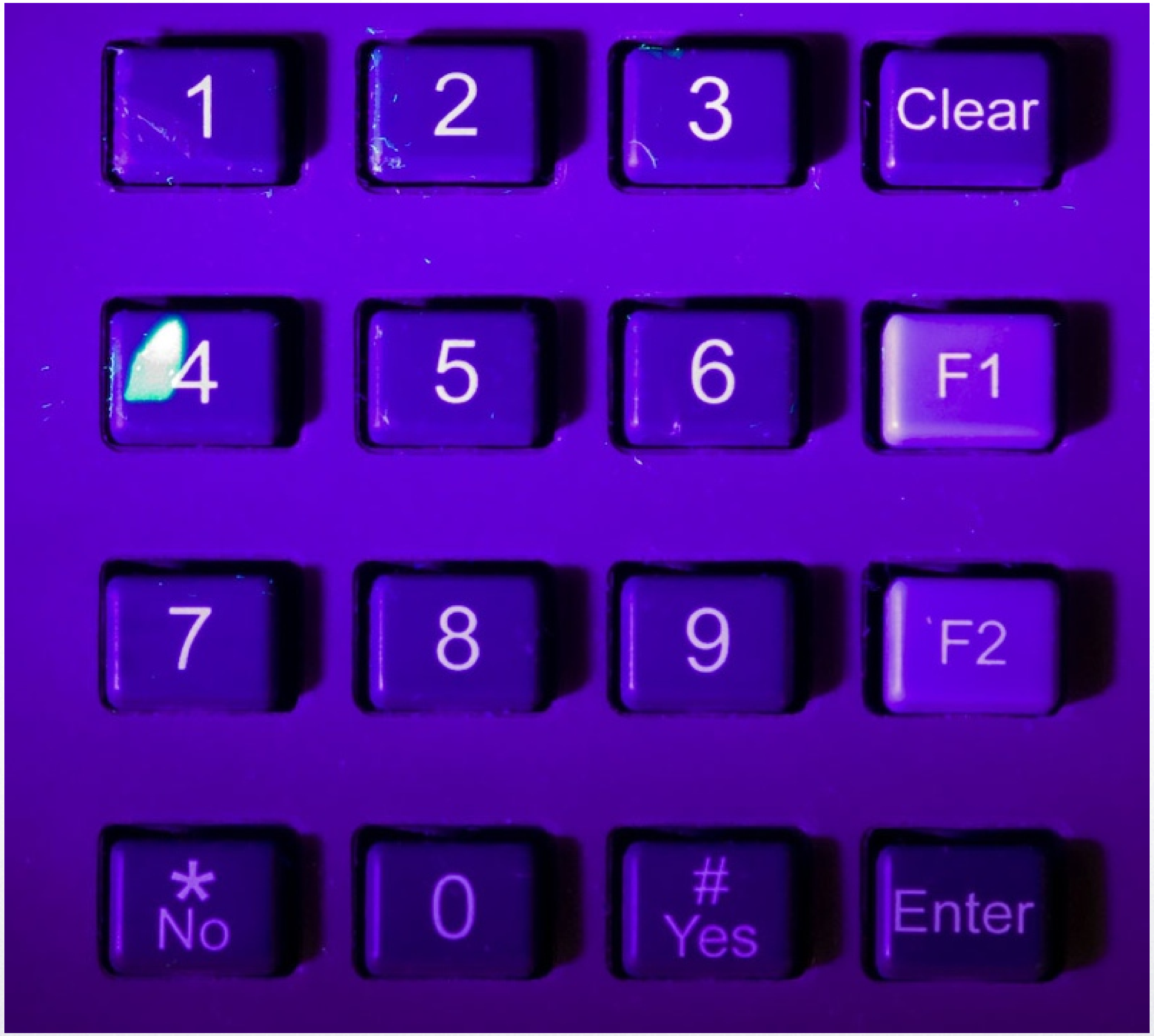
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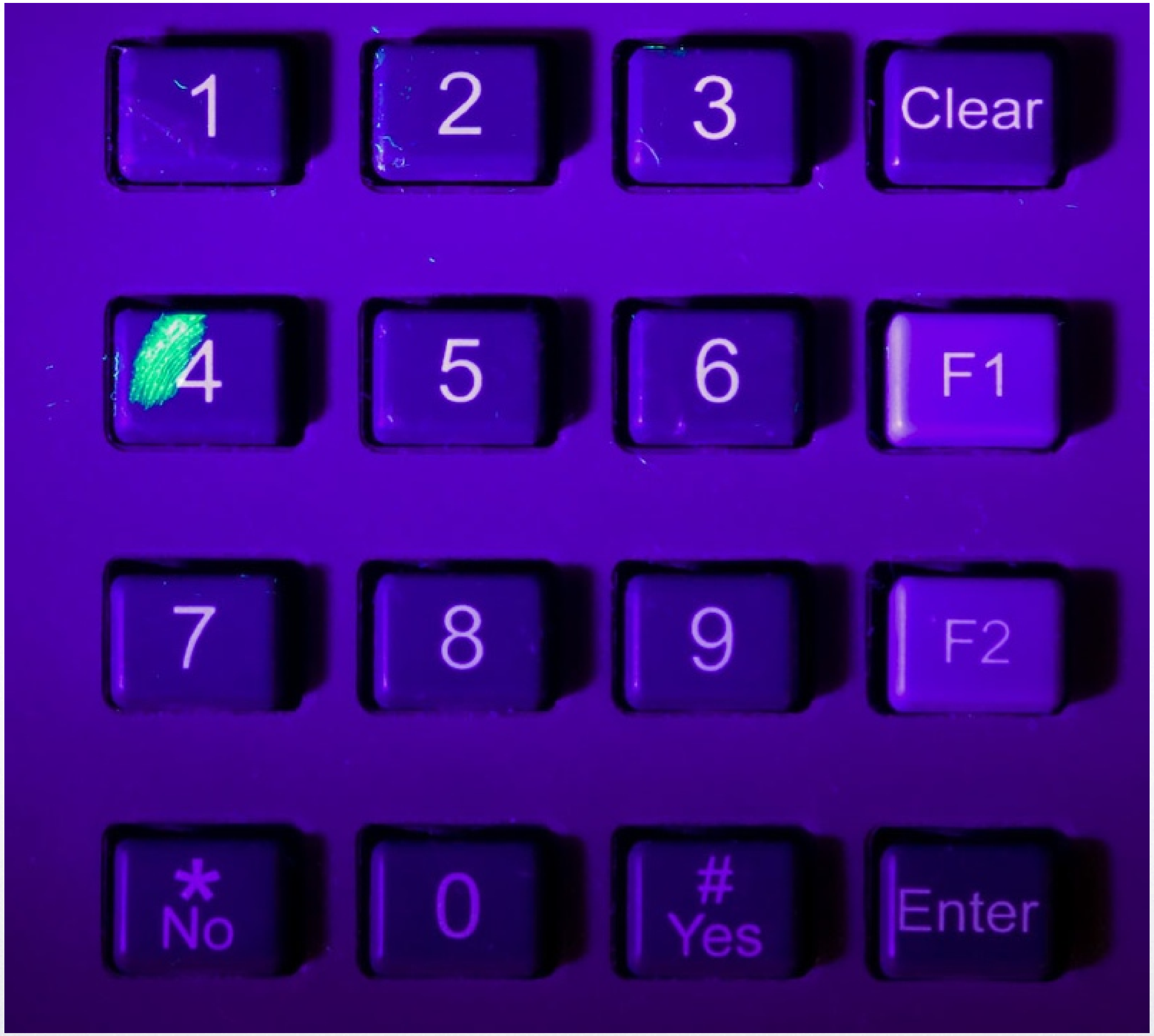
