Improved function and reliability of automatic small arms using electrophoretically applied self-lubricating coatings.

Peter Hope, LVH Coatings Ltd.,

Birmingham, UK.

John Moses Browning (1855 – 1926)

Owner of 128 patents covering gun design.

Inventor of the *slide* autoloading mechanism that characterises almost all automatic handguns

A classic example is the Colt 1911…

COLT 1911 Standard model.

LVH Electrocoat

COLT 1911 – slide, frame, spring and barrel components.

LVH Electrocoat

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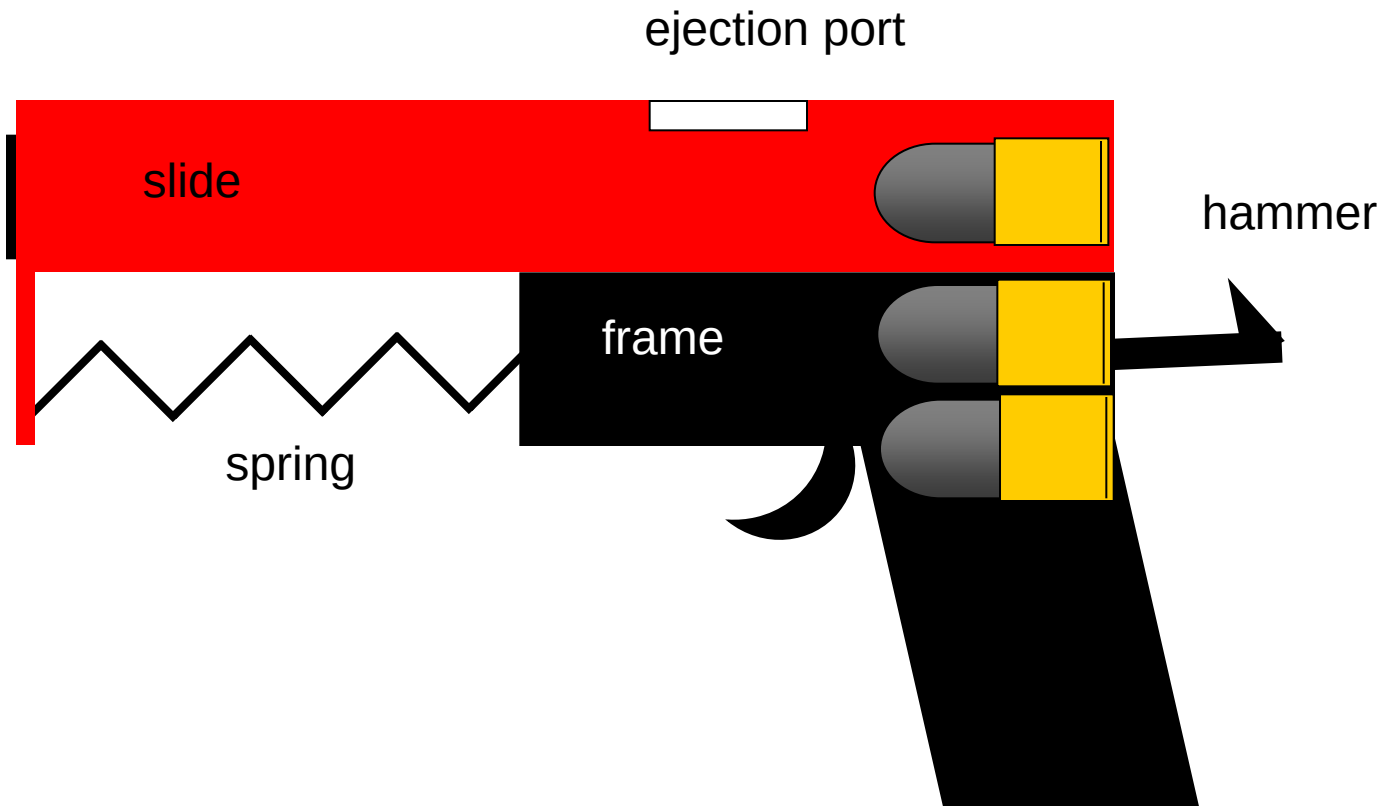
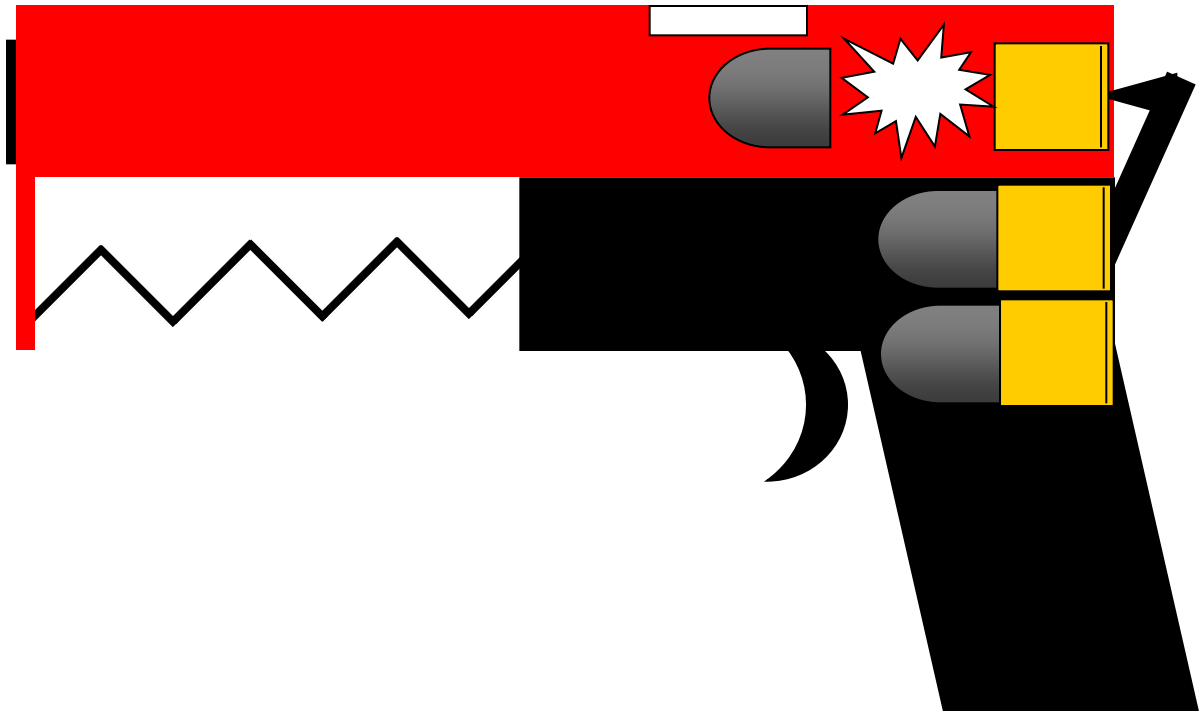
Slide type semi-automatic handgun mechanism.

