Bank Vault Anatomy

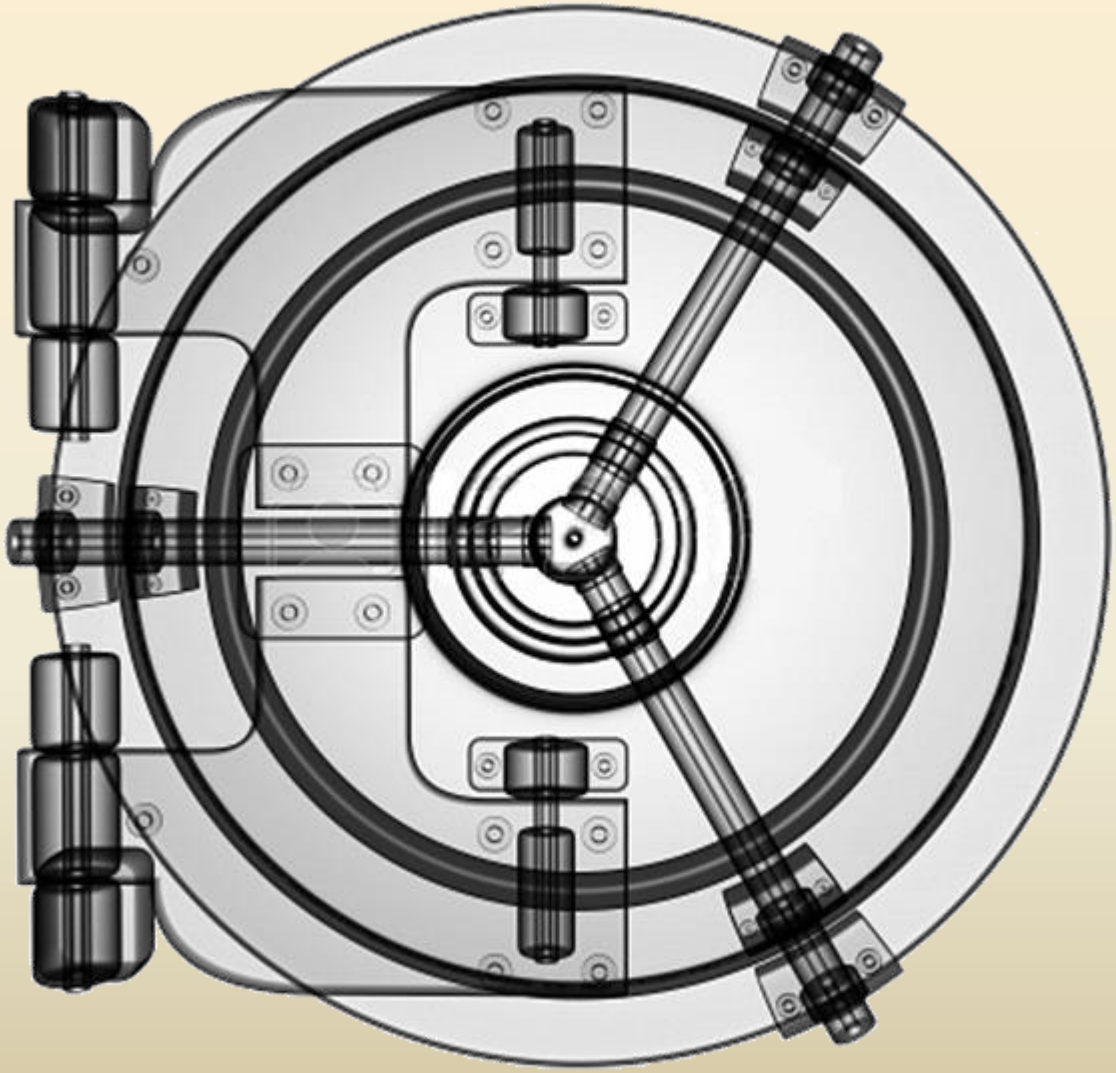

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Table of Contents

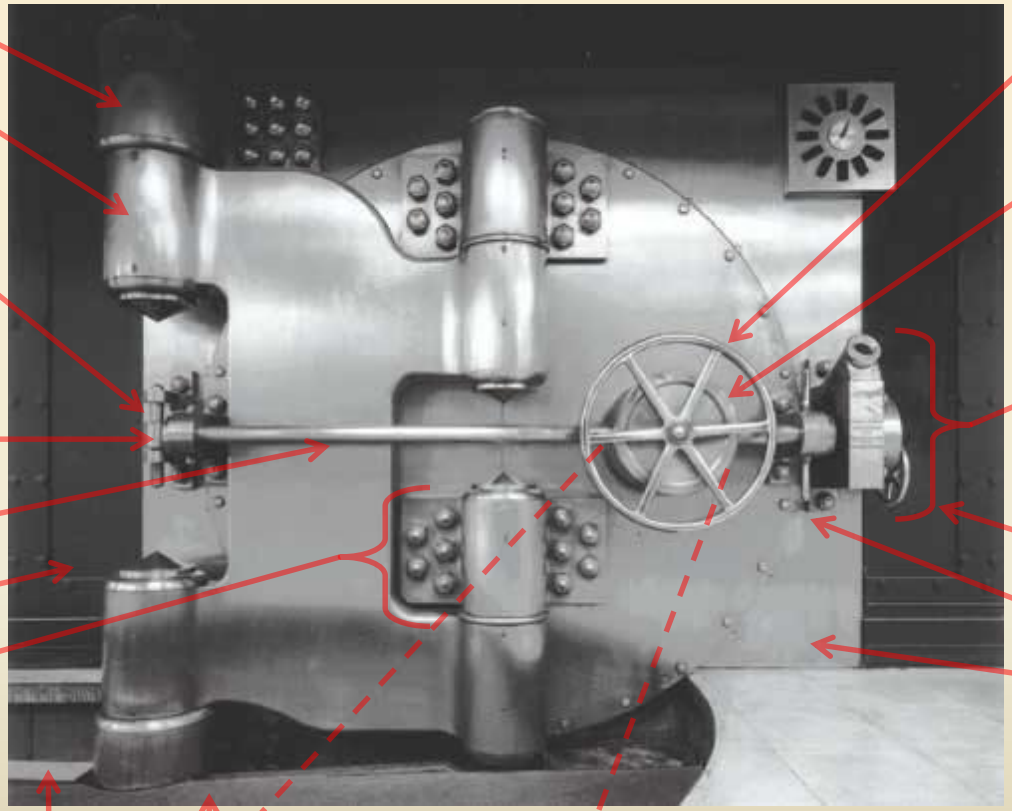
Bank Vault Anatomy is a semi-technical guide to bank vaults built in the early 1900s.

View this presentation in other file formats to see animations, videos, active links and images.

Vault Door Exterior

The Dominion Bank Safe Deposit Vault Door

built in Toronto Canada in 1914, currently the One King West Hotel & Residence



Door Jamb Hinge Block

Crane Hinge Knuckle (Ball and Roller Bearings)

Pressure Hinge and Stanchion (stanchions at both ends)

Pressure Cam (eccentric) and Anchor Point at both ends (decompressed)

Pressure Bars

Door Frame

Door Hinge Block

Pressure System Hand Wheel

Pressure Mechanism/ Gear Drum (capable of exerting pressure = to 1/3 of door weight)

Dual Custody, Remote Combination Viewer and Pressure Housing

Bolt-Throwing Hand Wheel

Door Handles

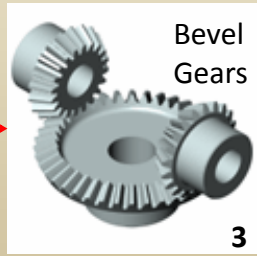
Door Jamb

Door Specifications
Weight: 44 tons (88,000 Lbs.)
Opening: 7.5' (90")
Depth: 4.5' (54")
Jamb: 12' x 15' x 3'
Max. Pressure: 15 tons (30,000 Lbs.)

