Principles and Repair Tips

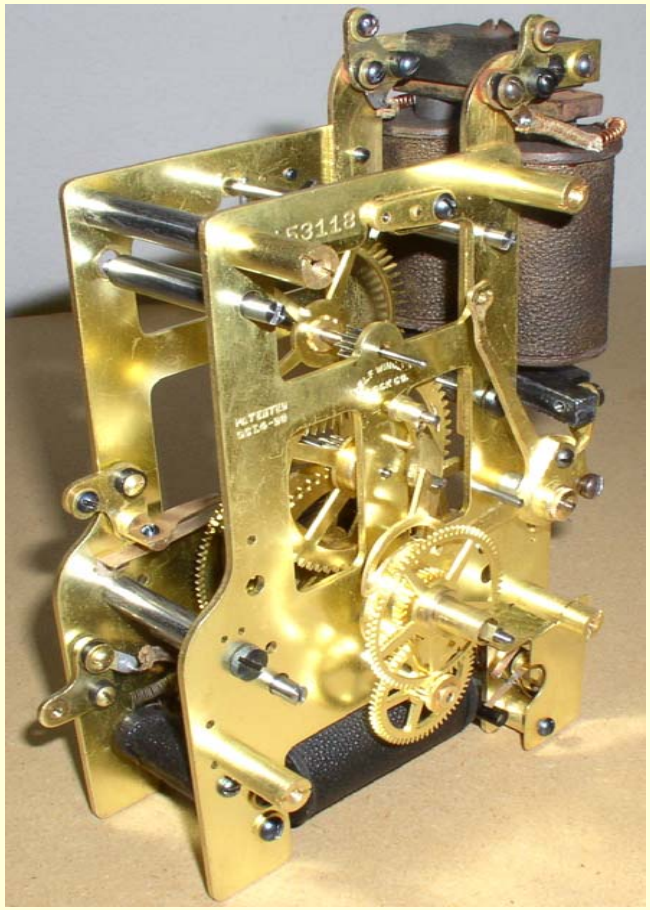
for Self Winding Clocks

Ken Reindel

NAWCC Chapter 15

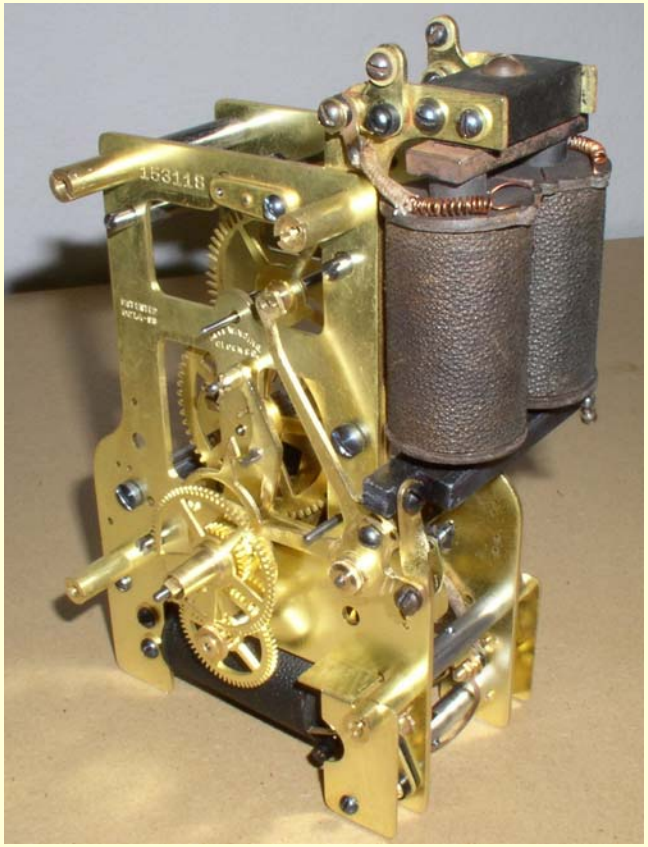
Objective

- De-mystify electrical principles
- Enrich Understanding
  - Electrical
  - Mechanical
- Offer solid *technical* foundation
- Provide interesting repair tips from the bench



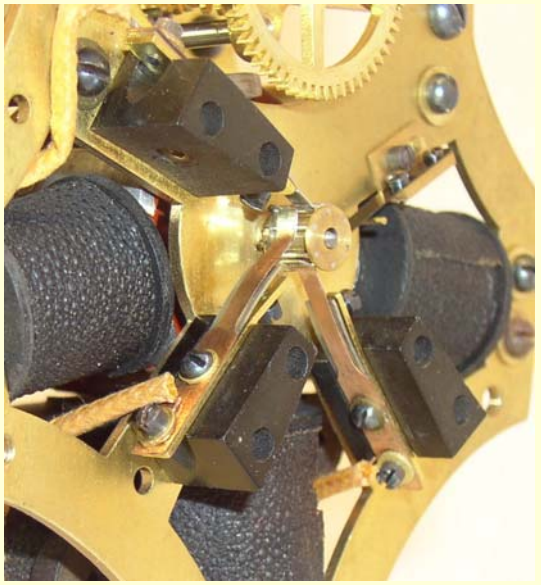
Agenda

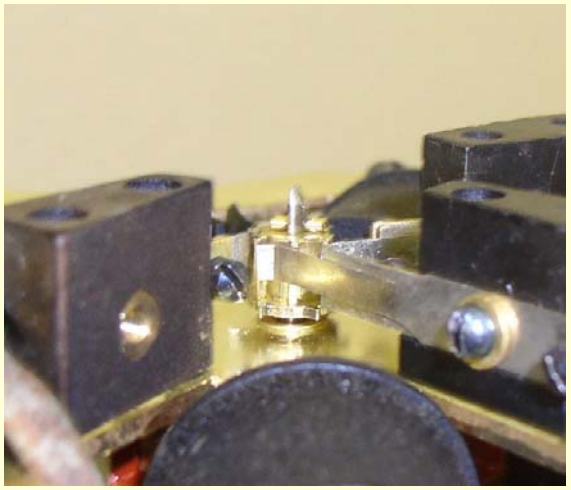
- **Basic Electricity**
- **Volts, Ohms, Amps**
  - **Ohm's Law**
  - **Batteries, resistors, wire**
  - **Power Law**
- **SWCC Style F Movements**
- **Contacts**
- **Battery Killers and their Cures**
- **Mechanical Repair Tips**
- **Motors**
- **Synchronizing Components**
- **Making Basic Electrical Measurements Lab**
  - Optional, if you want to stay and play