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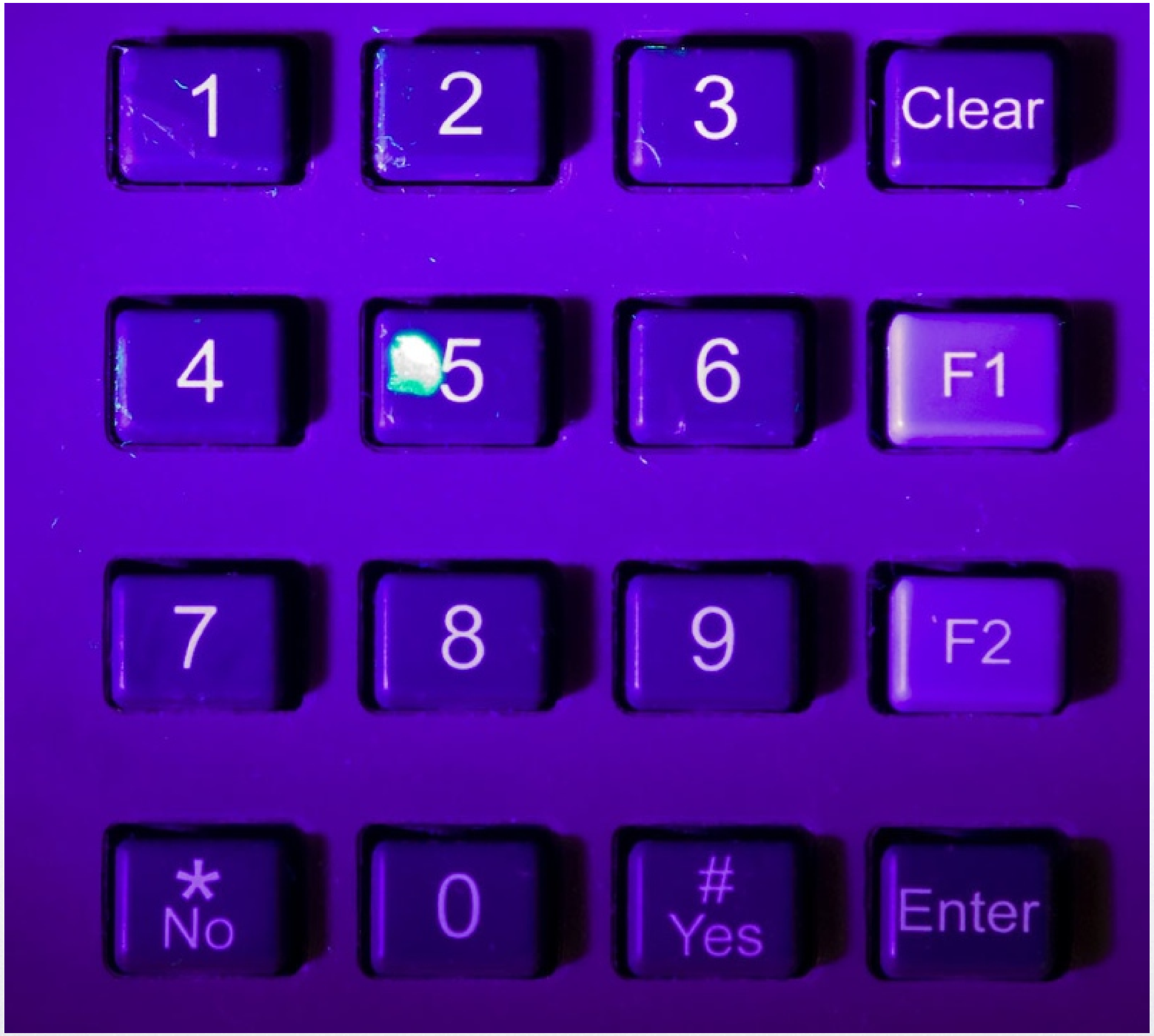
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Electronic keypads