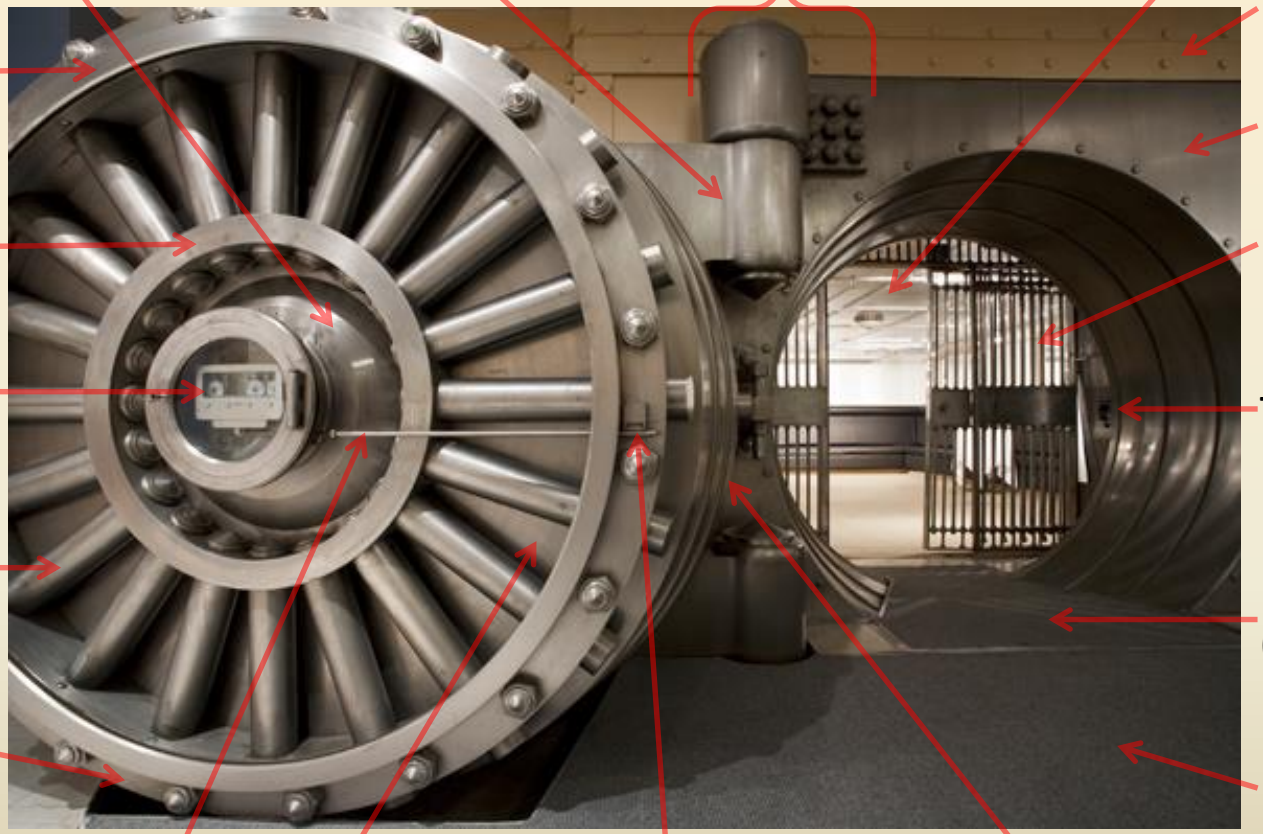
Door and Entrance Platforms (lowered)

Worm Shaft & Gear

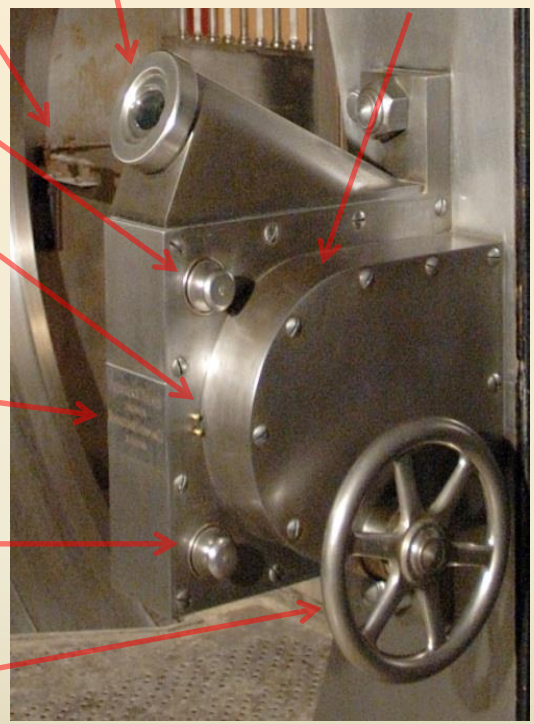
1) Hand Wheel cranks Worm Shaft
2) Worm Shaft cranks Worm Gear
3) Worm Gear cranks Bevel Gears
4) Bevel Gears crank Pressure Bars
5) Pressure Bars crank Pressure Cams
6) Pressure Cams rotate on Anchor Points



Vault Door Interior



Dual Custody, Remote Combination Viewer



Note – Combination Locks and Bolt-Throwing Mechanism are located inside the vault creating a solid vault door with no spindle holes. Entry requires two points of attack (door and jamb) which doubles the time required to breach the vault.

The 'Remote Combination Viewer' designed by Frederick S. Holmes is referred to by other names including **Illuminated Dial-Case**, **Periscope Attachment**, and **Telescopic Box**.

"Note level walk-way, bolt-throwing hand wheel and **illuminated dial-case** on frame, and combination lock-operating knobs on front jamb pressure housing."

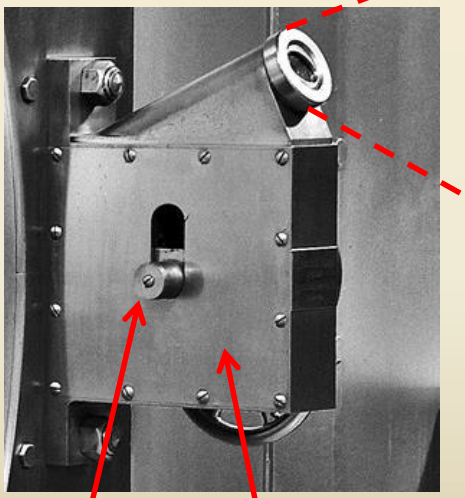
"In the more recent modern vaults there is a **periscope attachment** to the side of the door frame from which this combination is set so that no one can look over the shoulder of the person opening the door or setting the combination and ascertain the sequence of numbers used."

"The **telescopic box** at the right reveals the combination dial only to the person who manipulates it."

See all Remote Combination Viewer Descriptions

Remote Combination Viewer Video

Illuminated, stationary combination dial with rotating pointers:
#1 Hand - 1st combination lock/top knob
#2 Hand - 2nd combination lock/bottom knob



Pressure Housing

Pressure Anchor Point (decompressed)

Click above to see the combination dial pointers in action (from the Pennsylvania Treasury Vault)

Bolt-Throwing Mechanism

Bolt-Throwing Jamb Pins
mounted on interior door jamb

Door jamb damage due to door entering jamb unparallel

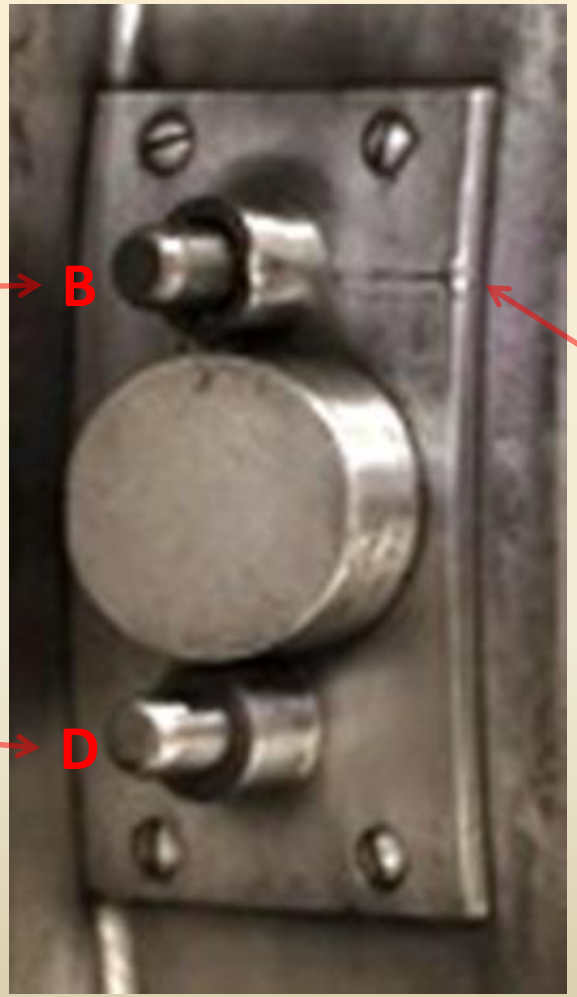
Open:
A pushes **B**
to retract locking bolts

via the Bolt-Throwing hand wheel on the Remote Combination Viewer

Close:
C pushes **D**
to extend locking bolts

Lower jamb pin removed to prevent door from locking

Bolt-Throwing Door Pins
located at the 9:00 Locking Bolt



Notice the ding and deep groove on the plate and dented door pin collar caused when the upper jamb pin was extended while closing the door.

Both door jamb pins must be retracted while opening/closing the door.

Boltwork Videos

Boltwork action is hidden behind a static concealment disc – directly behind the locking bolts. The rotating drive plate operates the locking bolts via diagonal slots that engage rotating pins or with pivoting 'L' shaped cams.