What we WON'T Cover

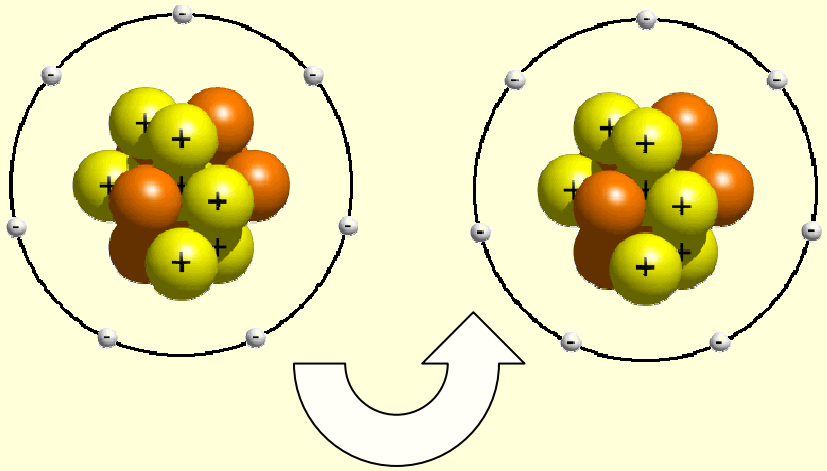
- Common adjustments
  - Info available on line
  - Also available in Tran Duy Ly American Clocks Vol. II
- Details on Style A and C Restoration
  - Stop by afterwards





The Atom

- Composed of:
  - Protons
  - Neutrons
  - Electrons
- Protons and neutrons are tightly bound into a nucleus
- *Electrons are relatively loosely held and can be moved in and out of atomic shells*



Electrons can be moved from atom to atom by electrical pressure

Electrons can also be freed by chemical reactions, creating electrical pressure

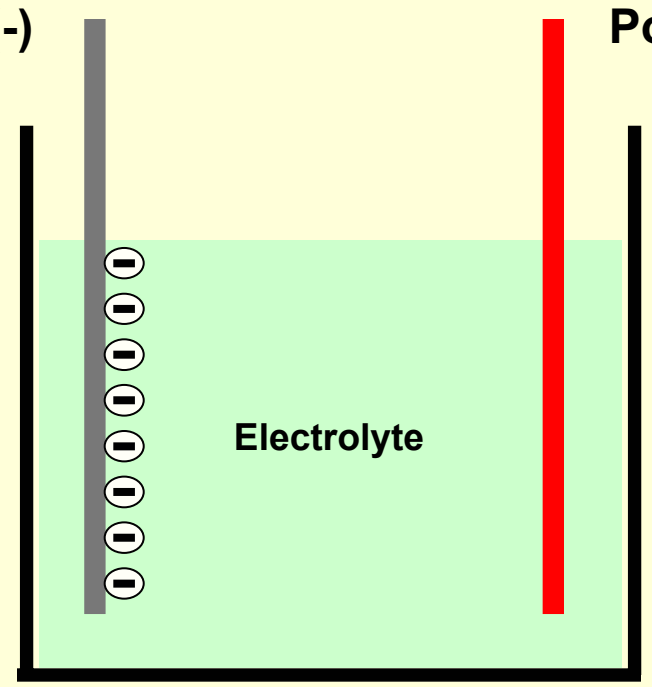
Insulators and Conductors

Insulators are materials that do not readily allow the electrons in their atoms to move freely from atom to atom. Examples are glass, wood, air.

Conductors are materials that freely allow movement of electrons between the individual atoms. Metals are the primary example.

How Batteries Work

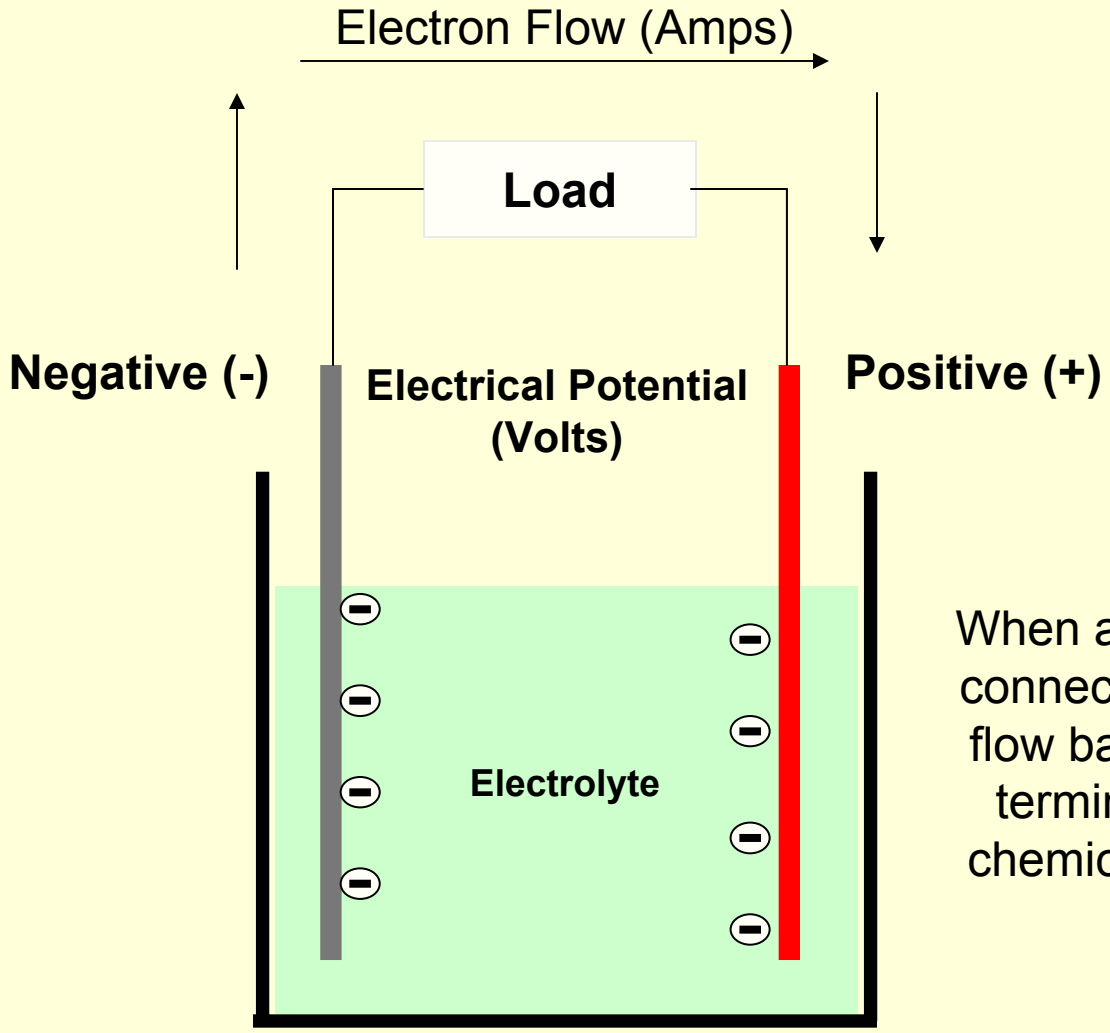
- A device for storing electrical pressure or potential
- Consists of 2 conducting plates and an electrolyte