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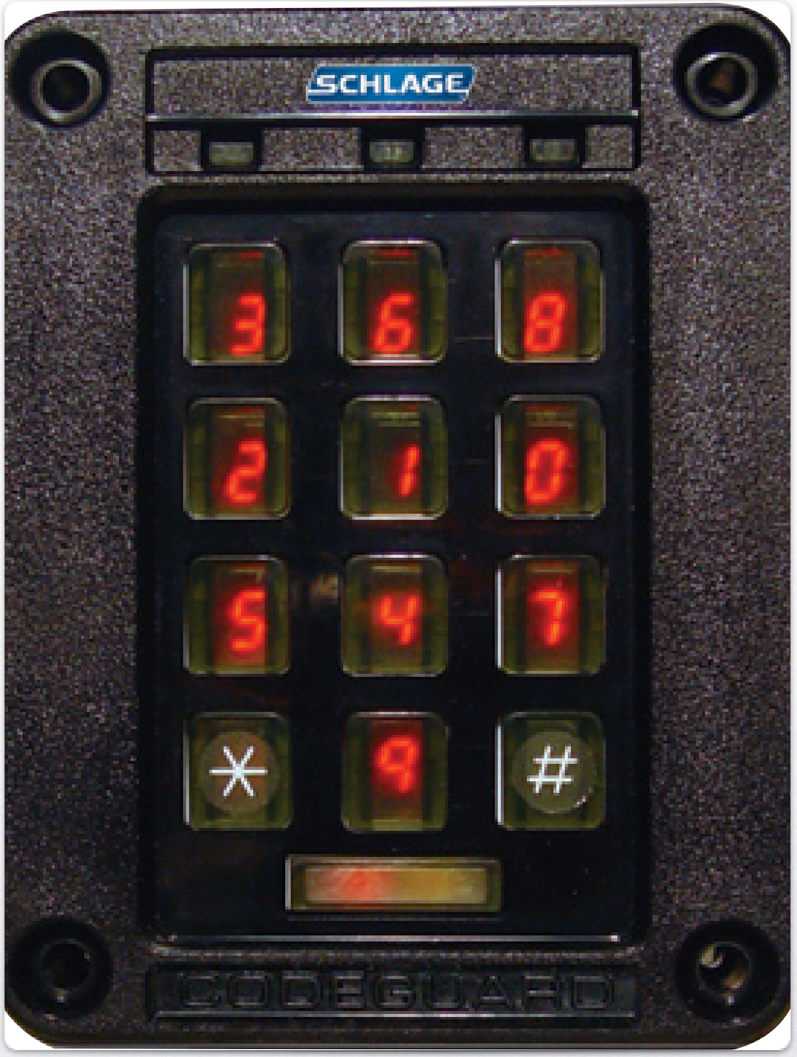
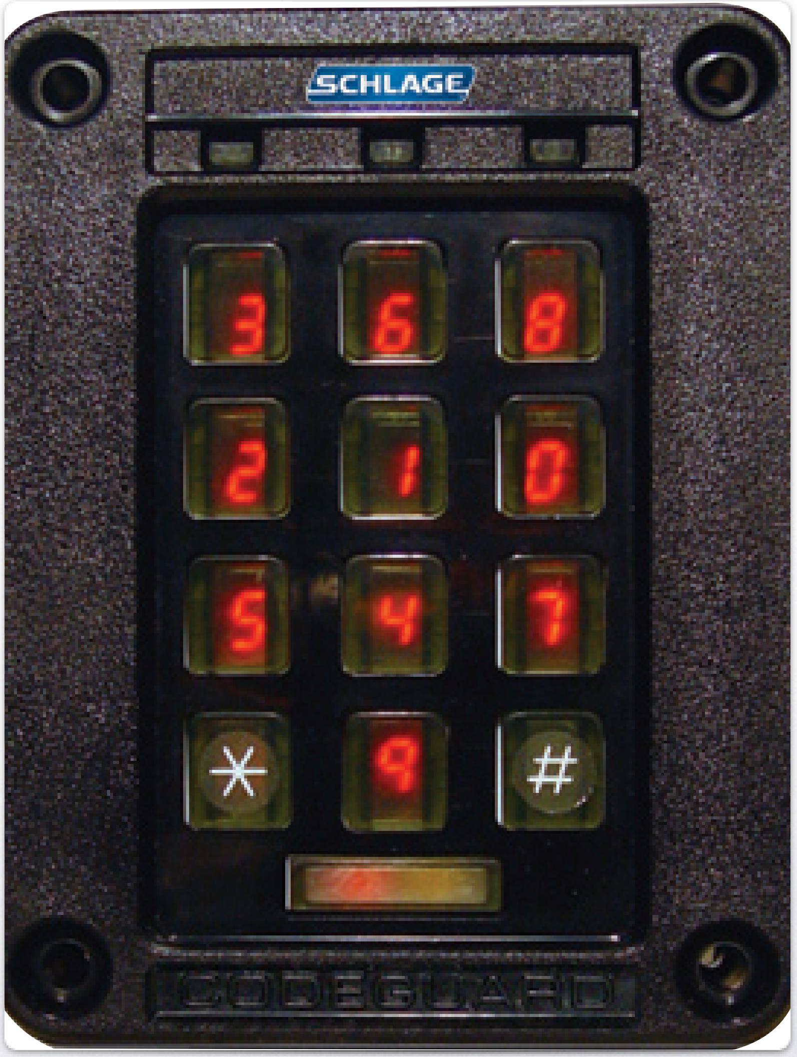