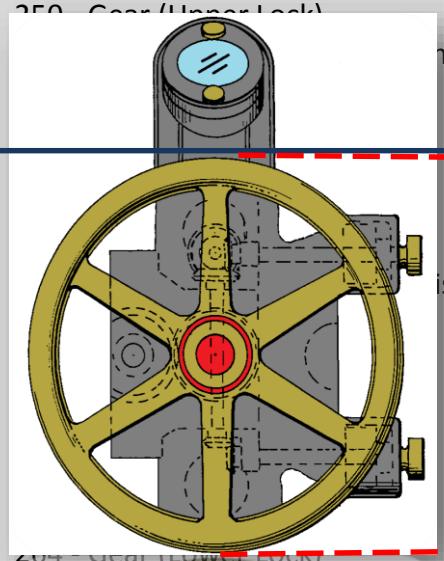
Rotating Drive Plate

Retracting Locking Bolt

Click pictures to see the boltwork in action

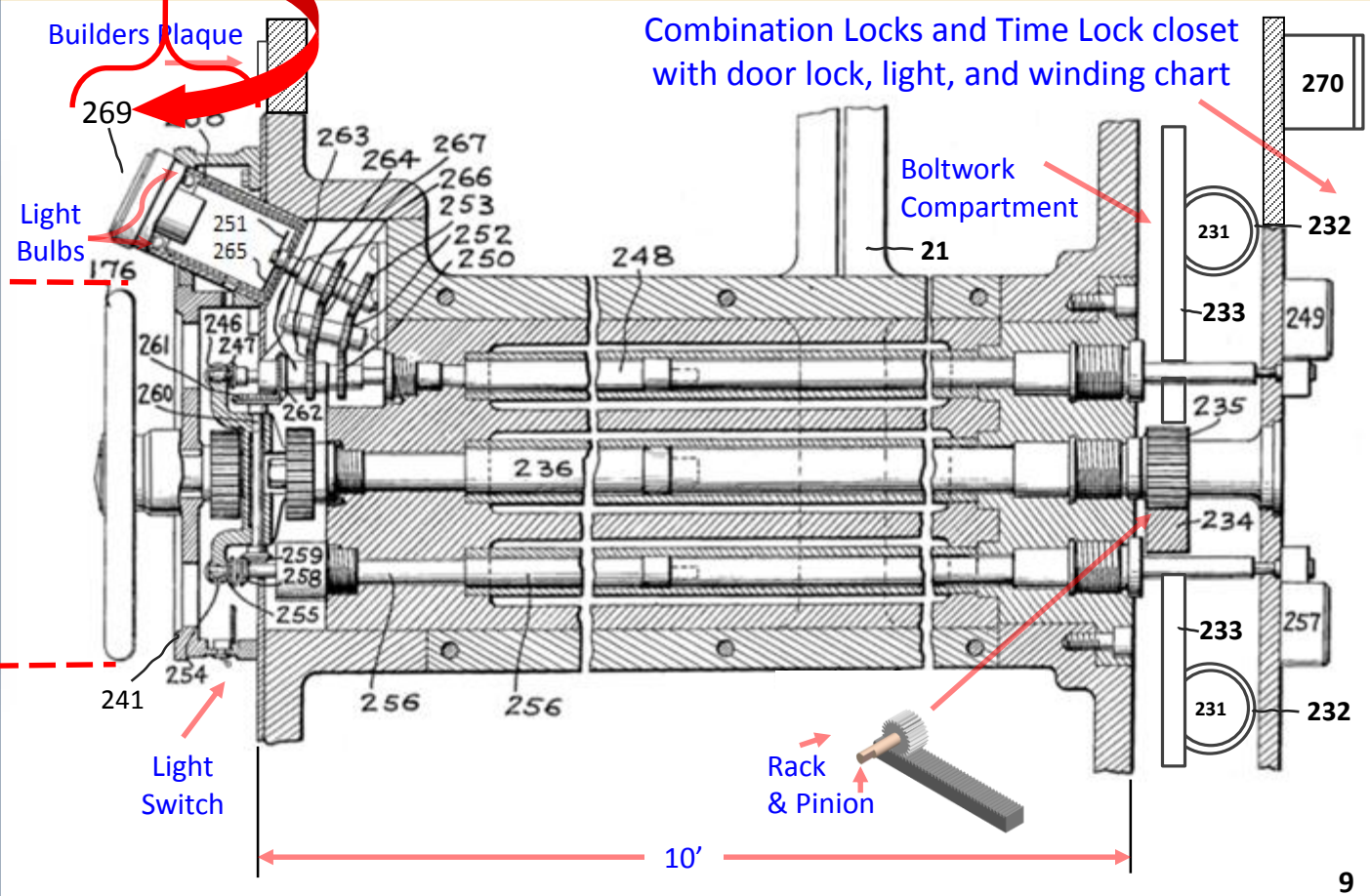
Remote Combination Viewer/Bolt-Throwing Mechanism Patent

21 - Side Frame
176 - Hand Wheel (6 Spoke)
231 - Locking Bolt (4 Total)
232 - Locking Bolt Pocket (4 Total)
233 - Locking Bolt Carriage
234 - Rack Bar/Gear
235 - Pinion Gear
236 - Bolt Actuating Shaft
241 - Gear and Viewer Housing
246 - Bevel Gear (Upper Lock)
247 - Bevel Gear (Upper Lock)
248 - Combination Shaft/Spindle
249 - Combination Lock Mechanism
265 - Combo Dial Pointer (#2 Hand)
266 - Gear (Lower Lock)
267 - Gear (Lower Lock)
268 - Combination Dial Housing
269 - Sight Opening/Eyepiece
270 - Time Lock (Yale-4 Movement)

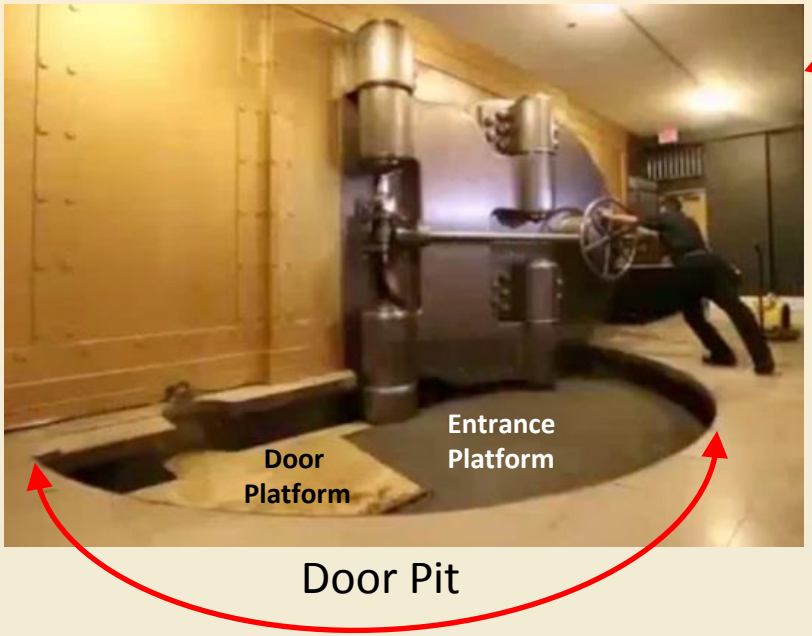


"Figure 21 is a vertical longitudinal section of a portion of the locking mechanism for the closure member." from Vault, U.S. Patent # 2,081,316. This design was used on the rotating vault at the PA Treasury Vault and a similar design was used at the NY Federal Reserve Bank.

Side View (Cross Section)



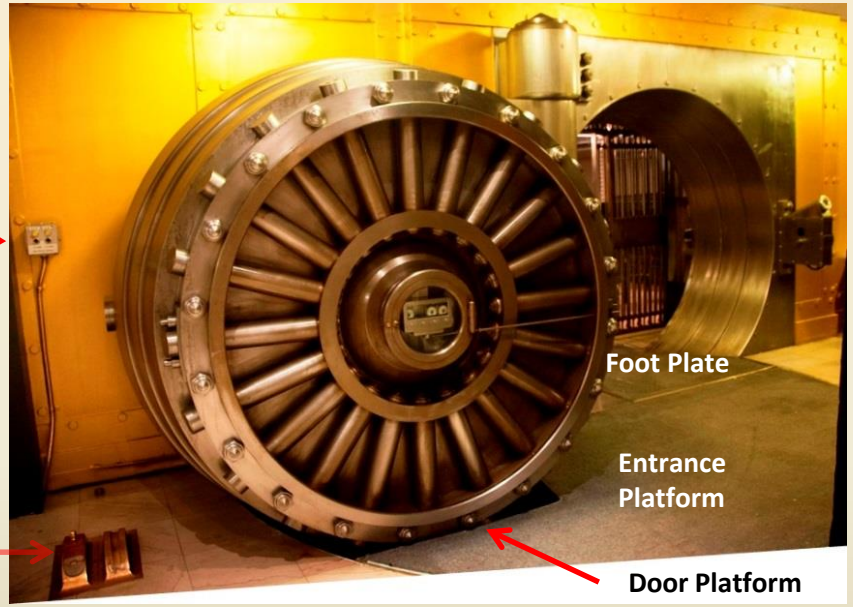
Vault Platform Operation



Door Opening/Closing - Both platforms lowered, Foot Plate raised

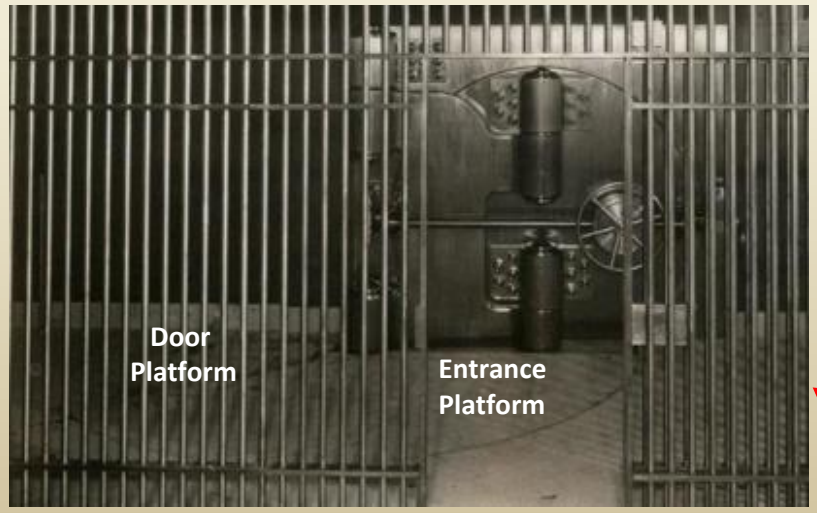
Watch the video

Automatic Platform Controls



Manual Platform Controls (original)