1. The hammer is already cocked and the first round chambered by manual retraction and return of the slide.



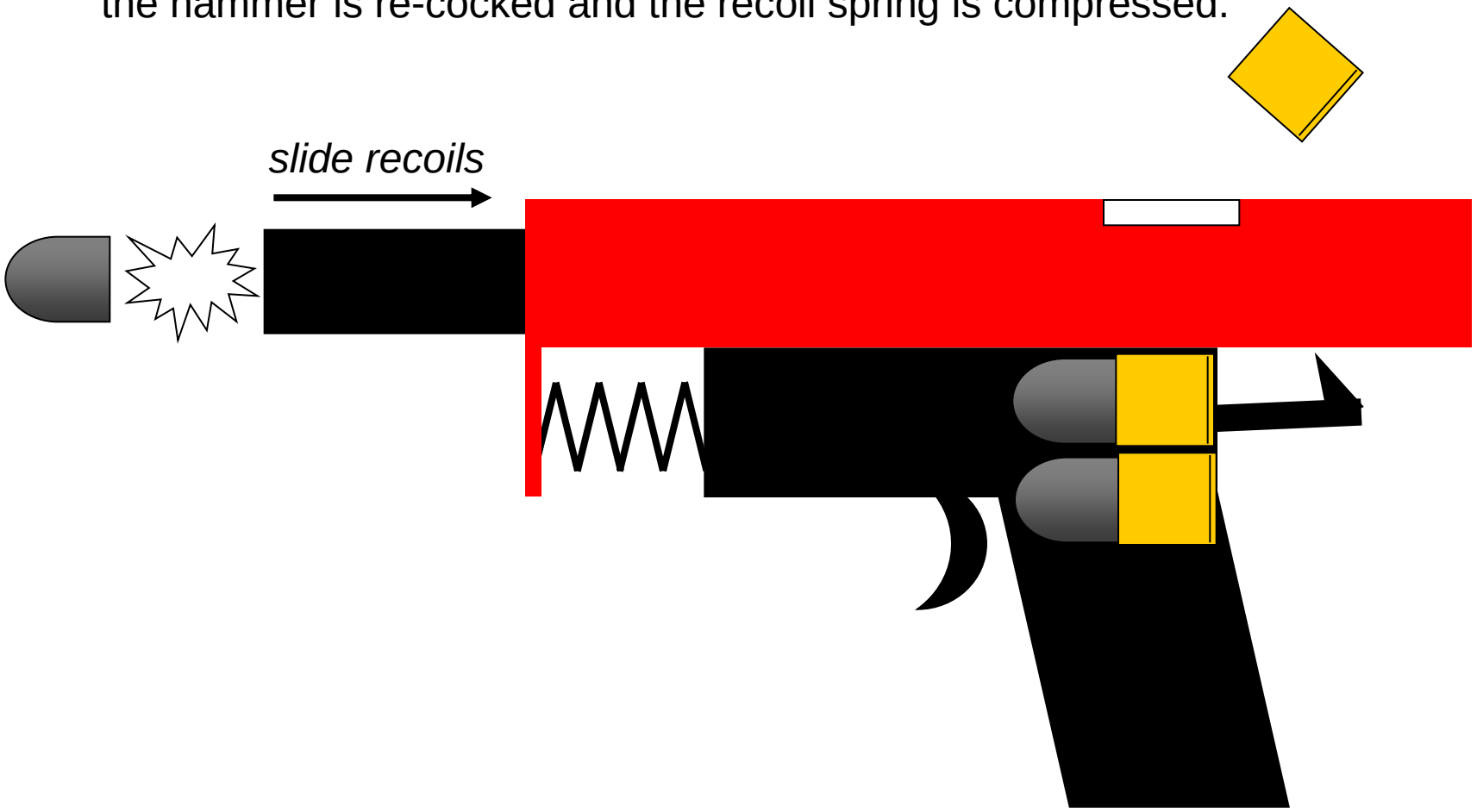
Slide type semi-automatic handgun mechanism.

2. Trigger is pulled causing hammer to detonate the charge inside the cartridge. The round is propelled through the barrel.



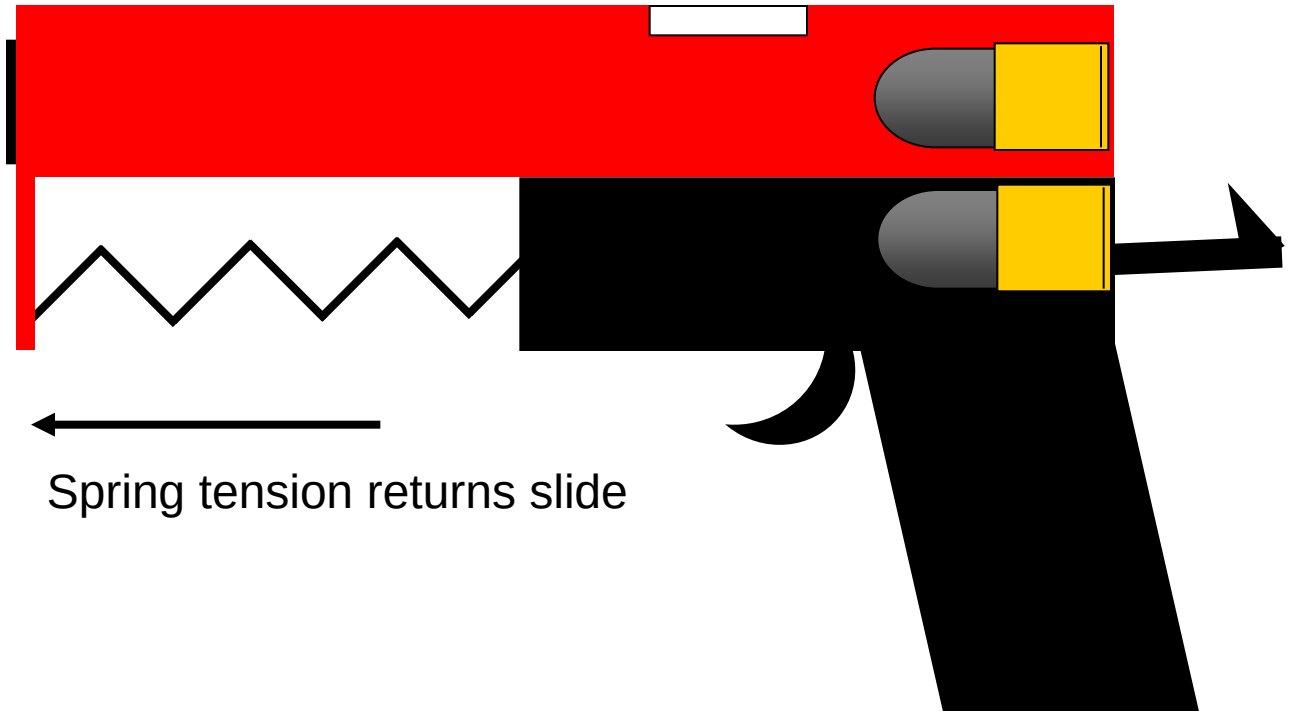
Slide type semi-automatic handgun mechanism.