The electrolyte and a conductor react chemically, releasing an abundance of electrons

This abundance of free electrons results in electrical pressure or potential, measured as voltage

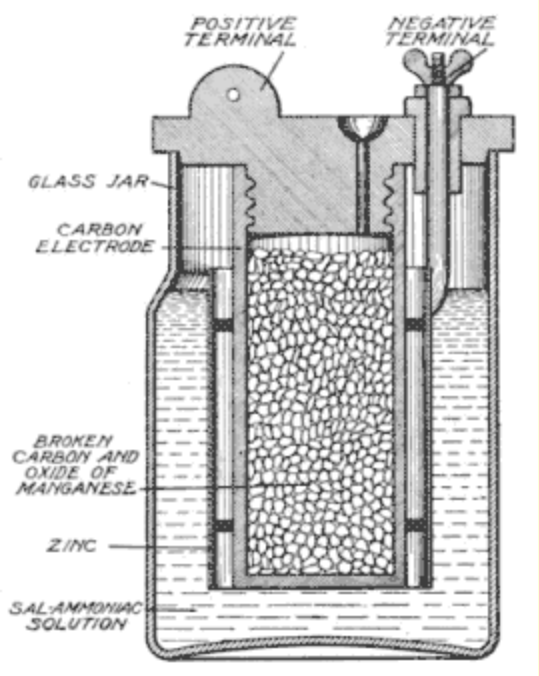
Battery Connected



When an external path is connected, the electrons flow back towards the + terminal and create a chemical reaction at the anode.

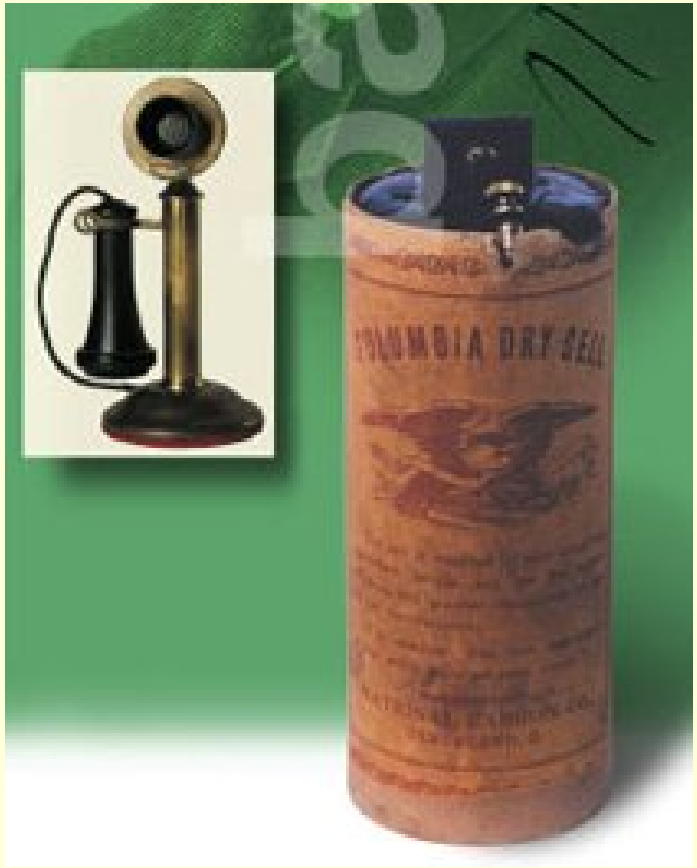
The Leclanché Cell

- Earliest practical battery (1866-1900)
- Forerunner of Dry Battery
- Patented; over 20,000 built
- MESSY!
  - Had a tendency to spill
- 1.5 volt cell