Door Open - Entrance Platform raised, Door Platform and Foot Plate lowered



Door Closed – Both platforms and Foot Plate raised

Vault Door Open/Close Procedures

Vault Door Open Procedure

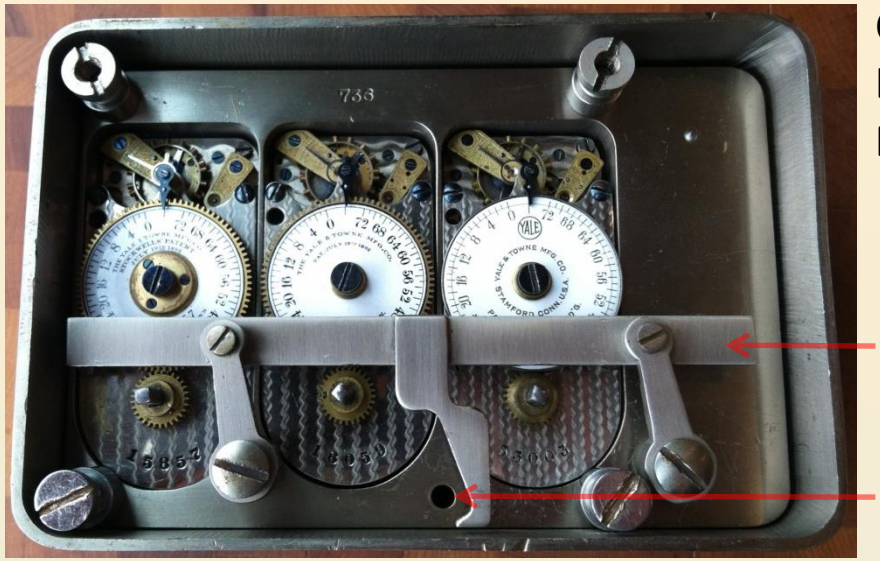
1) **Time Locks** - Wait for one of the time locks to run down/stop (releasing snubber)
2) **Platforms** - Lower vault door and entrance platforms
3) **Combinations/Locking Bolts** - Dial proper combinations and retract locking bolts
4) **Pressure System** - Disengage pressure system (decompress)
5) **Open/Latch** - Pull vault door open to door stop, engage latch
6) **Platform/Bridge** - Raise entrance platform and lower the bridge

View Detailed Vault Open /Close Procedures here

Vault Door Close Procedure

1) **Time Locks** - Wind time locks accordingly
2) **Bridge/Platform** - Raise bridge and lower entrance platform
3) **Obstructions** - Clear vault door jamb of any obstructions
4) **Unlatch/Close** - Unlatch vault door and push until seated in door jamb
5) **Pressure System** - Engage pressure system (compress)
6) **Locking Bolts/Combinations** - Extend locking bolts (closing snubber) and scramble combinations
7) **Platforms** - Raise vault door and entrance platforms

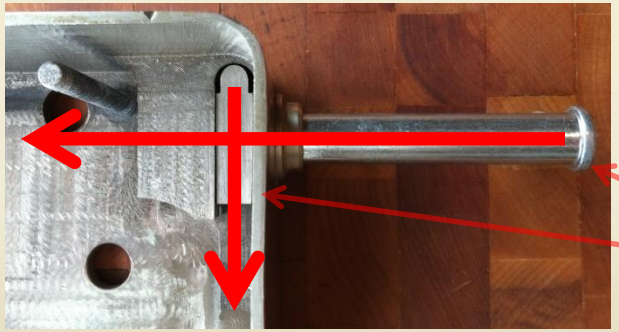
Time Lock



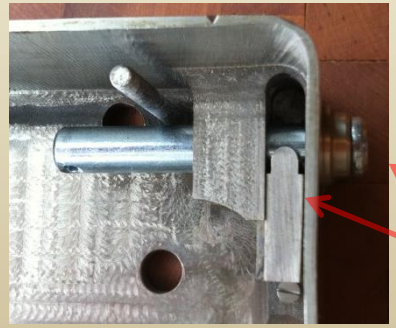
Case Manufacturer: Yale & Towne
Location: Stamford, CT
Model: Triple K

Trigger Assembly

Hold-Open Knob (missing)

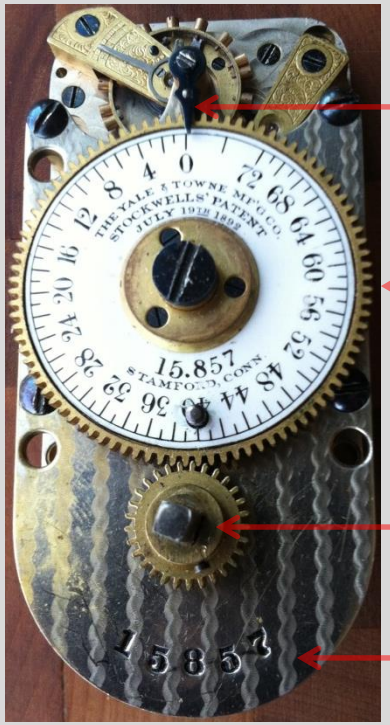


Locked - prevents Locking Bolts from retracting
- Snubber Bar Extended
- Snubber Raised



Unlocked - allows Locking Bolts to retract
- Snubber Bar Retracted
- Snubber Lowered

Movement Manf.: Seth Thomas
Model: L
Patent: Stockwell's
Patent Date: July 19th 1892



Indicator

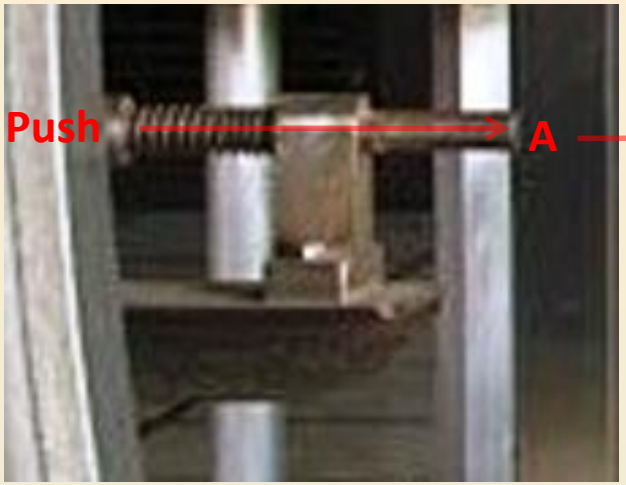
Display Wheel Gear

Winding Arbor

Serial #

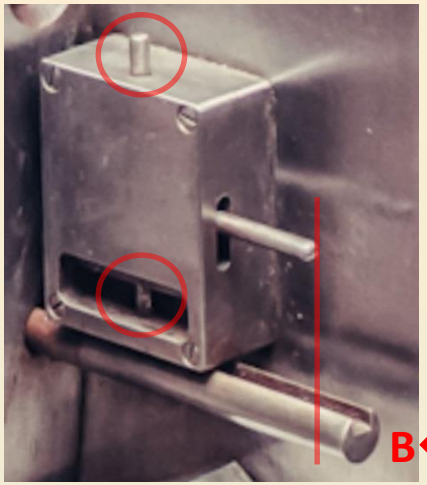
Time Lock Release and Remote Flag/Lock

The Time Lock Release and Remote Flag/Lock are located at the 3:00 Locking Bolt



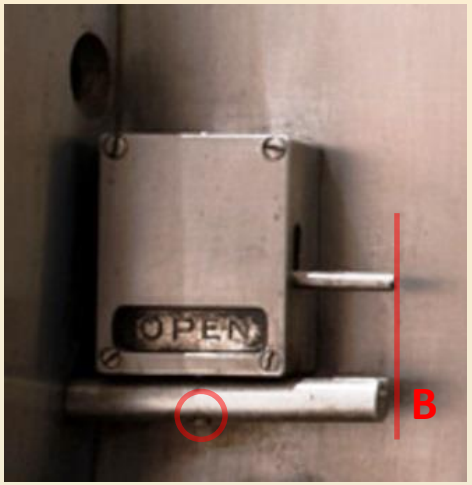
Time Lock Release Actuator - Manual plunger, mounted on interior door jamb. **A** pushes **B** to disengage the Time Lock for accidental lock-ins