3. The slide is retracted by the recoil force, the cartridge case is ejected, the hammer is re-cocked and the recoil spring is compressed.



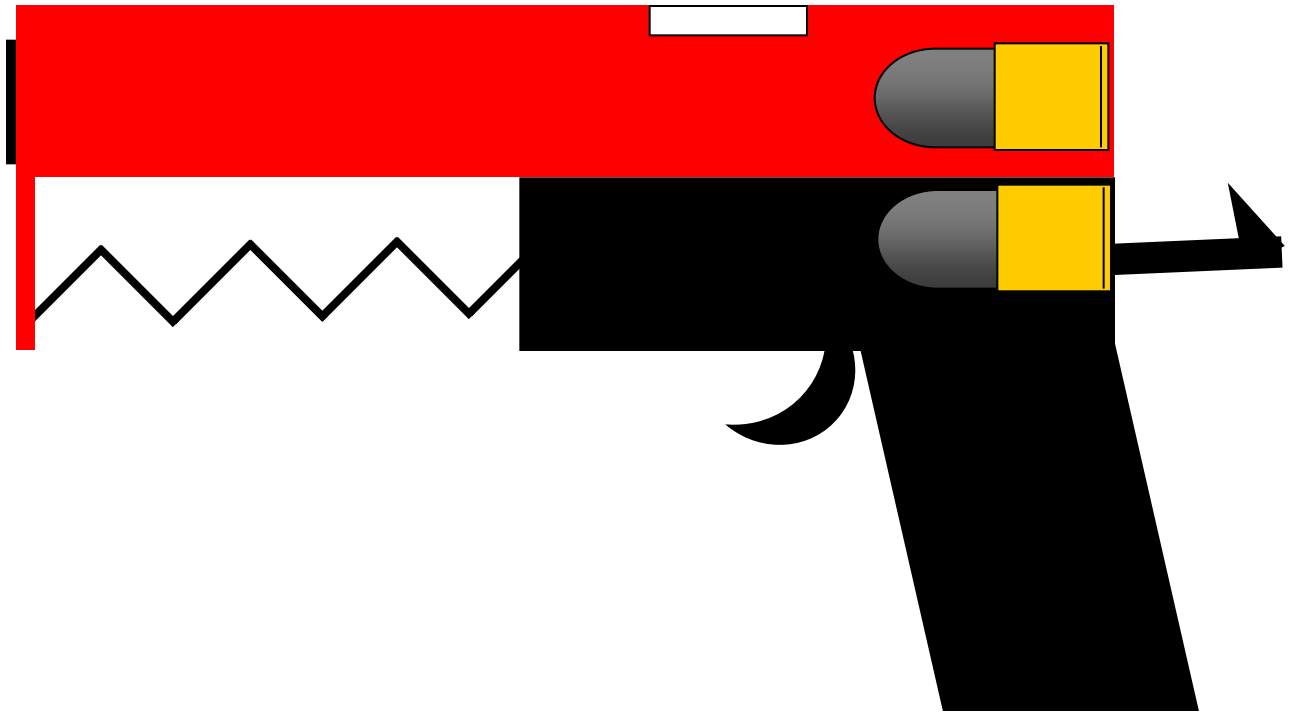
Slide type semi-automatic handgun mechanism.

4. The compression strain in the recoil spring is converted back to kinetic energy in the slide which returns to the rest position, chambering the next round in the process. The weapon is thus automatically reloaded ready for firing.



Slide type semi-automatic handgun mechanism.

Maintaining the automatic function requires free movement of the slide, retaining sufficient kinetic energy to complete the firing, ejecting, re-cocking and re-loading cycle.



Isaac Newton (1643 -1727)

Formulator of:
The Three Laws of Motion
(amongst other things).

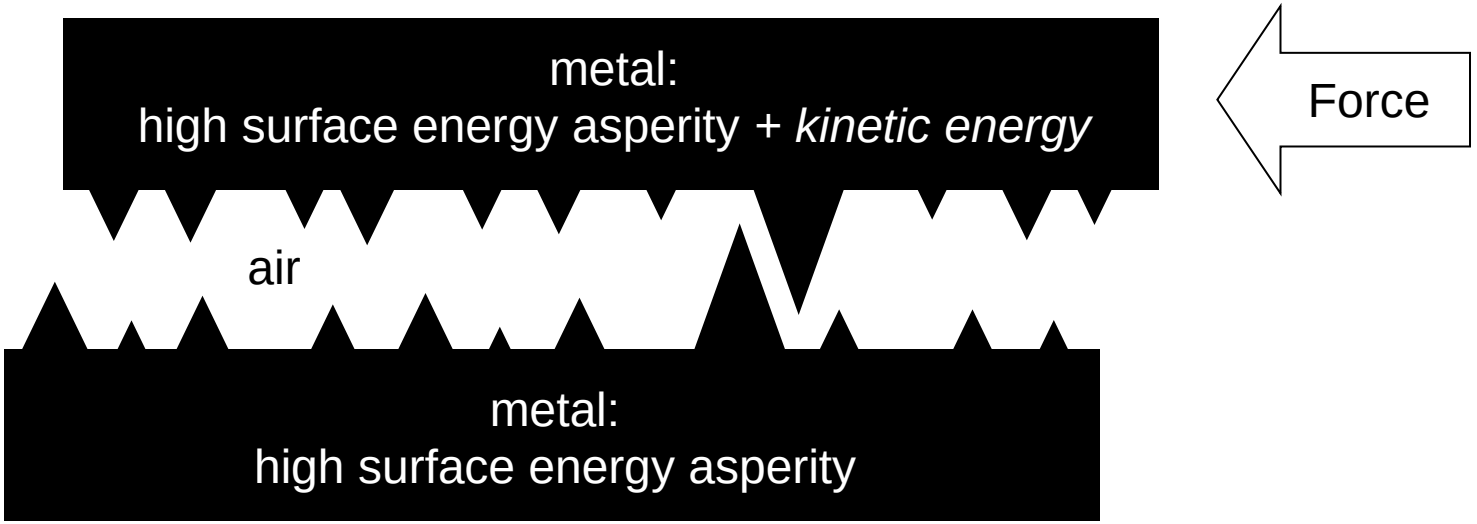
The action of the Colt 1911 Model is a classic demonstration of Newton's laws of motion.