Photograph by Schlage

Electronic keypads

- Dynamically changing "scramble-key" high-security keypads fix most of these problems



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Electronic keypads

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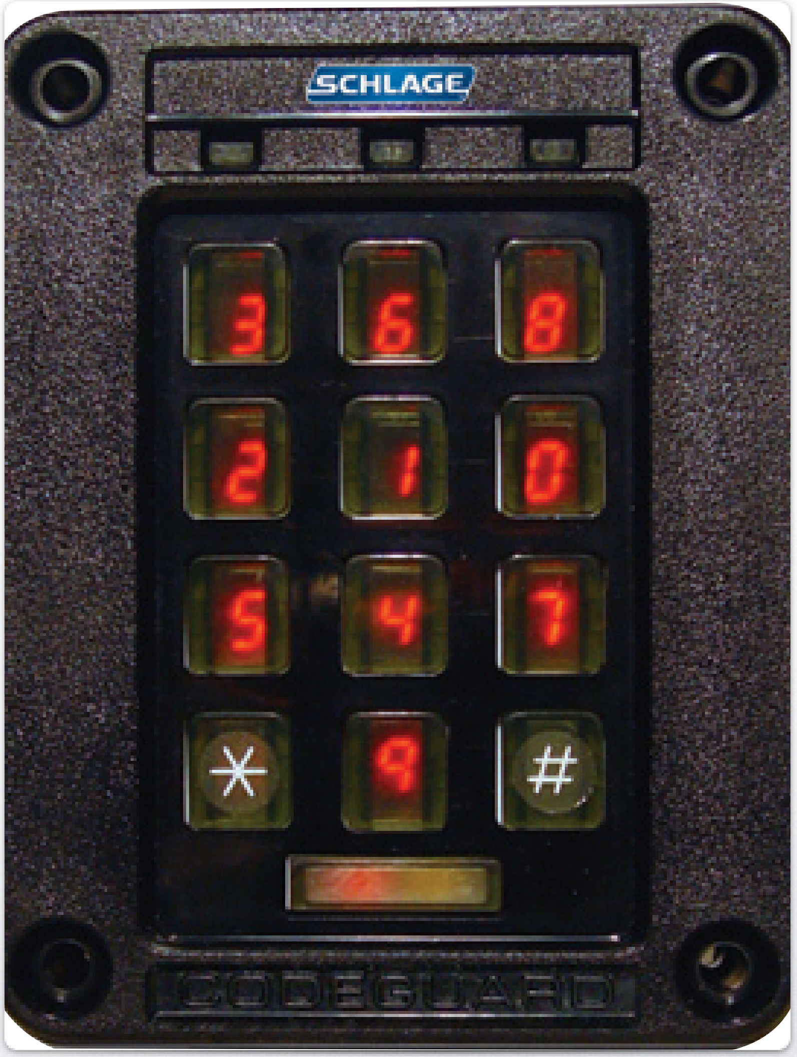
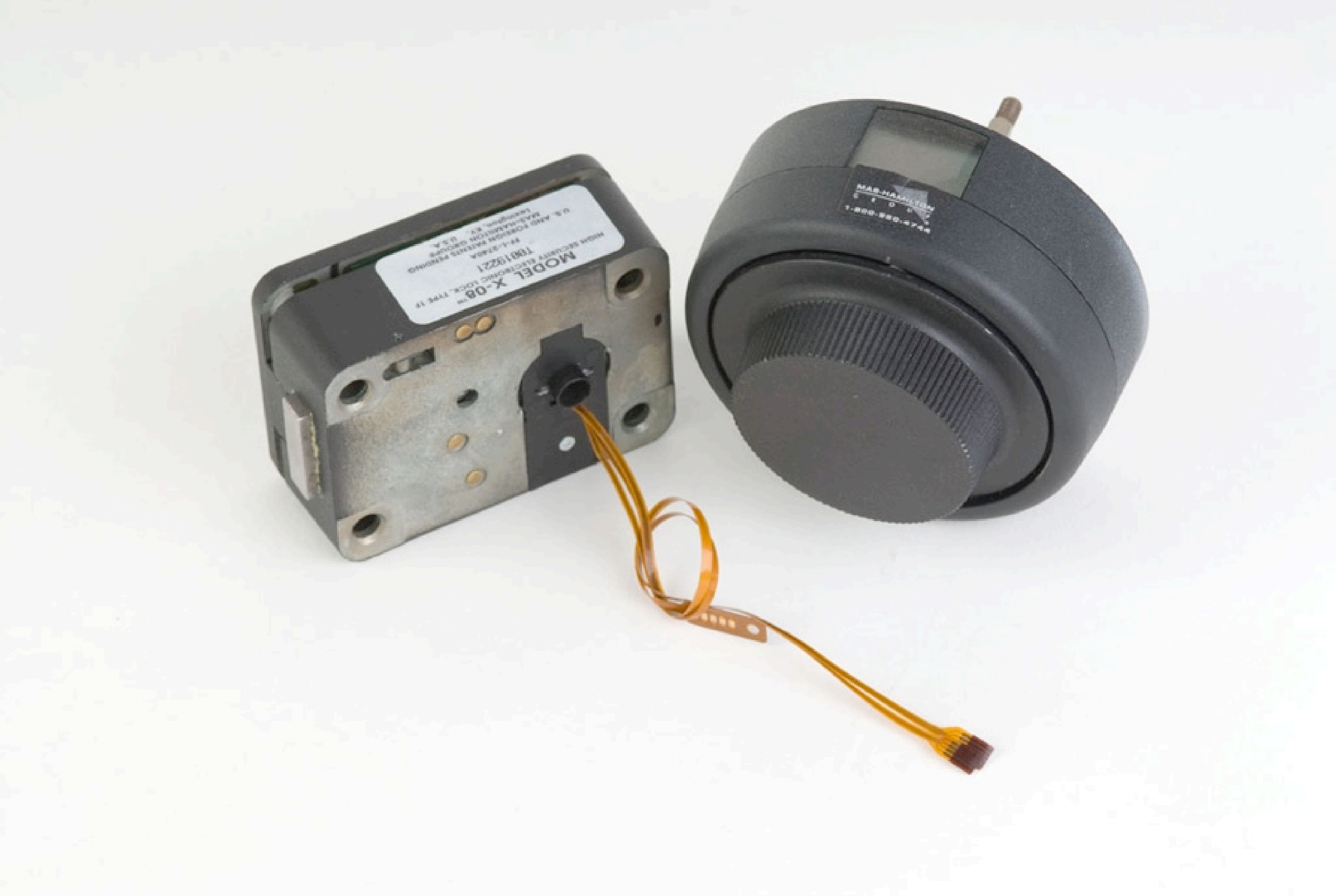
- Users can still distribute the combination



Photograph by Schlage

Safe-type electronic locks



Safe-type electronic locks

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- Audit trail usually available
  - LaGard Navigator
    - Web-based lock designed for ATMs, extensive audit trail
    - User connects smart phone or PDA loaded with client software that allows the lock to communicate with the server

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- Very secure
- Audit trail usually available
  - LaGard Navigator
    - Web-based lock designed for ATMs, extensive audit trail
    - User connects smart phone or PDA loaded with client software that allows the lock to communicate with the server
- Some are vulnerable to spiking and other safe-technician tricks

Biometrics

- Voice
- Face
- Fingerprints
- Hand geometry
- Retina scan
- Iris scan
- Signature