"Should, by accident, one of the clerks be locked in the vault at the time it is closed, he can push a button release the dogging mechanism of the time locks and telephone to the officers of the bank, who would operate the combination locks and effect his release, after which the time-lock devices would be reset and the doors locked. Frederick S. Holmes was the vault engineer." [From the RI Hospital Trust Co. article in **Architecture and Building** magazine, 1920]



Time Locks Engaged – Prevents Locking Bolts from retracting

- Button extended
- Lever raised
- Flag Lock Pin retracted allowing Release Bar movement
- Release Bar extended (past end of Lever)
- No flag



Time Locks Disengaged – Allows Locking Bolts to retract

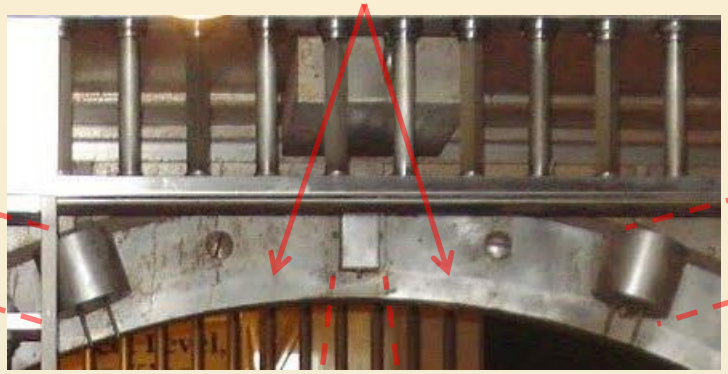
- Button depressed
- Lever lowered
- Flag Lock Pin extended thru Release Bar preventing its movement
- Release Bar retracted (flush with Lever)
- 'OPEN' flag is visible

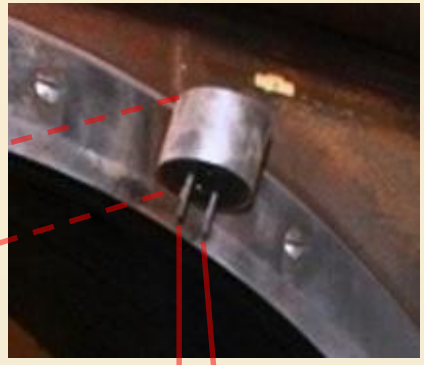
Other Vault Features

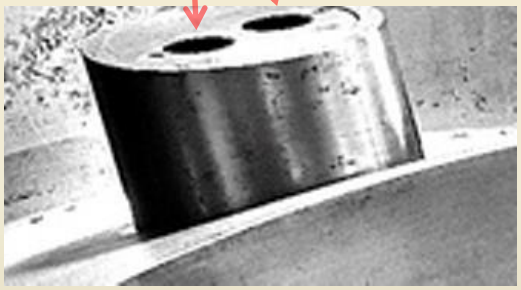
Electrical Contact at 11:00 (interior)

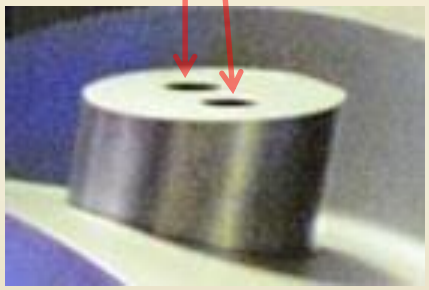
Locking Bolt Bearing Ring (tapered)

Electrical Contact at 1:00 (interior)









Electrified Locking Bolt at 11:00 (exterior)

Bolt Extension Indicator at 12:00 (interior)

Electrified Locking Bolt at 1:00 (exterior)

- Alarms
- Communications
- Decoration

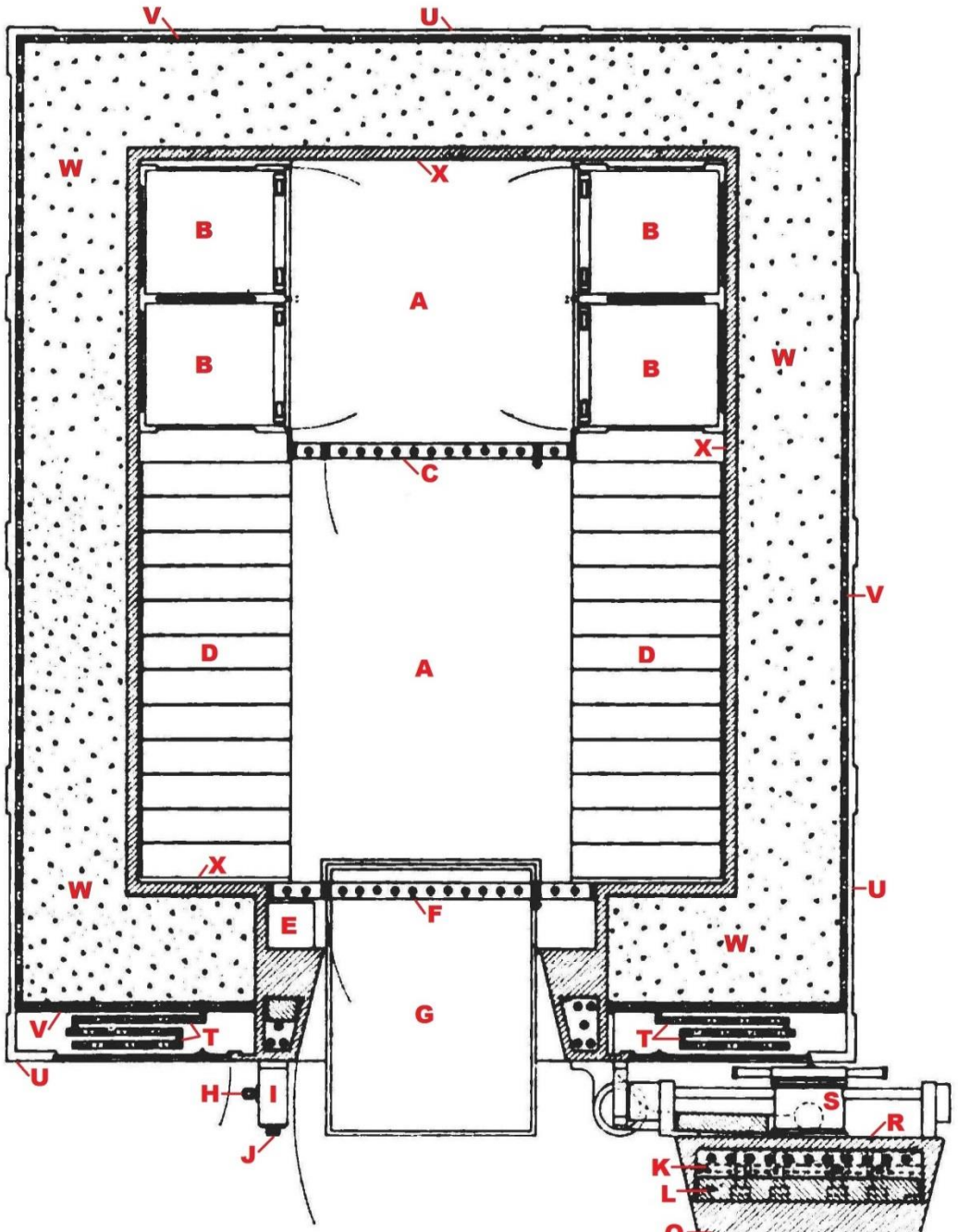
- Emergency Doors
- Lighting
- Periscopes

- Power
- Railings
- Ventilation

Vault Room Plan

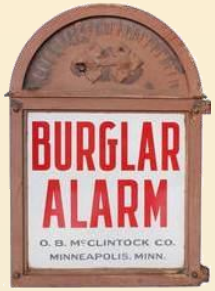
LEGEND

- **A** – Aisle
- **B** – Security and Coin Lockers
- **C** – Grille Gate
- **D** – Safe Deposit Boxes
- **E** – Combination Locks & Bolt-Throwing Mechanism in Housing
- **F** – Day Gate
- **G** – Foot Plate
- **H** – Bolt-Throwing Handle/Hand Wheel
- **I** – Pressure Housing
- **J** – Combination Lock Dials
- **K** – Reinforced Concrete
- **L** – Anti-Cutter-Burner Section
- **M** – Bolt Work
- **N** – Time Lock and Housing
- **O** – Glass Door
- **P** – Cast Bolt Frame
- **Q** – Laminated Construction
- **R** – Low Steel Casting
- **S** – Pressure Mechanism/Gear Drum
- **T** – Electric Protection Cover Doors & Stiles (shown collapsed) – sections are expanded and connected to enclose the door jamb after door is closed
- **U** – Exterior Finish
- **V** – Electric Protection Panels
- **W** – Rail or Rod Reinforced Concrete
- **X** – Tool and Cutter-Burner Resisting Lining