together with classical Thermodynamics and Conservation of Energy…..

Automatic handgun action according to Newton.

1. The body remains at rest or at constant velocity unless acted upon by a force.
   - The round remains in the chambered cartridge until the propellant is detonated.
2. Upon application of force, the body accelerates in the direction of the force.
   - Upon firing, the round is discharged from the chambered cartridge.
3. An equal and opposite colinear reaction is simultaneous.
   - The recoil action of discharging the round retracts the slide, ejecting the spent cartridge case, cocking the hammer, and chambering the next round upon reciprocal action of the recoil spring.

<u>Classical Tribology</u> – frictional drag arising from the fusion of surface asperities (roughness) and subsequent fracture.



Metal-air-metal representational model of two sliding surfaces (the asperity will typically be at micro to nano level)

<u>Classical Tribology</u> – frictional drag arising from the fusion of surface asperities (roughness) and subsequent fracture.

Impingement and fusion of asperities converts kinetic energy into heat.

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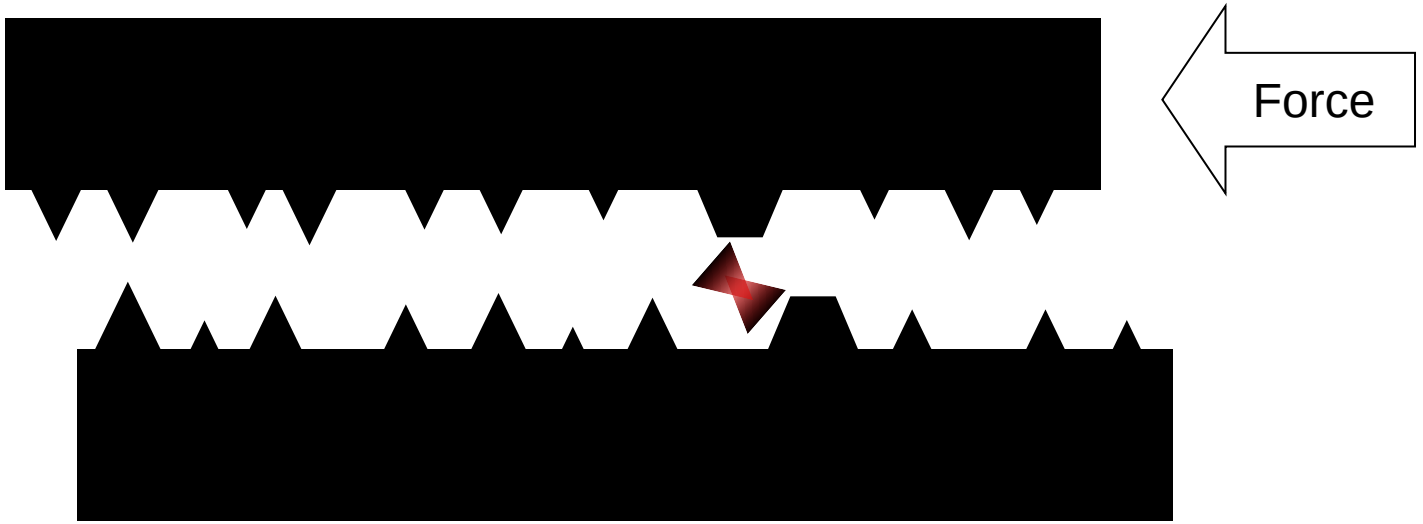

Wear debris becomes ‘third body’ with transfer of kinetic energy.
The ‘two body’ system of the metal-air-metal model has predictable motion properties, the motion of a ‘third body’ within this system is difficult to predict.