Voice pattern recognition

- Reliability
  - Time, stress, illness
- Easy to defeat

Face recognition

Hold up a photo or a laptop

Fingerprints

Fingerprints

- Guess what your fingers leave behind on the sensor?
  - Use gummi bears, breath, water-filled bag (condom)

Fingerprints

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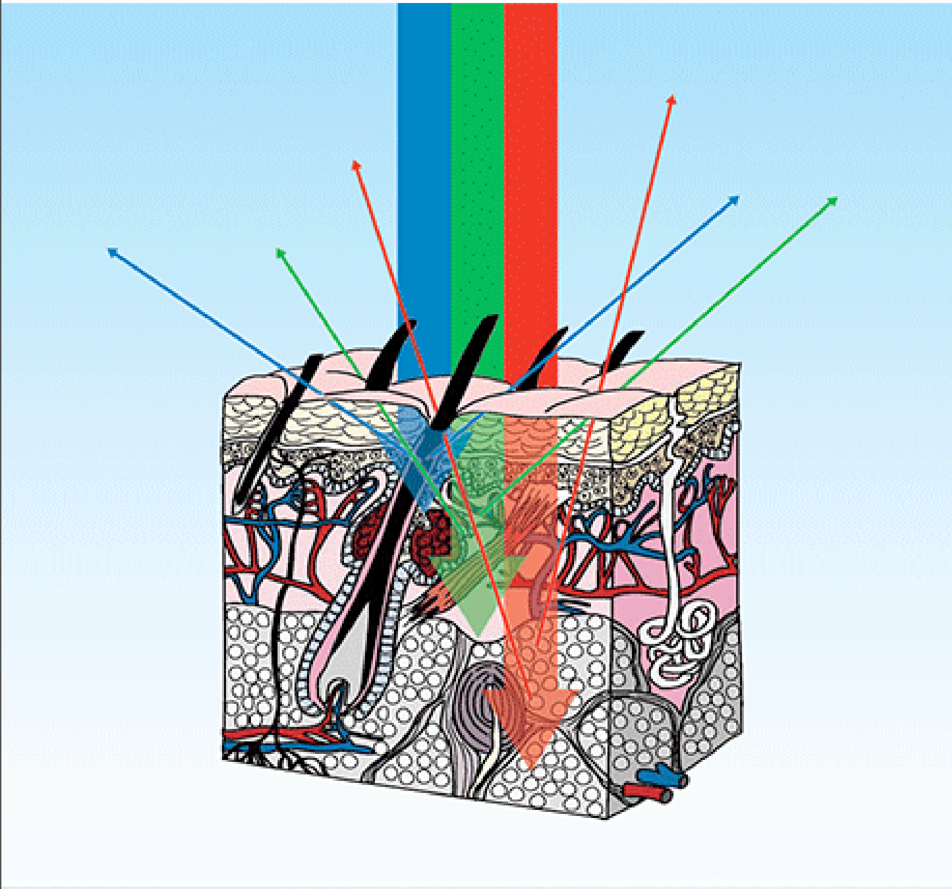
- Environment around the sensor has fingerprints too

Fingerprints

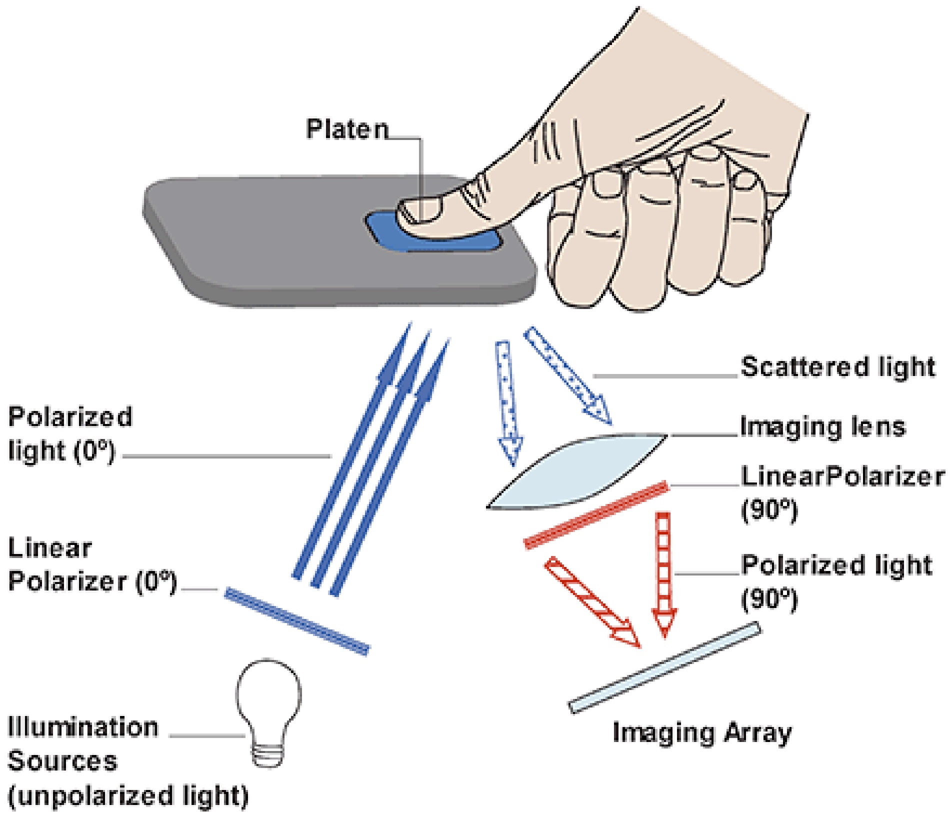
- Guess what your fingers leave behind on the sensor?
  - Use gummi bears, breath, water-filled bag (condom)
- Environment around the sensor has fingerprints too
- Supervision by trained guards