Plan of Typical Bank Vault of Effective Construction and Moderate Cost (in 1916)

Burglarious Deterrents



- Air Tight
- Alarms/Gongs
- Armed Guards/Sharp Shooters
- Bandit Barrier/Patrol Passage with mirrors on all sides
- Bomb-proof/Drawbridges/Moats/Sliding Floors/Suspended Observers (Bank of France)
- Bullet Proof Glass
- Chisel-proof
- Composite Vault Doors with Cast Steel, Concrete, Copper, Corundum/Aluminum, Jail Rods, Low Steel, and Nickel Steel Armor layering
- Electrified Cover Doors and Vault Lining
- File-proof
- Fireproof
- Flooding
- Gun Turrets/Ports/Slots
- Heavy steel plating around combination locks and bolt-throwing mechanism
- Harveyized Nickel Steel Armor Plate Vault Lining
- Infusite
- Mob-Proof
- Periscopes/Tresoroskops
- Poison/Toxic Gas
- Rock Concrete
- Size/Mass
- Small artillery cannon
- Steam Blasts
- Steam Tight
- Steel Paneled Cladding
- Shock Sensors
- Sulfur
- Tear Gas (Article, Brochure)
- Thermal Contacts
- Time Locks
- Triple Sections of 125 Lb. Nickel Steel Rail Interlocked Reinforcing
- Waterproof
- Water Tight

Burglarious Tools

of the Creepers, Soup Men, and Yeggs

(Smithsonian article , July 1984)

Hand Tools

- Bar Spreaders
- Block and Tackle
- Bolt Cutters
- Calipers
- Center Punches
- Chisels
- Clamps
- Drills/Bit Braces
- Files
- Hammers
- Hack Saws
- Knives
- Lock Picks
- Mallets
- Pick Axes
- Pry Bars
- Ratchets/Sockets
- Ropes/Leather Straps
- Screw Drivers
- Screw Jacks
- Shovels
- Sledge Hammers
- Wedges
- Winches/Chain Falls
- Wood Blocks
- Wrenches

Diebold Safe & Lock Co. ad from 1879

Corrosives

- Acid

Pneumatic Tools

- Blow Pipe
- Pump

Electric Tools

- Chisels
- Drills
- Jack Hammers

Explosives

- Dynamite
- Gunpowder
- Nitroglycerin
- Thermite

Torches

- Burner Cutters
- Burning Bars
- Oxy-Acetylene

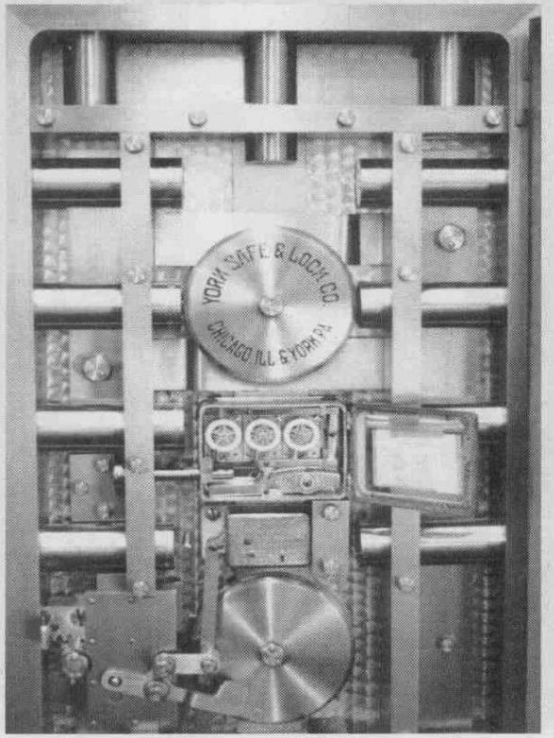
How Vault Doors Work

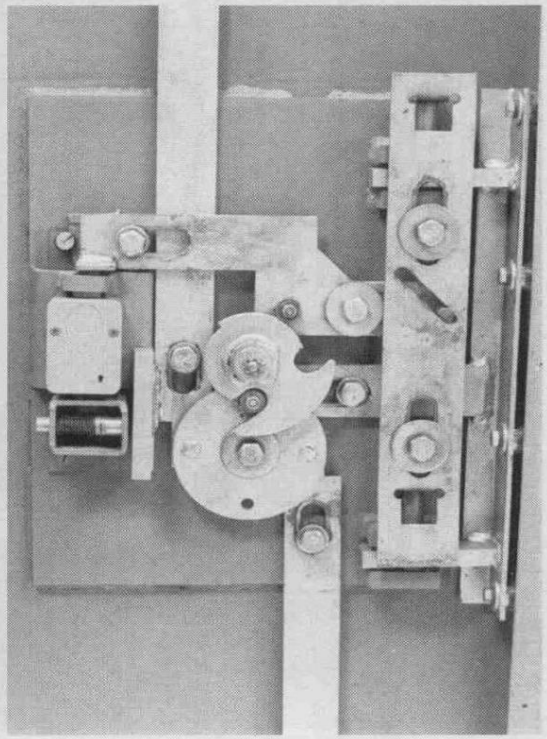
Both safes and vaults are boxes designed to keep treasures safe. A vault is a permanently installed strong-room large enough to walk into; a safe is something smaller and semi-portable, and when the box is very small (and usually permanently attached in a vault or safe or inside a wall or floor), it is called a money chest.

All sides are solid except for the door side. To integrate the door to the rest of the box, round solid steel rods (called bolts) extend from the inside of the door into the door's frame, making the door and box an integral unit. Even with the door's hinges removed, the bolts extending from all four edges of the door make the door and box literally inseparable. The rods or bolts are connected together and articulated so that when a handle on the outside of the safe is turned, the bolts extend into the door frame or retract back into the door in unison.

Figure A, left. Vault door bolts that move in unison into the door frame of the vault with the turn of the vault door's handle.

Figure B, right. Small safe door's bolt mechanism. The door handle turns the cam that moves the bolts in unison into and out of the safe door's frame.





To prevent the bolts from moving once they are extended into the frame, a safe or vault lock is applied. Usually the lock has a short locking bar that extends into the operating cam of the door's bolt work, blocking the movement of the cam and thus preventing the movement of the bolt work when the outside handle is turned.

Usually the lock is a combination lock that needs a certain combination of turns or a certain electronic code to move the locking bar away from the door's bolt work cam, thereby freeing the cam so that it can retract the door's bolt work when the outside handle is turned.

How Time Locks Work

Information on the previous page and this page is from the National Association of Watch and Clock Collectors Bulletin – Time Locks: Their History from Beginning to End by David Christianson, December 2004

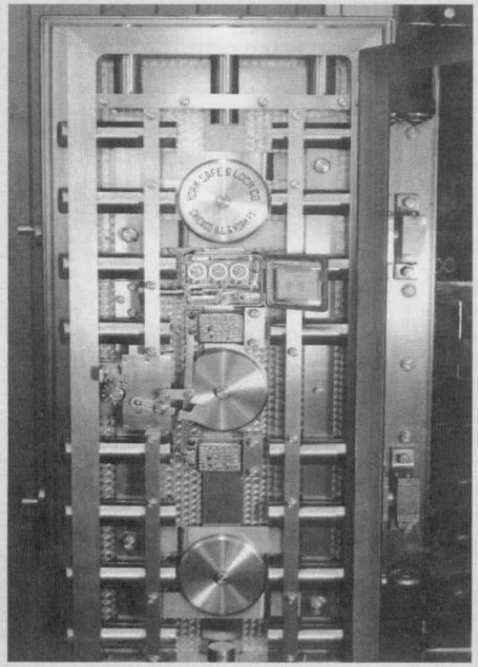
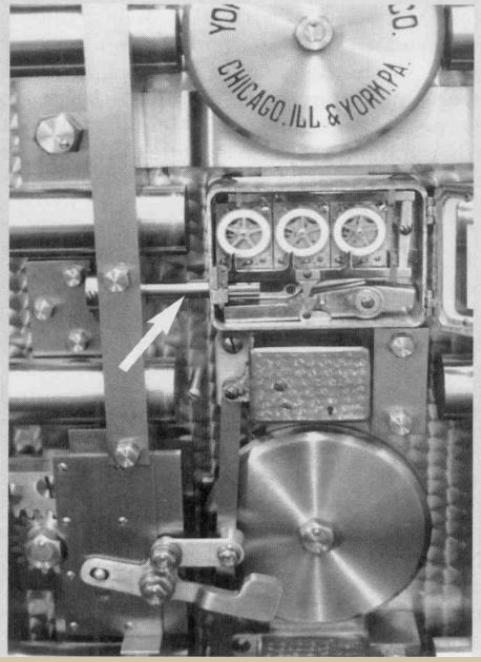


Figure C, above. Time lock in the middle of the vault's bolt work.



A time lock is another type of safe or vault lock that is designed to remain locked until a certain number of hours have elapsed since the door was closed and the lock set.

Most time locks consist of one or more timepiece movements that control a release bar. The release bar blocks a hole in the side of the time lock case (the case that holds the movements and the release bar mechanism).