Gonda™ Leclanché Cells

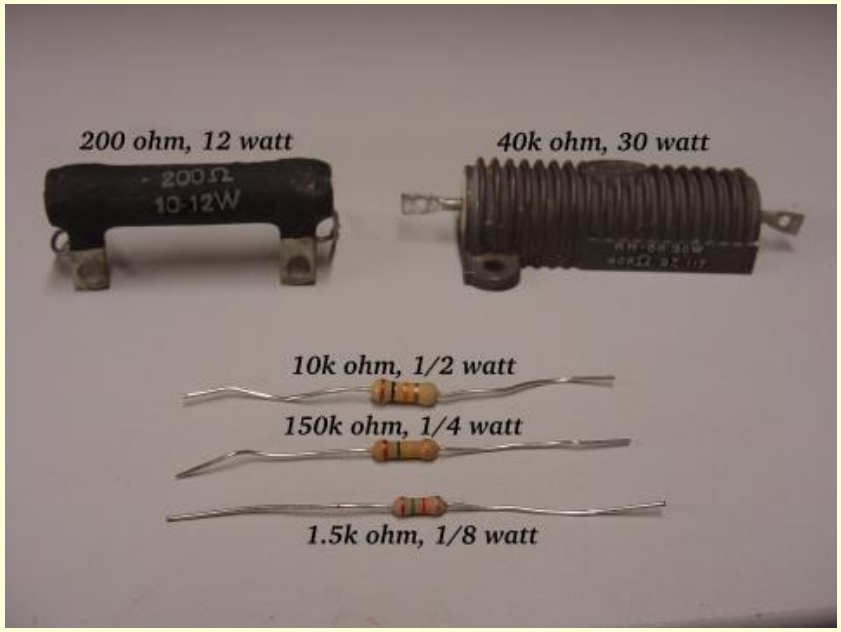
The Columbia Battery



http://acswebcontent.acs.org/landmarks/drycell/columbia.html

Resistors

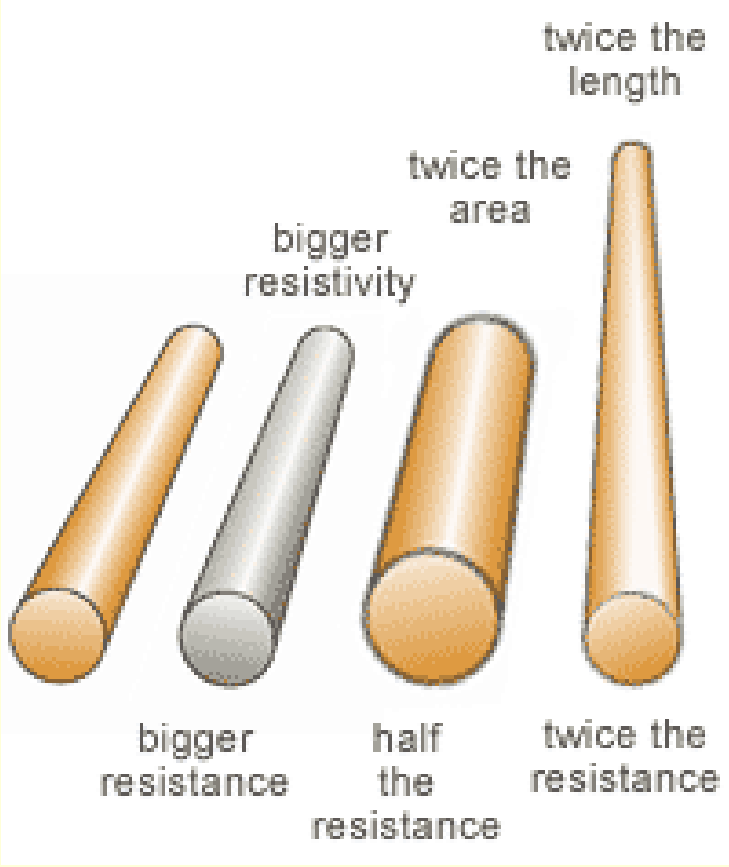
- Many electrical loads are resistive (at least partially)
  - Motors, light bulbs, heating elements, etc.
- Other examples of resistors:



Resistors are measured in Ohms (Ω)

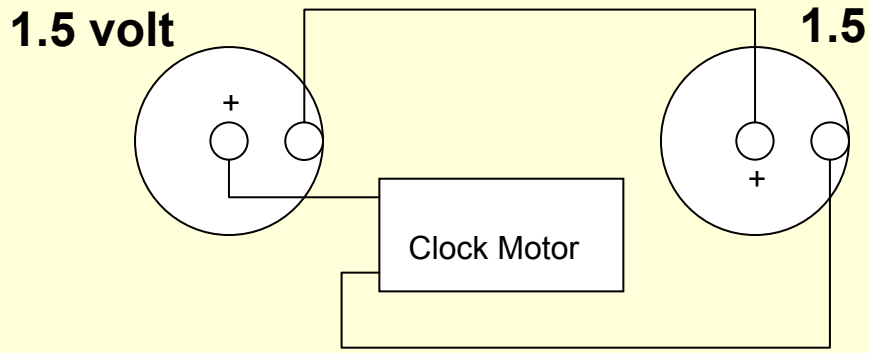
Wire Resistance

- Wire resistance varies by length and thickness
- Also depends on the type of wire e.g., copper vs. NiCr



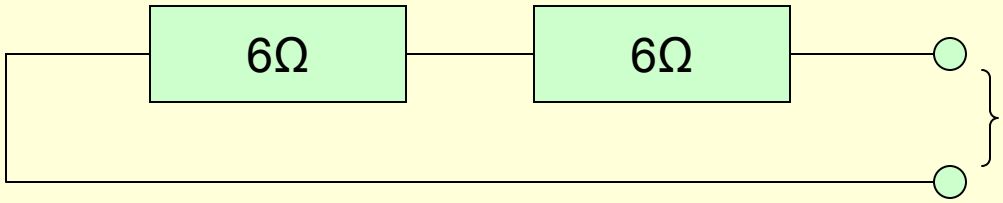
Series Circuits

- Batteries in SERIES add:



Clock motor “sees” 3 volts

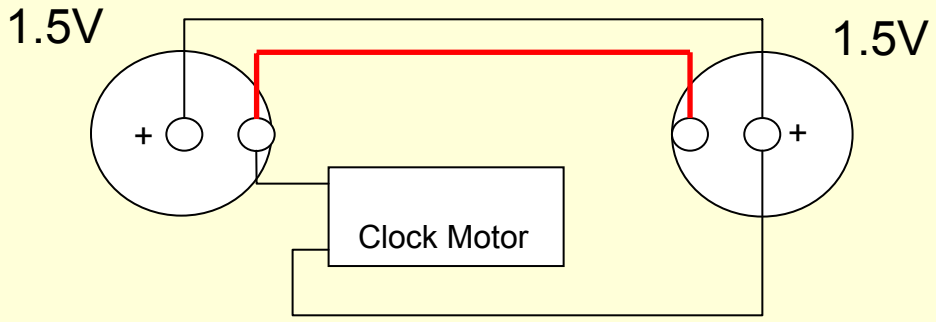
- Resistors in SERIES also add:



Total Resistance = 12Ω

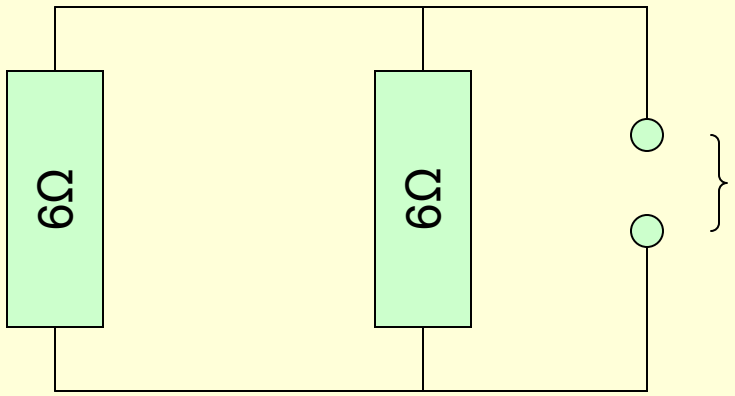
Parallel Circuits

- Batteries in PARALLEL of same voltage will output that voltage, but increase Amperage capacity



Clock motor "sees" 1.5 volts which may not be sufficient

If each battery can supply 2 amps, two in parallel can supply 4 amps.