Multispectral imaging

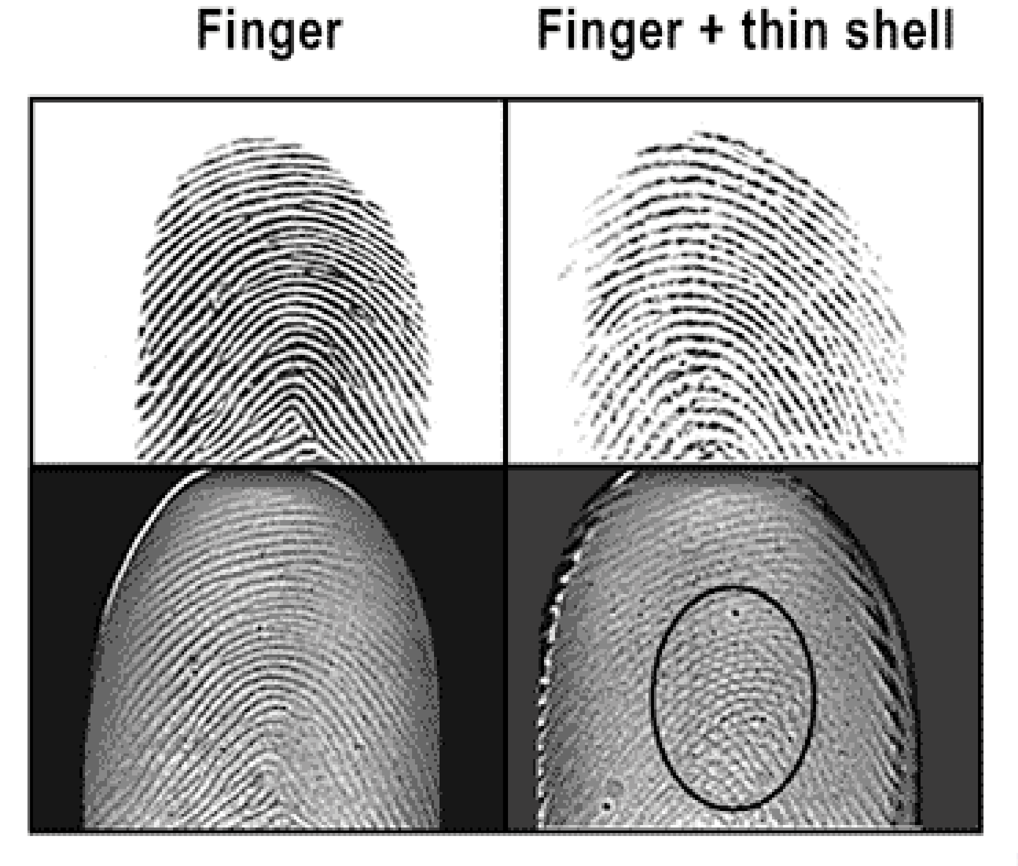
- The manufacturer claims that it:
  - Does not require contact between the finger and reader
  - Is capable of reading when the reader is immersed in water
  - Inherently differentiates between a live finger and any prosthetic