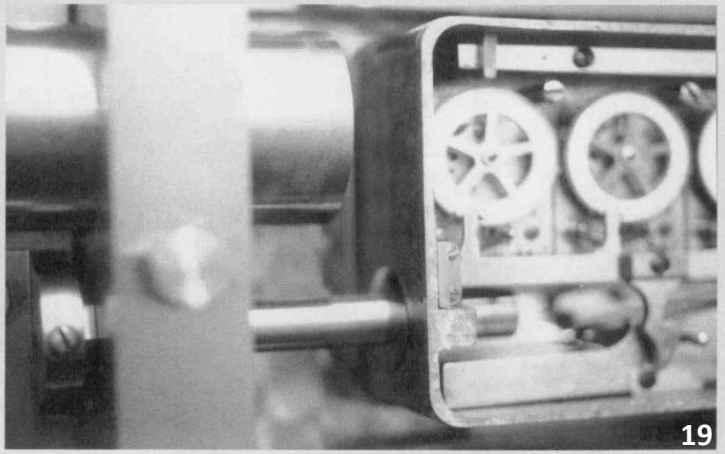
The time lock case is positioned inside the safe or vault door in the path of a connecting bar that is attached to the safe door's moving bolt work (Figure C). With the combination lock unlocked, the door handle can turn, retracting the door's bolt work. But with the small connecting rod positioned between the bolt work and the time lock, the bolt work cannot move if the connecting rod cannot enter the time lock case; and the door remains locked by the time lock, even though the combination lock is unlocked and not interfering with the bolt work (Figure D).

When the time lock releases its release bar at a specified time, the release bar moves away from the hole in the time lock case and allows the connecting rod on the door's bolt work to enter, allowing free movement of the bolt work as the outside door handle is turned and the bolts retract from the door frame (Figure E).

If the safe is not opened within about 15 or 20 minutes of its designated opening time, the release bar simply returns to its

Figure D, left. The time lock's release bar drops out of the way when the time lock movements reach opening time, allowing the connecting rod or pin on the bolt work to enter the time lock case and thereby permitting free movement of the bolt work into and out of the door's frame.

Figure E. Closeup of the connecting rod entering the time lock case. The release bar rests at the bottom of the case, out of the way of the entering rod.



How Time Locks Work

(continued)

Information from the National Association of Watch and Clock Collectors Bulletin – Time Locks: Their History from Beginning to End by David Christianson, December 2004

position in front of the time lock case hole and interferes with the free movement of the connecting rod and the door's bolt work, no matter how hard the handle is turned, while the combination lock itself is unlocked.

Because mechanical timepiece movements can fail due to shock, wear, or (more commonly) neglected maintenance, redundancy of movements in a time lock case is important. Most time locks have two or more movements, yet one continually functioning movement is all that is required to free the release bar and permit the safe or vault door to be opened.

The act of setting the dial or display wheel to the number of hours until opening time also winds the movements. All movements are set and wound to the same opening time. For example, if the vault is closed at 6:00 p.m. and is to open at 8:00 a.m. the next day, the movements are set at 14 hours, the time between 6:00 p.m. and 8:00 a.m. Time lock companies provide winding charts to aid in calculating opening times, especially over a long weekend, which require setting the movements to a high number of hours (Figure F). Sometimes more specific instructions are needed to prevent mistakes (Figure G). Only one movement is required to move the levers of the time lock that will lower the release bar—just in case the other movements might fail (Figure H).

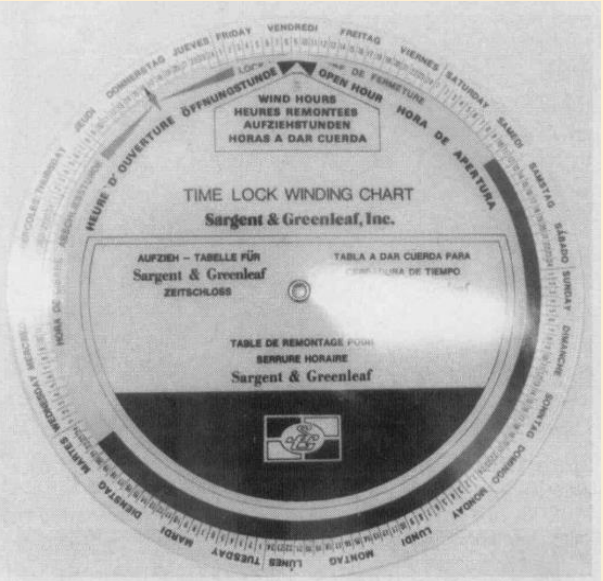


Figure F. Time lock winding chart provided with each new time lock, circa 1990.

Figure G. A homemade winding chart designed to prevent mistakes in setting the opening times of the time lock. Note the "Please don't boo boo again!"

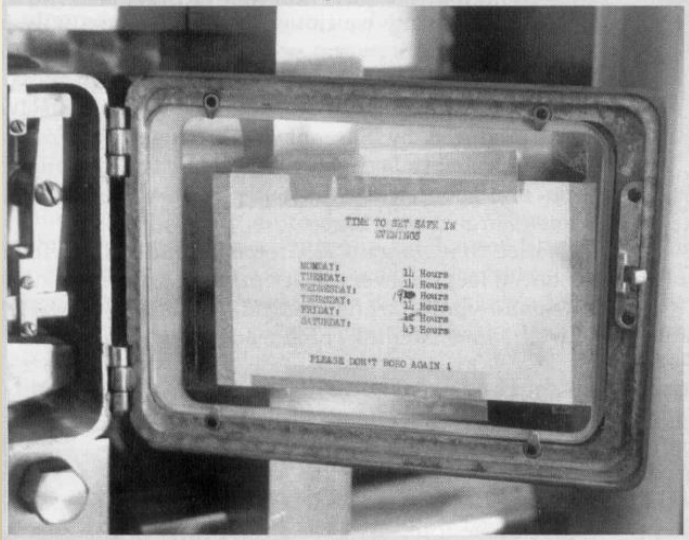
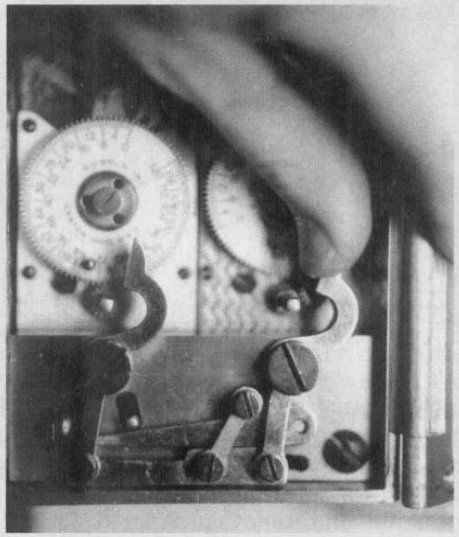
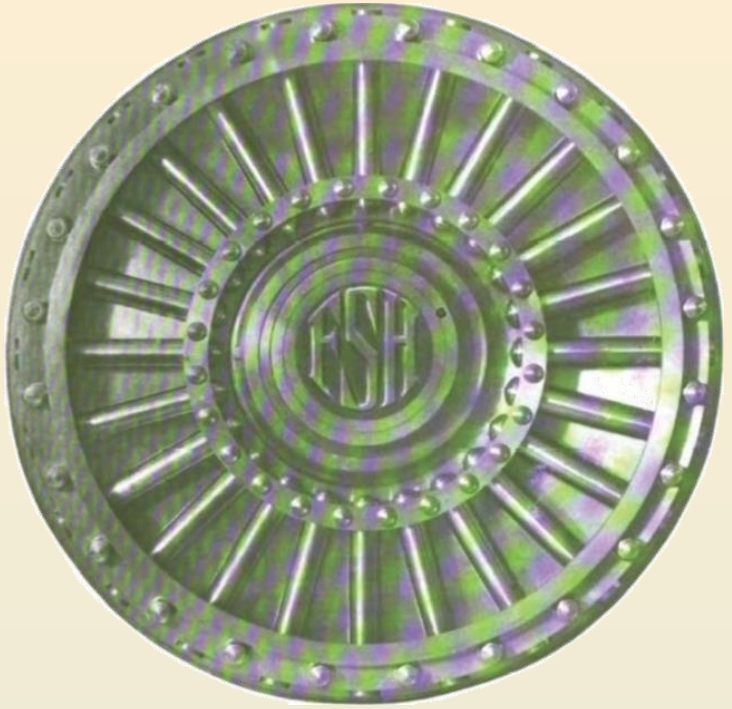


Figure H. Only one movement is needed to move the release bar levers and allow the safe door to be opened.



Frederick S. Holmes – Vault Engineer

FREDERICK S. HOLMES
BANK VAULT ENGINEER



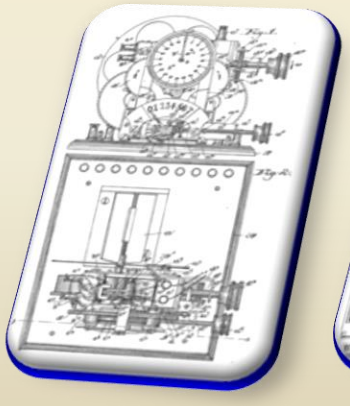
Frederick S. Holmes Company Logo

Frederick S. Holmes was a prominent bank vault engineer who designed vaults in the United States and Canada from the 1880s to the 1920s. He pioneered Remote Combination Viewers which forced burglars to make at least two penetrations. Holmes collaborated with renowned Architect Alfred C. Bossom on many projects and worked with all leading vault builders of the time: Herring-Hall-Marvin Co., Mosler Safe Co., Remington & Sherman Co., and York Safe & Lock Co.