N like value resistors in parallel reduce by:

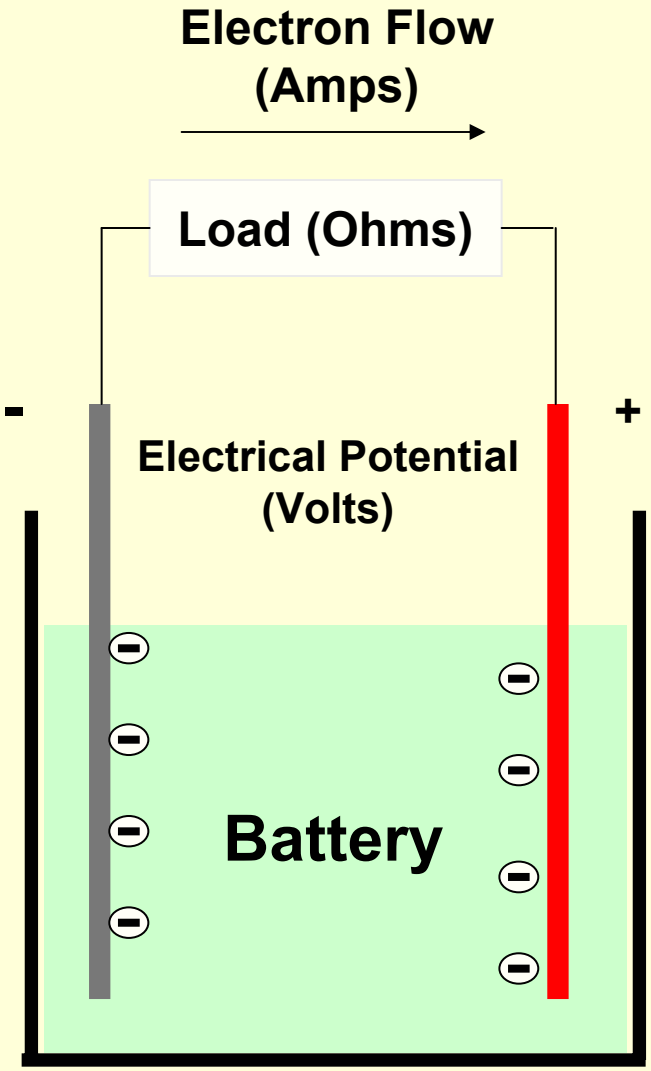
$R_p = R/N$

$6\Omega // 6\Omega = 3\Omega$

Elements of Electricity

- Voltage
  - Electrical Pressure or Potential
  - Batteries are an example of a voltage source
- Current
  - A measure of the FLOW of electricity
  - Measured in Amps
- Resistance
  - A measure of the restriction to FLOW
  - Measured in Ohms

Elements of Electricity



Ohm's Law:

Voltage = Amps x Ohms

Also,

Amps = Voltage/Ohms

Power (Watts) = Amps x Volts

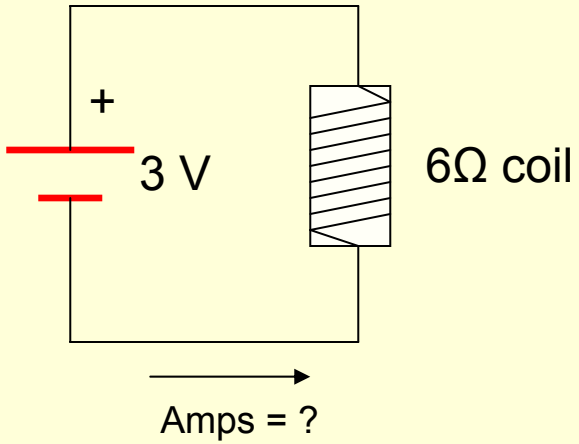
Power (Watts) = Volts^2/Ohms

Power is a measure of energy

Example Application of Ohm's Law

Coil resistance = 6Ω

Battery voltage = 3 volts



How many amps will be needed from battery?

Answer:

Amps = Volts/Ohms

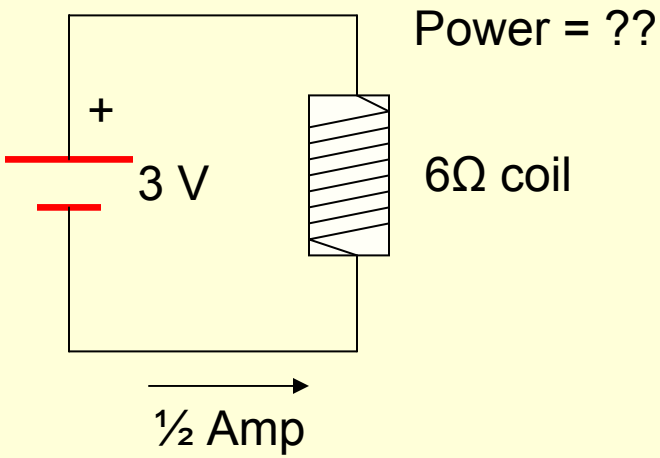
= 3 volts/ 6Ω

= ½ **Amp**

Let's keep going…..

- For the same circuit:

  How much power is dissipated in the coil?



Answer:

Power = Voltage^2/Ohms

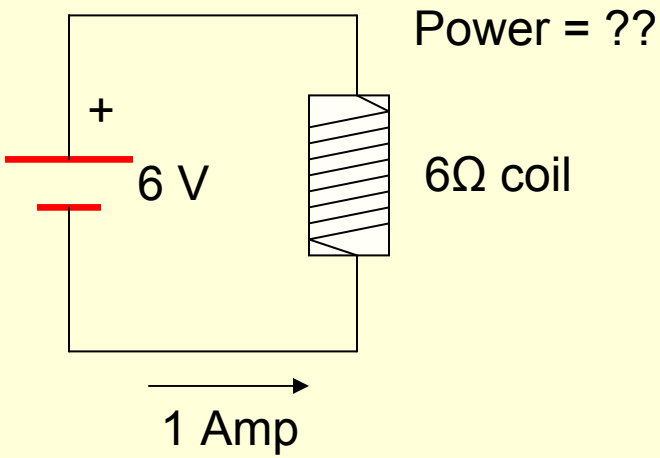
= 3^2 volts/6Ω

= **1.5 watts**

One more time…

- For the same circuit:

How much more power is dissipated in the coil if we use a Lantern battery which is 6 volts???