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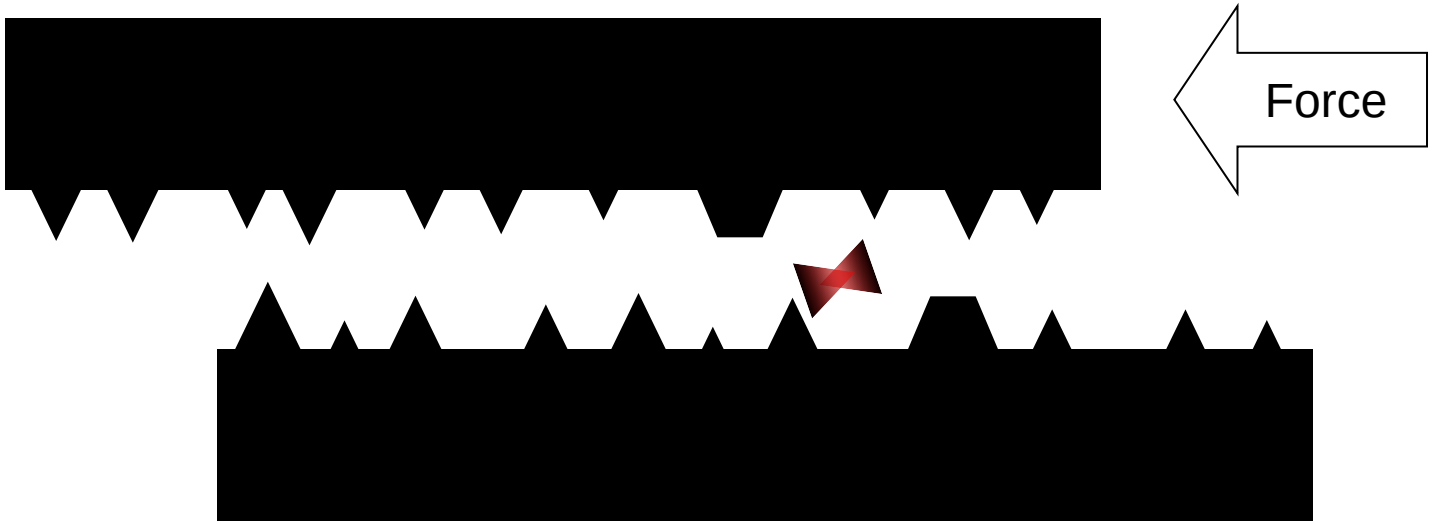
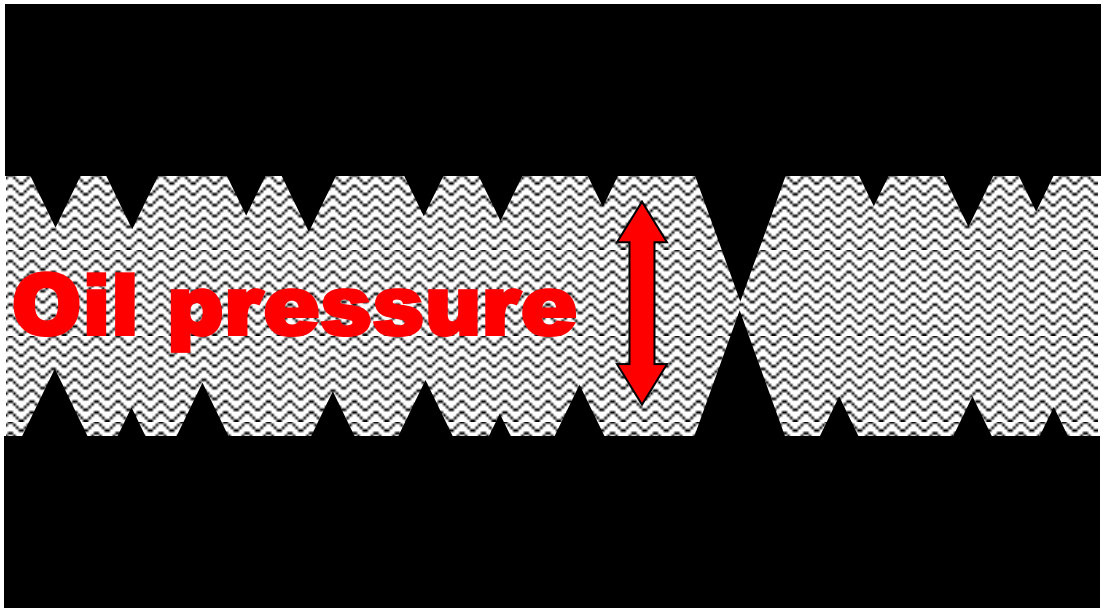


Wear debris becomes ‘third body’ with transfer of kinetic energy.

Classical Tribology – frictional drag arising from the fusion of surface asperities (roughness) and subsequent fracture.

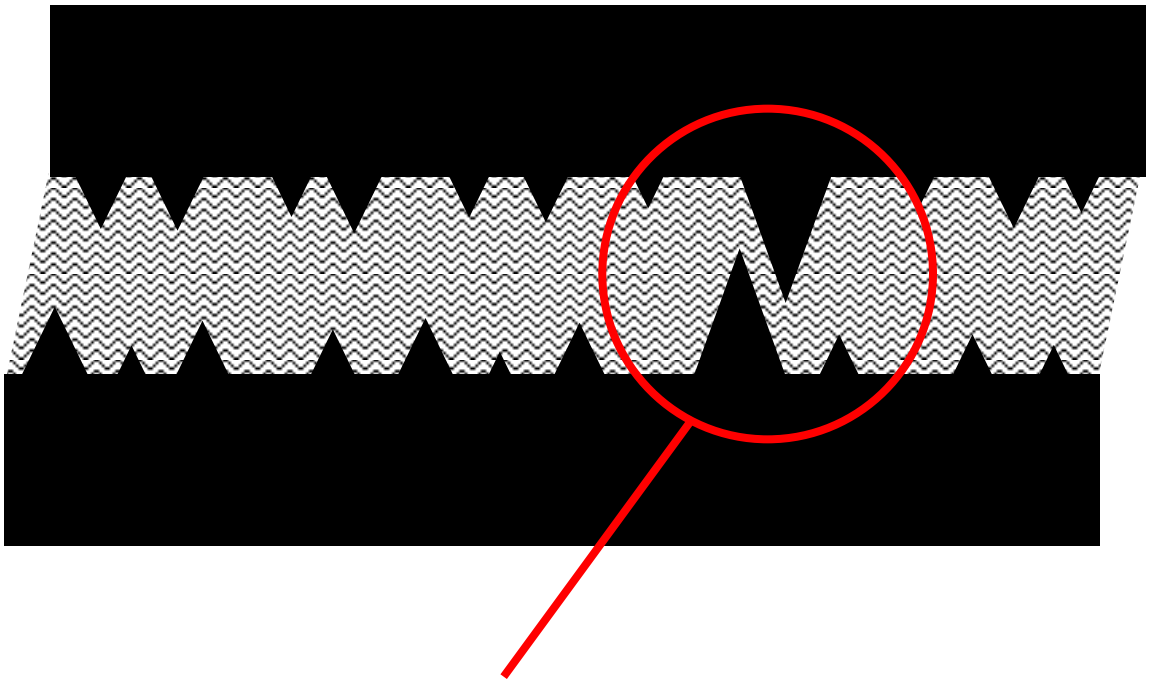
Wear debris bridges and fuses asperities converting its kinetic energy into heat.