Frederick S. Holmes – Patents

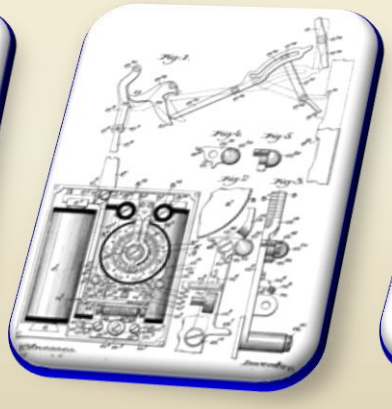
1. **Electric Safe Lock** - U.S. Patent # 438236 issued October 4, 1890 (Malden, MA)
2. **Electric Lock** - U.S. Patent # 467465 issued January 19, 1892 (Boston, MA)
3. **Electric Lock** - U.S. Patent # 477898 issued June 28, 1892 (Malden, MA)
4. **Removable Sill for Vaults or Safes** - U.S. Patent # 557389 issued March 31, 1896 (Philadelphia, PA)
5. **Safe** - U.S. Patent # 620073 issued February 21, 1899 (Philadelphia, PA)

1.



Electric Safe Lock

2.



Electric Lock

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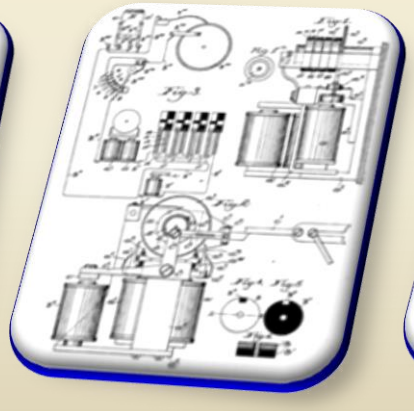

Electric Lock

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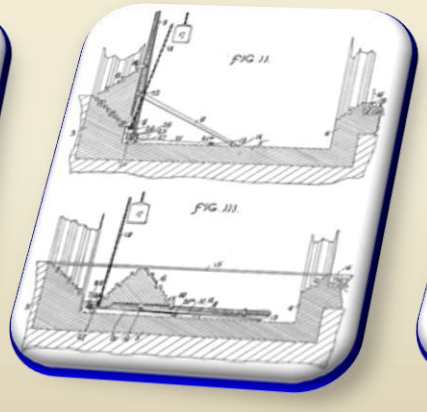
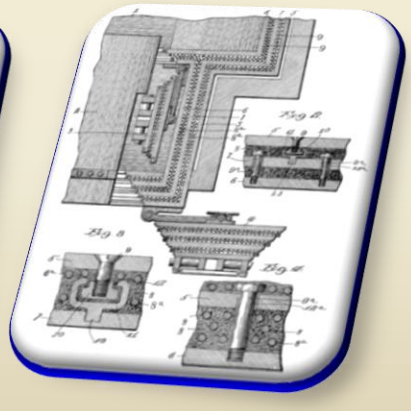


Removable Sill for Vaults and Safes

5.



Safe

Frederick S. Holmes - Articles

1905 - The Design and Construction of Modern Bank Vaults from The Architectural Review, December

1911 - Vault Building - The Backward State of the Art, the Reason and the Remedy from the Bankers Magazine, April

1911 - Why Insure Against Anything that Never Happens?, from The Bankers Magazine, January-June

1911 - Vault Building Problems from The Bankers Magazine, July-December

1912 - World's Largest Treasure Vault by Harvey Middleton with Holmes interview, from Technical World Magazine, September

1913 - Vaults – A Criticism from The Bankers Magazine, January-June

1916 - Protective Principles and Construction Methods - Part 1 of Modern Practice in the Design of Bank Vaults from The Brickbuilder, May

1916 - The Requirements of Small Banks - Part 2 of Modern Practice in the Design of Bank Vaults from The Brickbuilder, June. Reprinted in Construction magazine, November 1916

1917 - A New Concrete for Banks (describes Holmes testing methods) from The Bankers Magazine, June

1923 - Vault Protection from The Architectural Forum, June

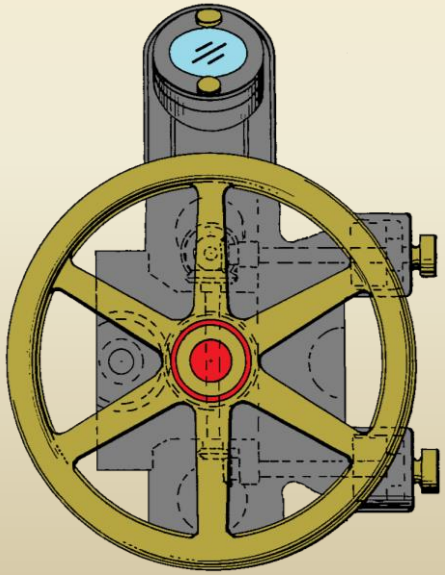
1928 - Bank Vault Construction and Equipment from The Architectural Forum, June.

1928 - Bank Vault Construction and Equipment in The Lure of the Lock (abridged from The Architectural Forum article, June 1928)

2005 - Monuments To Money by Charles Belfoure (excerpts from multiple Holmes articles)

Remote Combination Viewer Vaults

- **Cleveland Federal Reserve Bank** (largest bank vault door in the world):
  - Building of the Federal Reserve Bank of Cleveland
  - Commemoration Brochure
  - Modern Marvels video, 2010 (for purchase on Amazon): Doors episode
  - Wikipedia
- **JP Morgan Bank** – NY, Modern Marvels, 2000: Banks episode (306 MB)
- **New York Federal Reserve Bank -** The Key to the Gold Vault, 1991, 1998, 2004, 2008
- **One King West Hotel & Residence** – Toronto (formerly Dominion Bank)
  - Construction magazine article, December 1914
  - Safe Deposit Vault Specs
  - Movie Appearances: Jumper, Max Payne, and RED
- **Pennsylvania Treasury** – brochure and video (107 MB)



Complete list of Remote Combination Viewer Vaults
Find one near you!

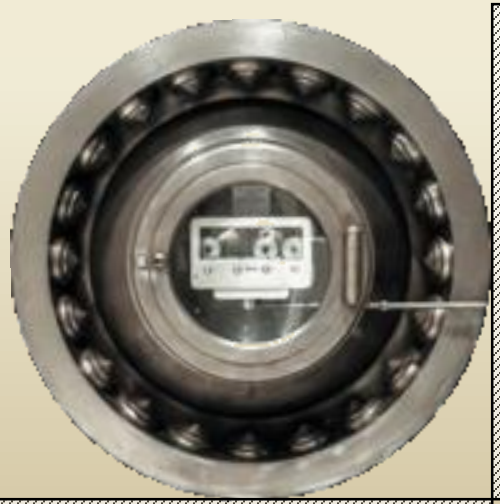
Online Picture & Video Gallery

Bank Vault Resources

- Antique Locks Forum
- Bank Vaults - Vault Doors, Volume 1 by Dave McOmie
- Bank Vaults - Wikipedia
- Federal Reserve Bank Vault Design:
  - Building a Home for 4,000,000,000 from The Bankers Magazine, 1922
  - How Uncle Sam Guards His Millions in Vaults of Federal Reserve Banks, from Popular Mechanics, 1931
  - Newest Bank Vaults Defy the Cracksman, from Popular Science, 1936
  - Science Foils the Safe Blower from Modesto News-Herald, 1929
- Fort Knox
- Guardian Building 360° Vault Panorama - Interior, Exterior
- Patents
  - Boltwork - U.S. Patent # 811696
  - Crane Hinge - U.S. Patent # 793,703
  - Double Door Vault with 8 point Pressure System- U.S. Patent # 1001221
    (a fine example of excessive engineering)
  - Platforms - U.S. Patent # 1601823
- Safe & Vault Technicians Association
- Vault Structures, Inc.
  - 360 Vault Door Brochure and video

Time Lock Resources

- American Genius – 19th Century Bank Locks and Time Locks by David Erroll & John Erroll, 2006 (for purchase on Amazon)
- Antique Locks Forum
- Bank Vault Time Lock Collection by Mark Frank
- John M. Mossman Lock Collection at the General Society of Mechanics & Tradesmen in New York City
- The Lure Of The Lock by Albert A. Hopkins, 1928 (for purchase on Amazon)
- Museum of Physical Security
- National Association of Watch and Clock Collectors Bulletins:
  - Horological Treasure Guardians by James Gibbs, 1965
  - Time Locks: Their History from Beginning to End
    by David Christianson, December 2004
- Time Lock - Wikipedia
- Time Lock Movements Guide by TMI, 2008
- Time Lock Servicing by Security Education Plus



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