Answer:

Power = Voltage^2/Ohms

= 6^2 volts/6Ω

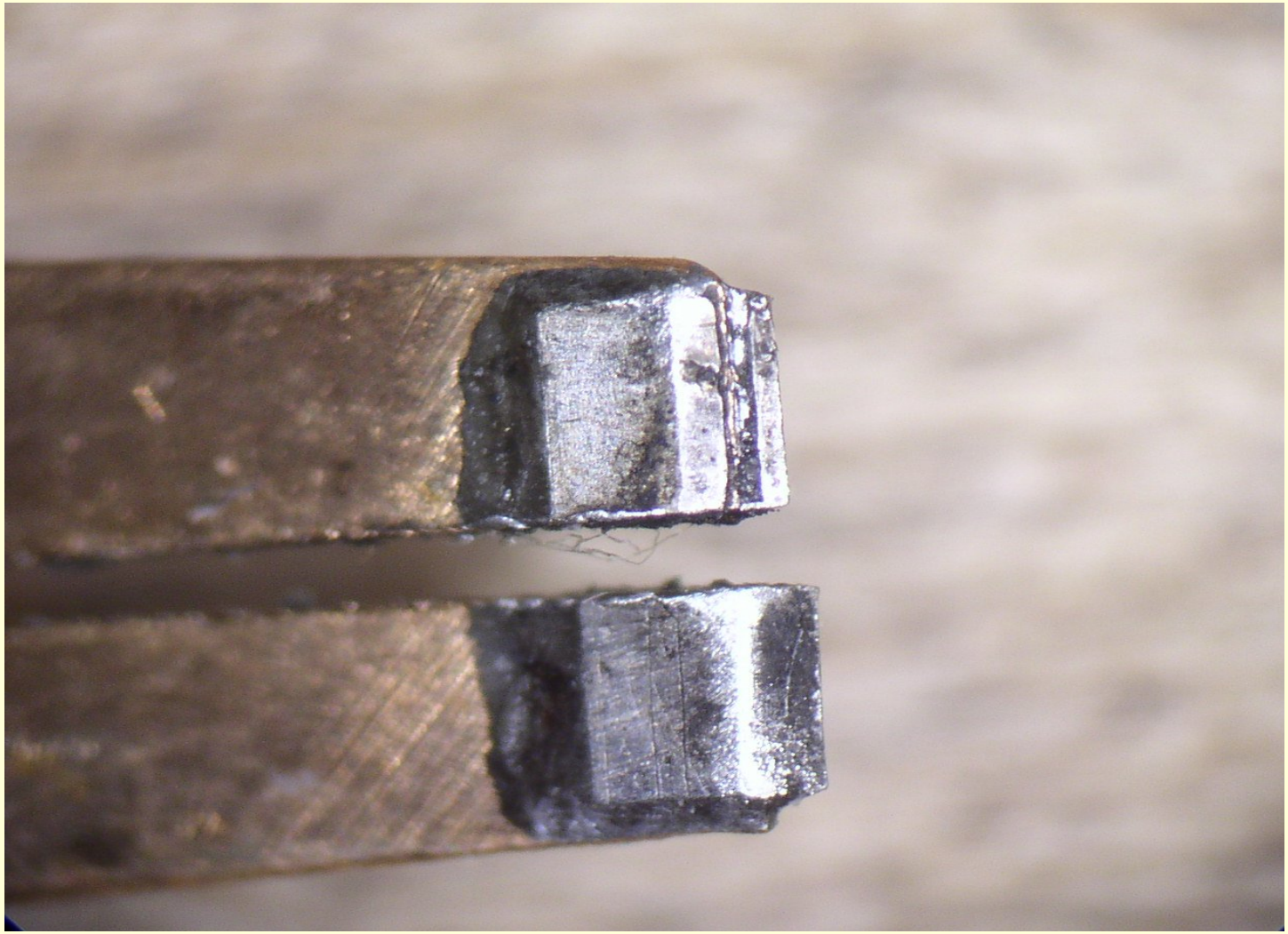
= **6 watts or 4x more than with 3 volts!!**

Which brings us to our first tip…..

- Double the voltage (6V) forces 4x the energy into the electrical components

- DO NOT USE in 3V clocks
  - Unless you use a voltage converter (eg, Model 1000)

Damage Done by 6 Volts



More Damage Done by 6 Volts

Contacts

- What makes a good contact???
  - Largely depends on the application, but for us….
- Low contact resistance
  - With light contact force
- Resistant to oxidation and arcing
  - High melting temp and resilience to burning
  - Fairly inert (does not grow an oxide in normal environments)
- Good hardness—wears well over time

Contacts

- What kind of materials offer these qualities?

Material	Low Contact R (at low force)	Resistance to Surface Films	Hardness (wears well)
Gold	Better	Best	Poor
Platinum (Palladium)	Better	Best	Better (especially Platinum-Iridium)
Silver	Best (initially)	Fair	Good
Tungsten	Poor	Good	Best (resists burning also)
Copper	Best (initially)	Poor	Poor

Contacts

- Platinum is the best pure material (non alloy)
- Palladium is ok but has a slight tendency to oxidize
- Platinum-iridium is great because of additional hardness
- Unfortunately both are VERY EXPENSIVE
- But they are WORTH IT!
  - Clocks restored with platinum will run much longer

http://store

DeoxIT® and DeoxIT® Gold G100L

- Caig Laboratories
- Proven over 50 year history
- Unbelievable results
  - Examples
- Only a very small quantity needed on CLEAN contacts to preserve them indefinitely
  - Don't flood contact with it
- Possible lubricant for Style A motor bearings and commutators
- http://store.caig.com

Basic Troubleshooting Guide

1. Check for dirt and grime on all contacts
   - Clean with alcohol
2. Make sure motor contacts are on top of pin
3. Check connections to motor
   - Solenoid—nuts loose on contacts?
4. Adjust hourly contactor

Testing Self Winding

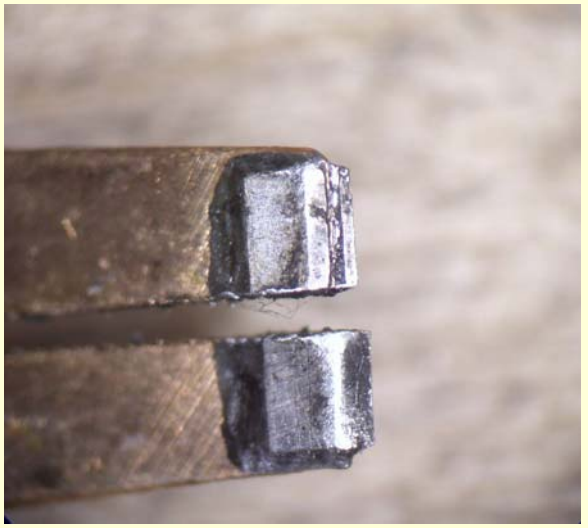
- Carefully remove verge
- Use finger to slowly let down escape wheel
- As hourly contactor comes up cam, slow down rate of release
- Stop escape wheel when winding starts; observe how the clock winds
- 8-12 seconds is good; 15 seconds “ok”