Classical Tribology – lubrication with oil provides a barrier, completely separating asperities……



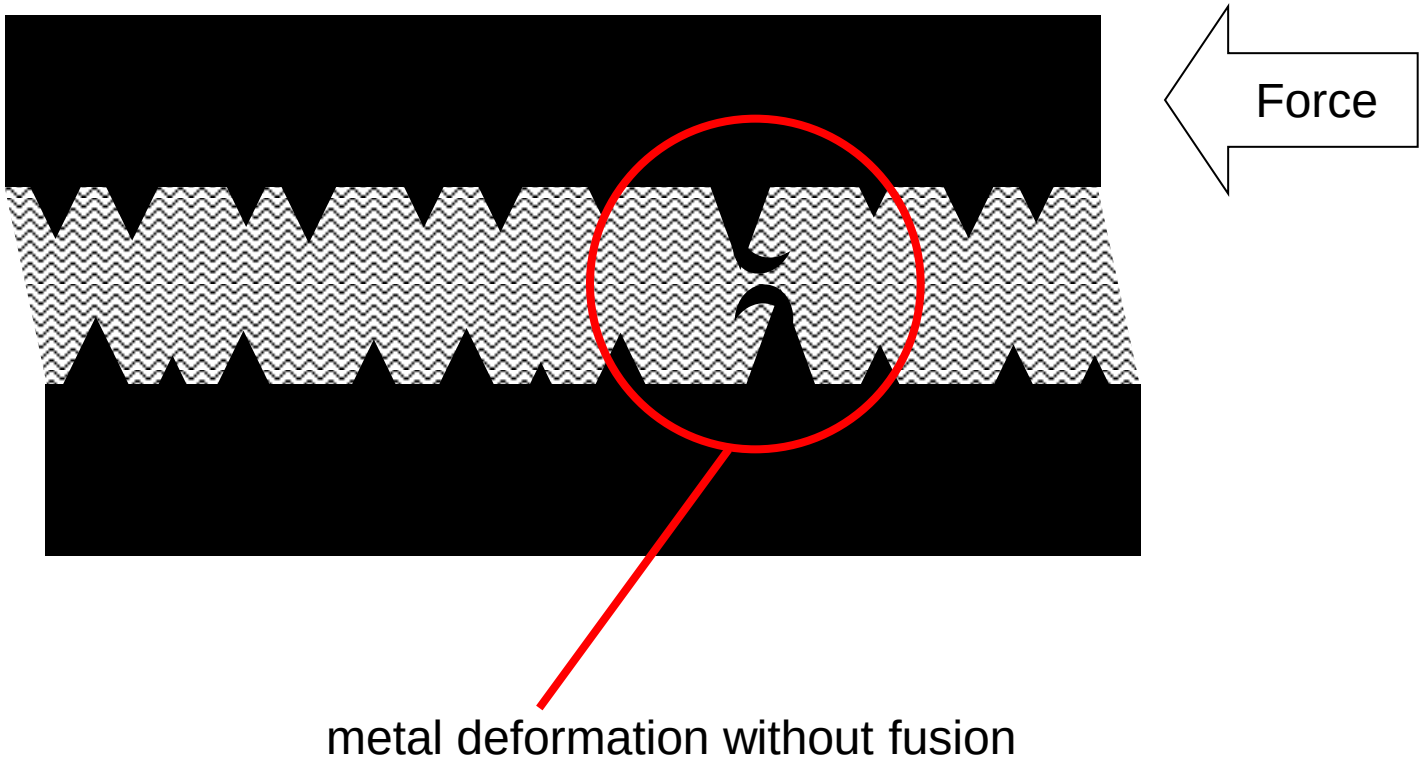
Lubricating oils characteristically have low surface energy.

Classical Tribology – lubrication with oil provides a barrier, completely separating asperities….. or acting as a low energy ‘cushion’ between them.



Compression of the oil between asperities at all levels.

Classical Tribology – lubrication with oil provides a barrier, completely separating asperities….. or acting as a low energy ‘cushion’ between them = insufficient surface energy for fusion.



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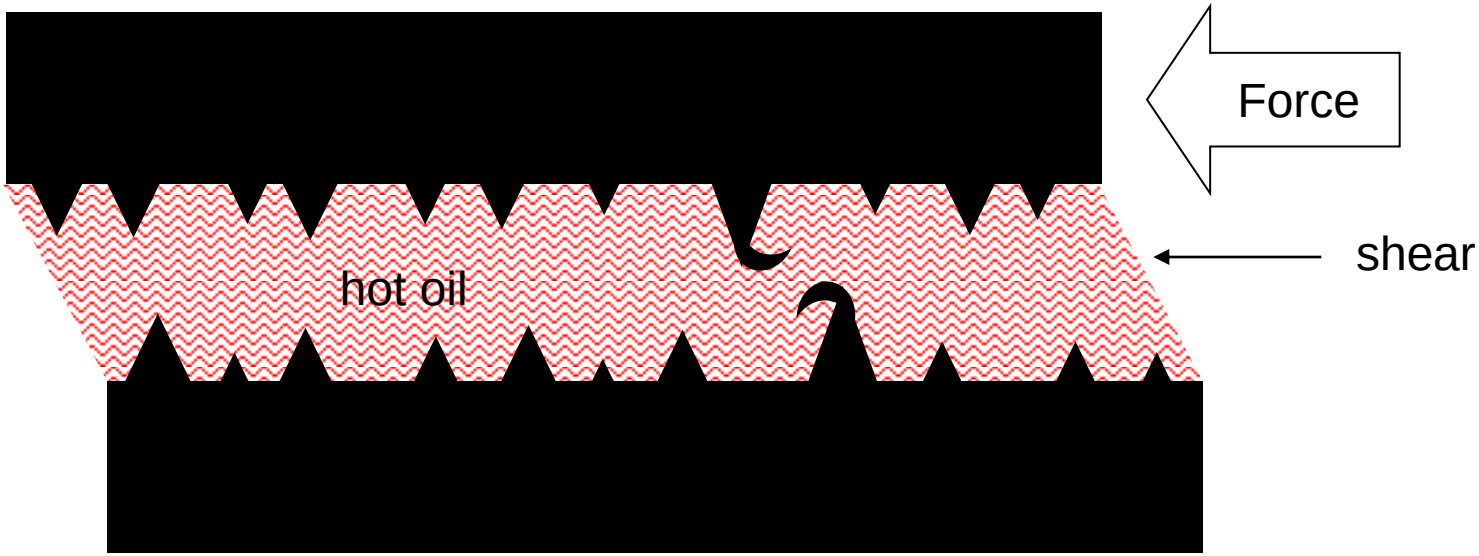


All parts of both surfaces are in contact via the oil which is both barrier and bridge. The oil is heated by the (shear) work done. This model is less likely to seize than the metal-air-metal model, but still efficiently converts kinetic energy into heat.

***Next problem*: The fate of *third bodies* in the metal-oil-metal model.**

Third bodies may be wear debris or foreign objects (e.g. dust, grit etc.)