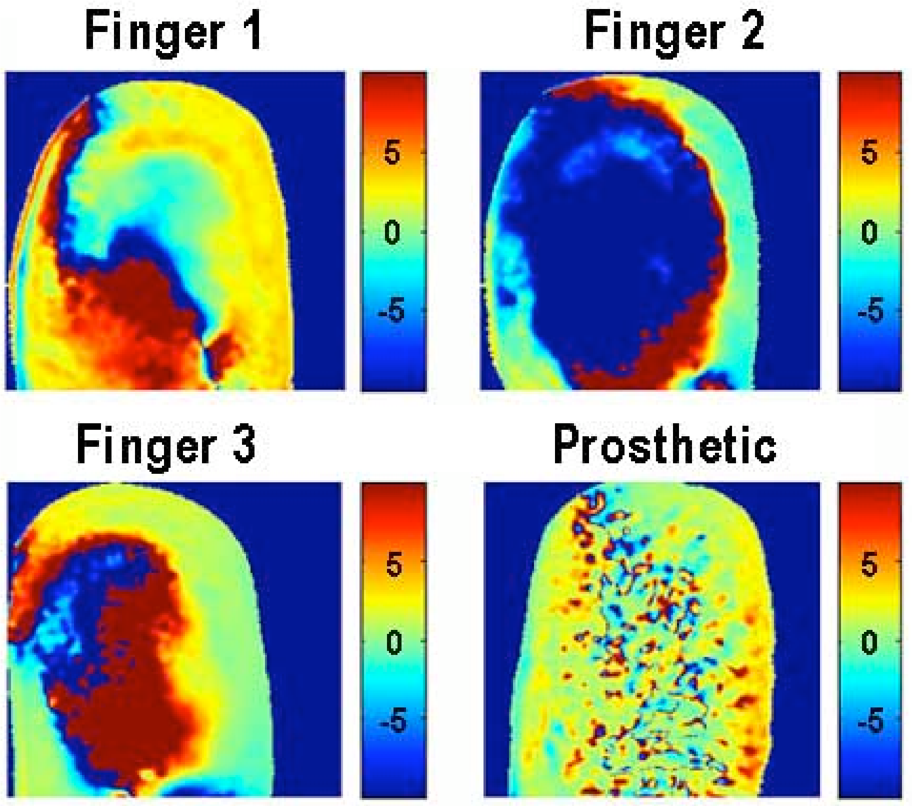


Multispectral Imager



Images from lumidigm.com





Images from lumidigm.com

Multispectral imaging

http://www.lumidigm.com

Hand geometry

- Hands are not unique
  - Privacy
- Dummy hands

Retina scan

- Nobody in the public literature has yet falsified a retina.
- Invasive

Iris scan

Iris scan

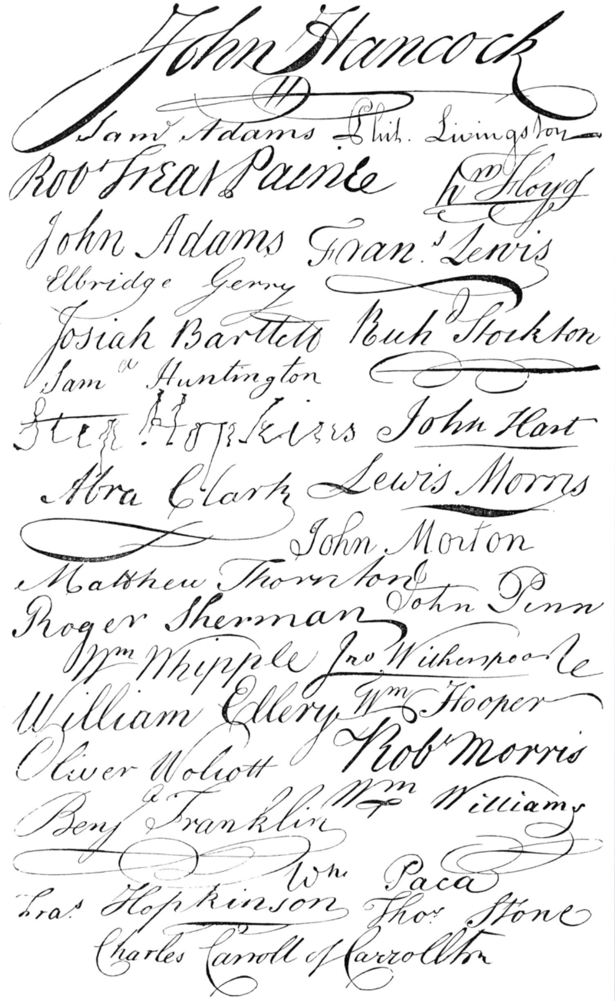
- Effectively zero error rate
  - 1 in 1 million Equal Error Rate
  - For FRR of 0.0001%, an FAR of 1 in a trillion (1×10^{-12}%)

Iris scan

- Effectively zero error rate
  - 1 in 1 million Equal Error Rate
  - For FRR of 0.0001%, an FAR of 1 in a trillion ($1x10^{-12}$%)
- Defeating iris scan
  - Magazine covers
  - Printing on contact lenses

Signature

- Measure pressure and velocity
- 1% ERR
  - Banks demand 1% FAR and 0.01% FRR
- Forging signatures is easy to learn


John Hancock
Saml Adams
Phil. Livingston
Robt Treat Paine
Wm Floyd
John Adams
Fran. Lewis
Elbridge Gerry
Josiah Bartlett
Richd Stockton
Saml Huntington
Step. Hopkins
John Hart
Abra Clark
Lewis Morris
John Morton
Matthew Thornton
John Penn
Roger Sherman
Wm Whipple
Jno Witherspoon
William Ellery
Wm Hooper
Oliver Wolcott
Robt Morris
Benj Franklin
Wm Williams
Wm Paca
Fras Hopkinson
Thos Stone
Charles Carroll of Carrollton

Further reading

- Ross Anderson’s Security Engineering
- Ross, et al. Handbook of Multibiometrics