Battery Killers

- Hourly contactors burned through to the solder
- Motor contactors on wrong side of pin
- Broken Winding Ratchet
- Springs wound up too tightly
  - You'll be throwing good batteries away
- Wires connected incorrectly (Style A or C)
  - Energizing motor full time
- Insulating washers missing or broken
- Loose Center Wheel Hub
- Recoil springs missing

Hourly Contactor Problem

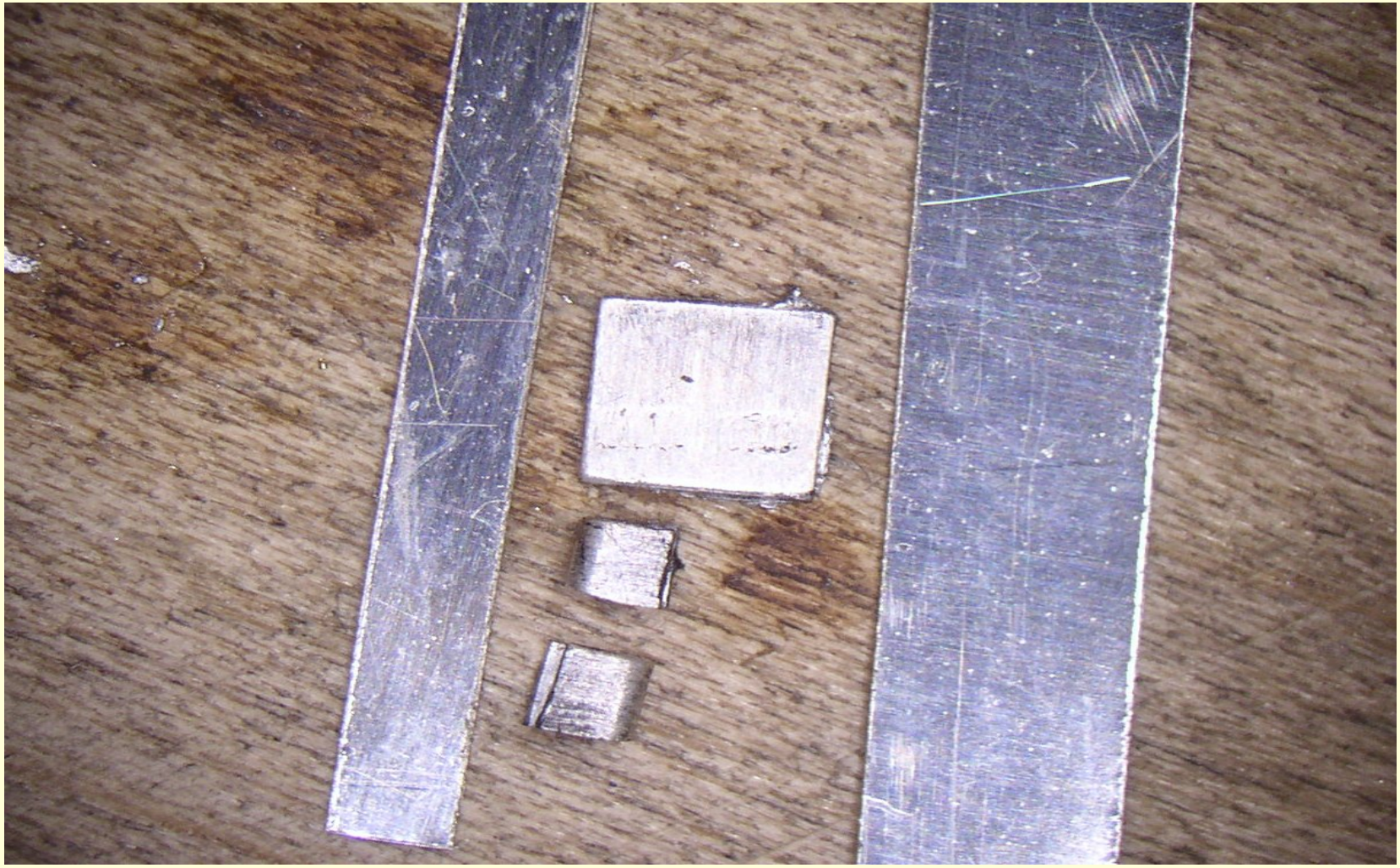
- Oxidized solder below Pt has higher resistance
- Poor contact approaching winding runs down battery
- Evidenced by motor “grumble” seconds or minutes prior to winding