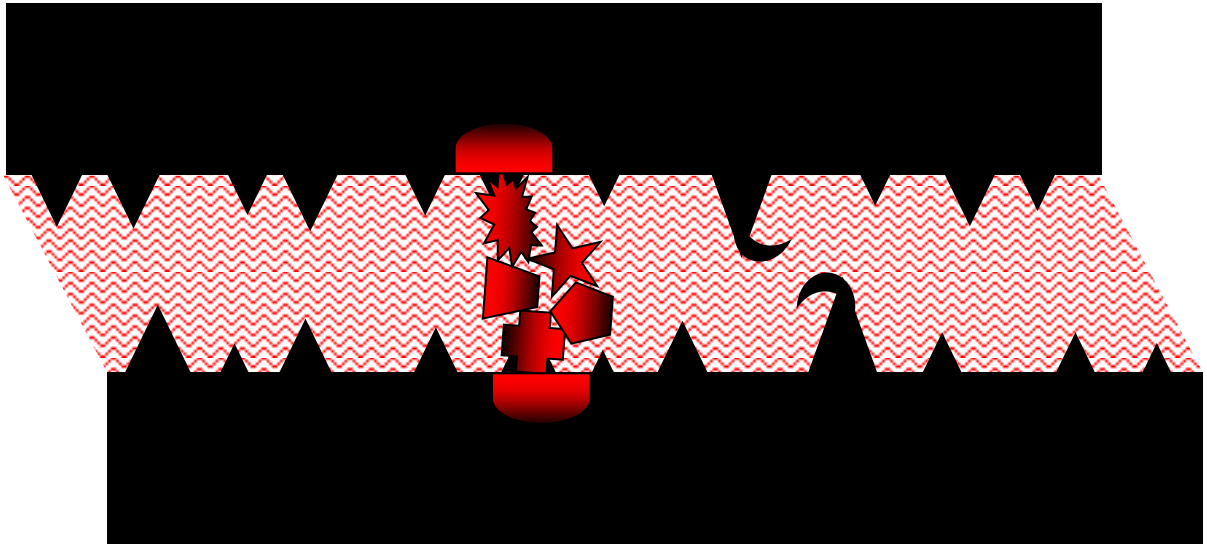
The fate of third bodies in the metal-oil-metal model.

Metal deformation without fusion:
- third bodies collide and coalesce.

The fate of third bodies in the metal-oil-metal model.

Metal deformation without fusion:
third bodies collide and coalesce;
-and can bridge the asperities of the
opposing metal surfaces.

The fate of third bodies in the metal-oil-metal model.



Accumulation of third bodies can lead to seizing even in the oil lubricated model.

Summary

- The accurately machined slide mechanism relies on recoil-generated kinetic energy to complete its cycle.
- Frictional effects convert its kinetic energy into heat, increasing the risk of cycle failure.
- Liquid lubrication alone does not prevent accelerated decay of kinetic energy due to ‘third body’ effects.

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Solution?

- Coat the sliding surfaces with a low surface energy (self lubricating) plastic material. Eliminate liquid lubrication.
- BUT – the close tolerances of the slide/frame sliding surfaces must be maintained.
- Electrophoretic deposition (Electrocoat) is the preferred coating method to follow the complicated machined design geometries at controlled and consistent thickness. *It can be used as a delivery system for dry film lubricants.*

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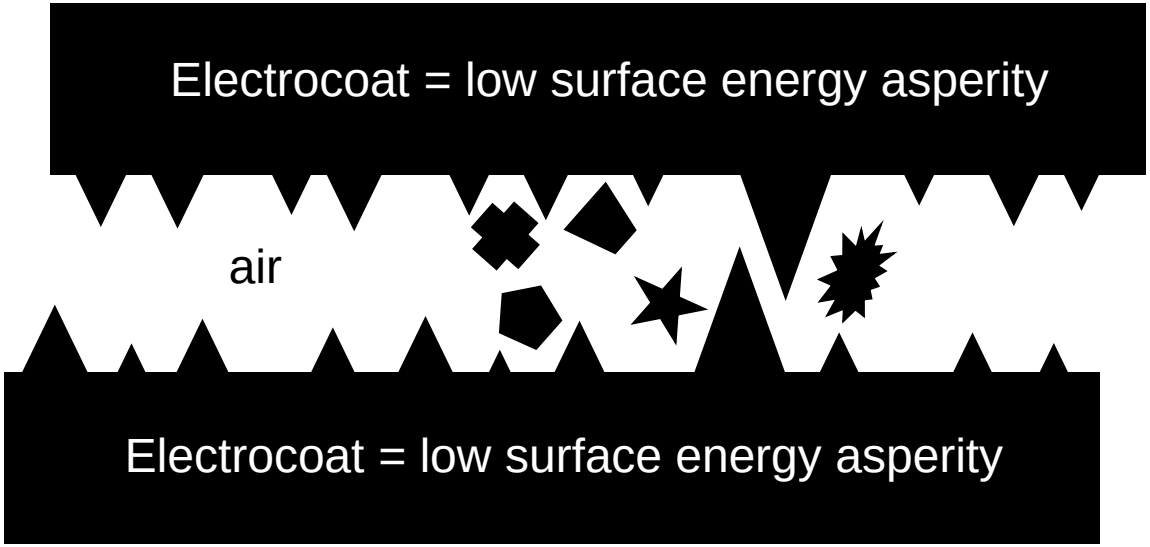
Tribology of the self-lubricating Electrocoat paint-air-paint model.



In this model, third bodies are restricted to foreign materials (dust etc.).
No wear debris is generated – only plastic deformation takes place.

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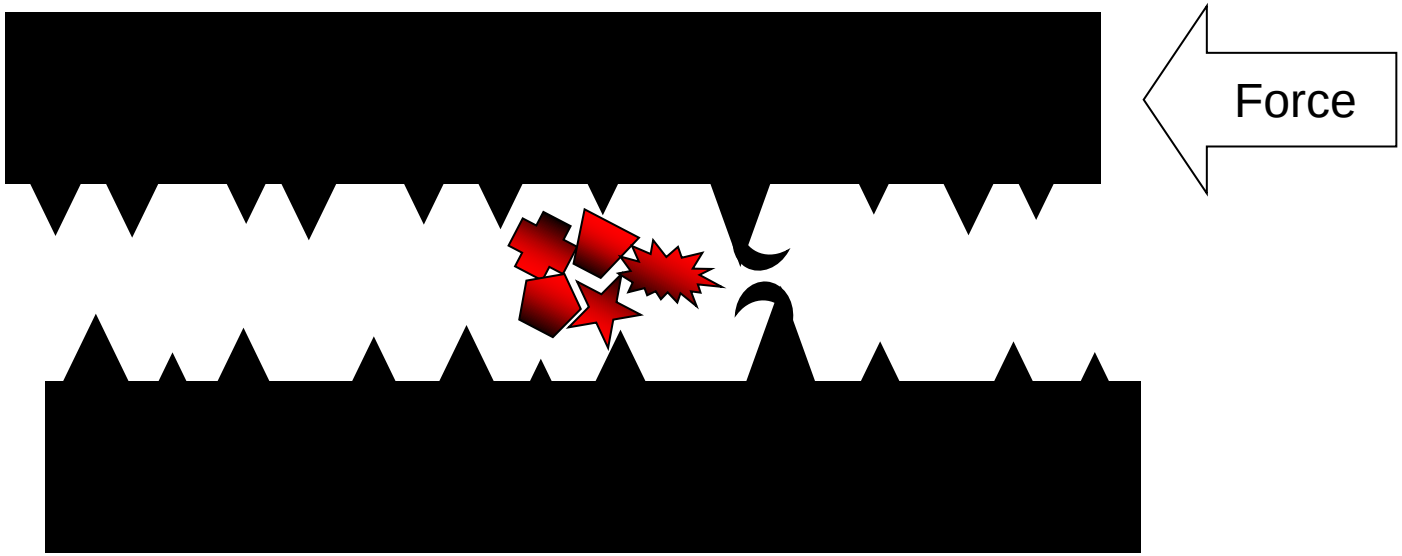

Plastic deformation of paint asperity without fusion. Third bodies may coalesce or fuse with each other.

Tribology of the self-lubricating Electrocoat paint-air-paint model.

Third bodies absorbed by ‘cushion’ effect of the paint film plasticity. The paint surfaces will ‘adapt’ to be the ‘least obstructive landscapes separated by air pressure. Less kinetic energy converted to heat (air has much lower heat capacity than oil).

Automatic weapons: problems with standard metal finishing.

- Metal-to-metal contact lubricated with oil is a maintenance issue.
- Any restriction of free movement can result in misfire or misload.
- Too much freedom of movement reduces accuracy.
- Conventional painting techniques cannot conform to engineering tolerances.

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- Single layer.
- *Completely conformal at constant thickness*.
- *Self-lubrication*.
- Self-colour.
- Corrosion protection.
- *Electrophoretic painting delivers all of these.*

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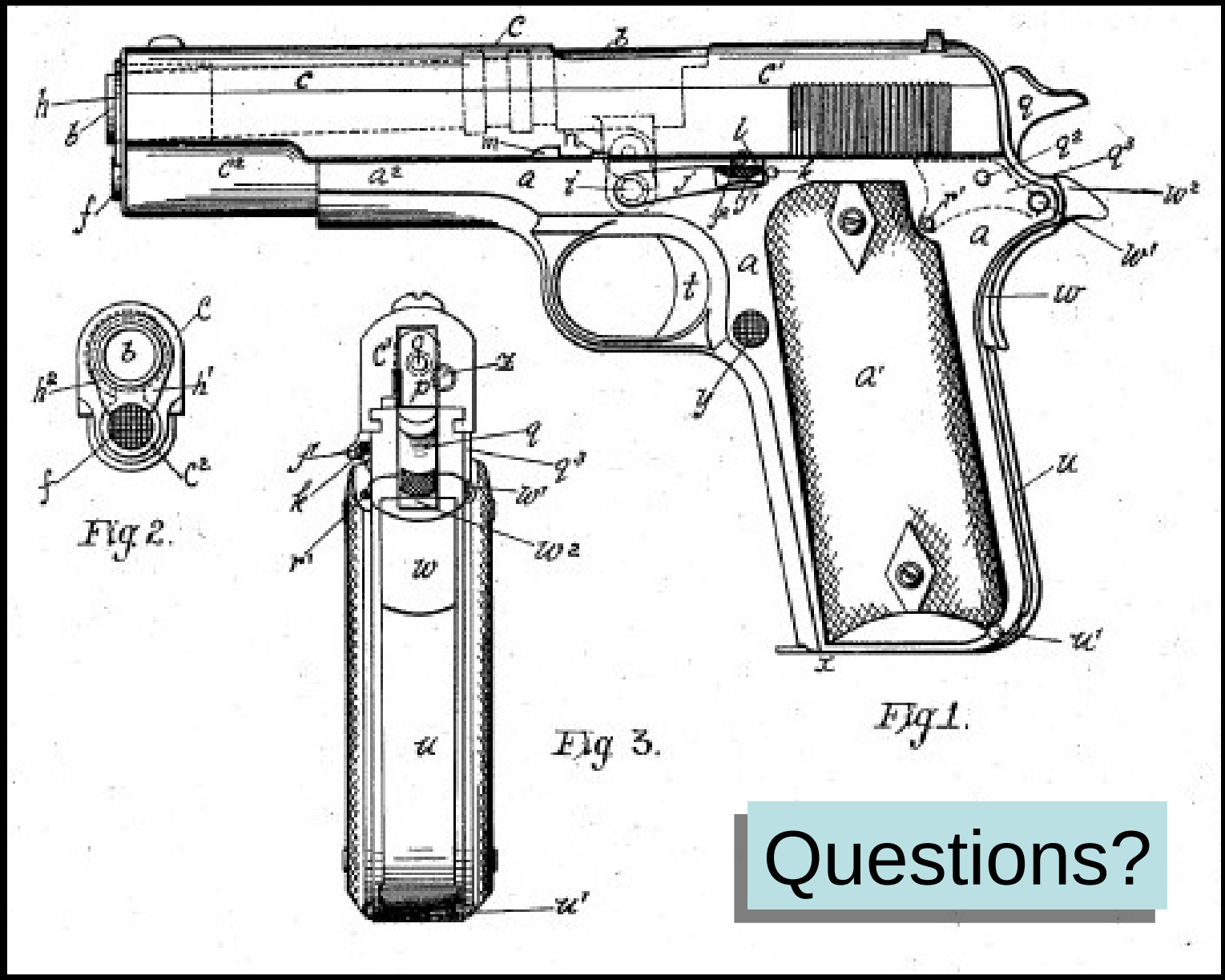
Fig 2.
Fig 3.
Fig 1.
Questions?