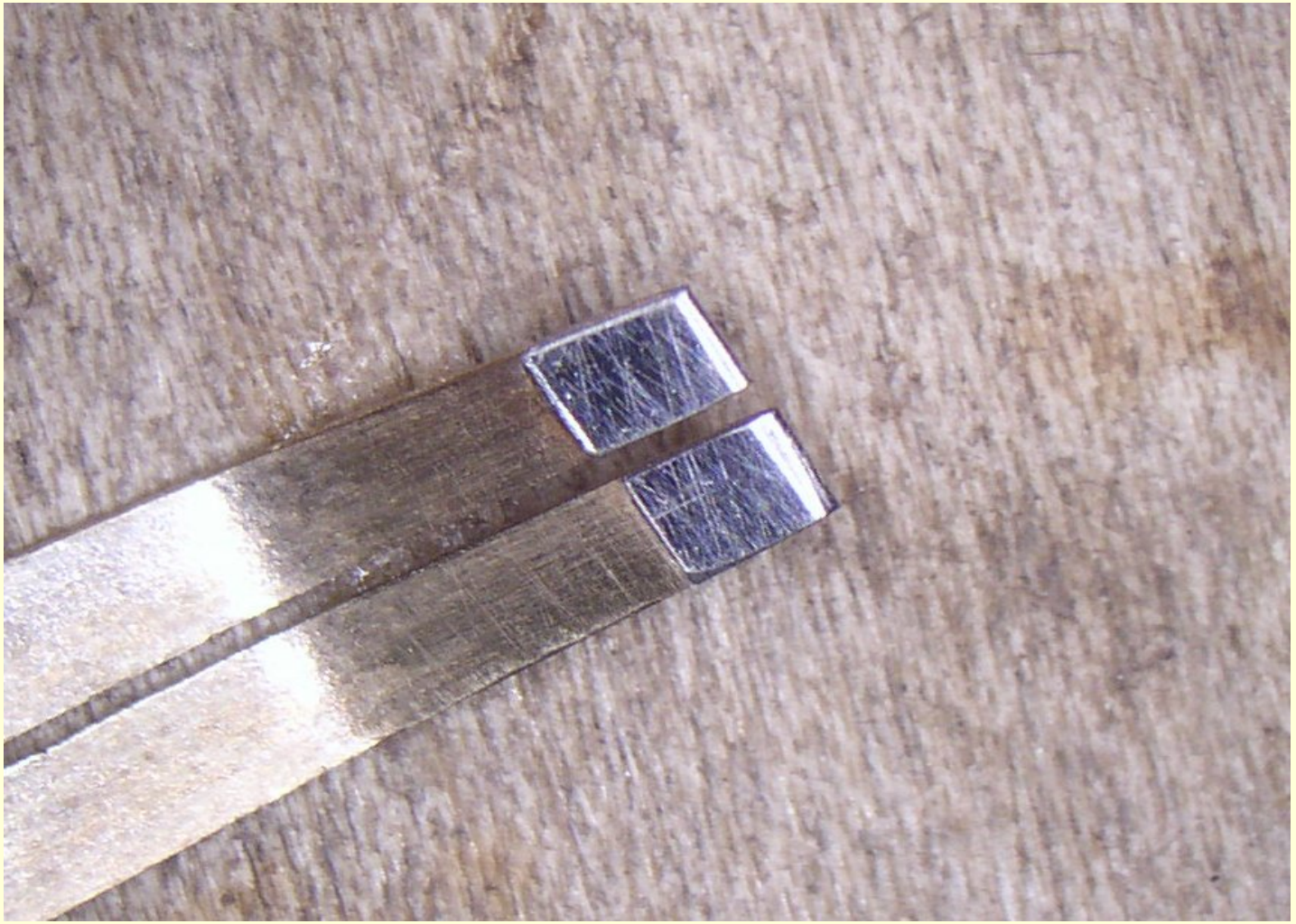
Repairing Hourly Contactor

- Procure Platinum sheet 0.002-0.003” thick
  - 0.004” thick preferred for large pad
- Cut into strip 0.060” x 0.156”
- Fold onto end of contactor
- Flux with Rosin flux
- Solder with Rosin core solder (0.032” dia)
  - Heat with soldering pencil until solder flows
- Trim with small file and fine paper
  - Do NOT abrade working surface

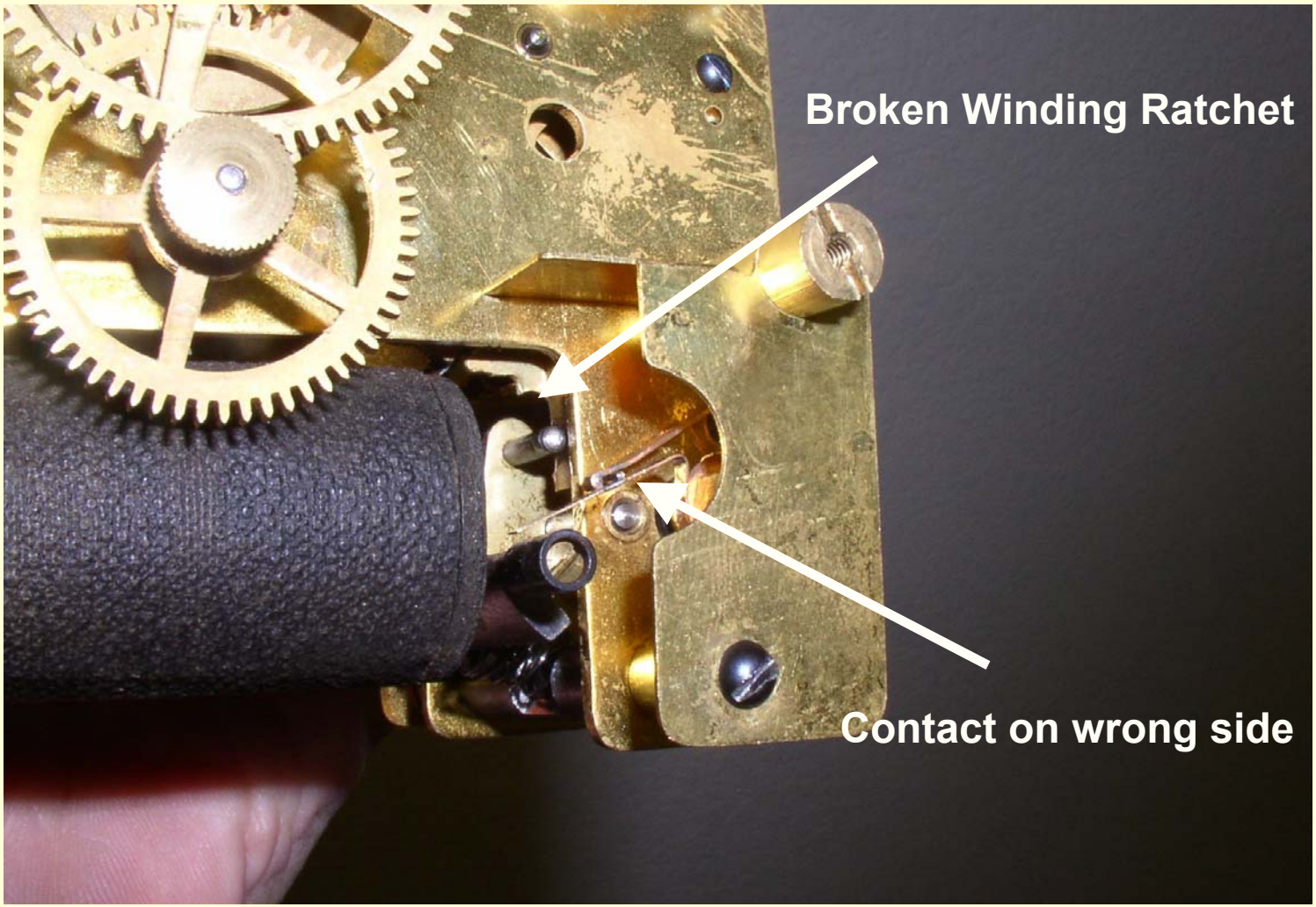
Sizing the Platinum Strips



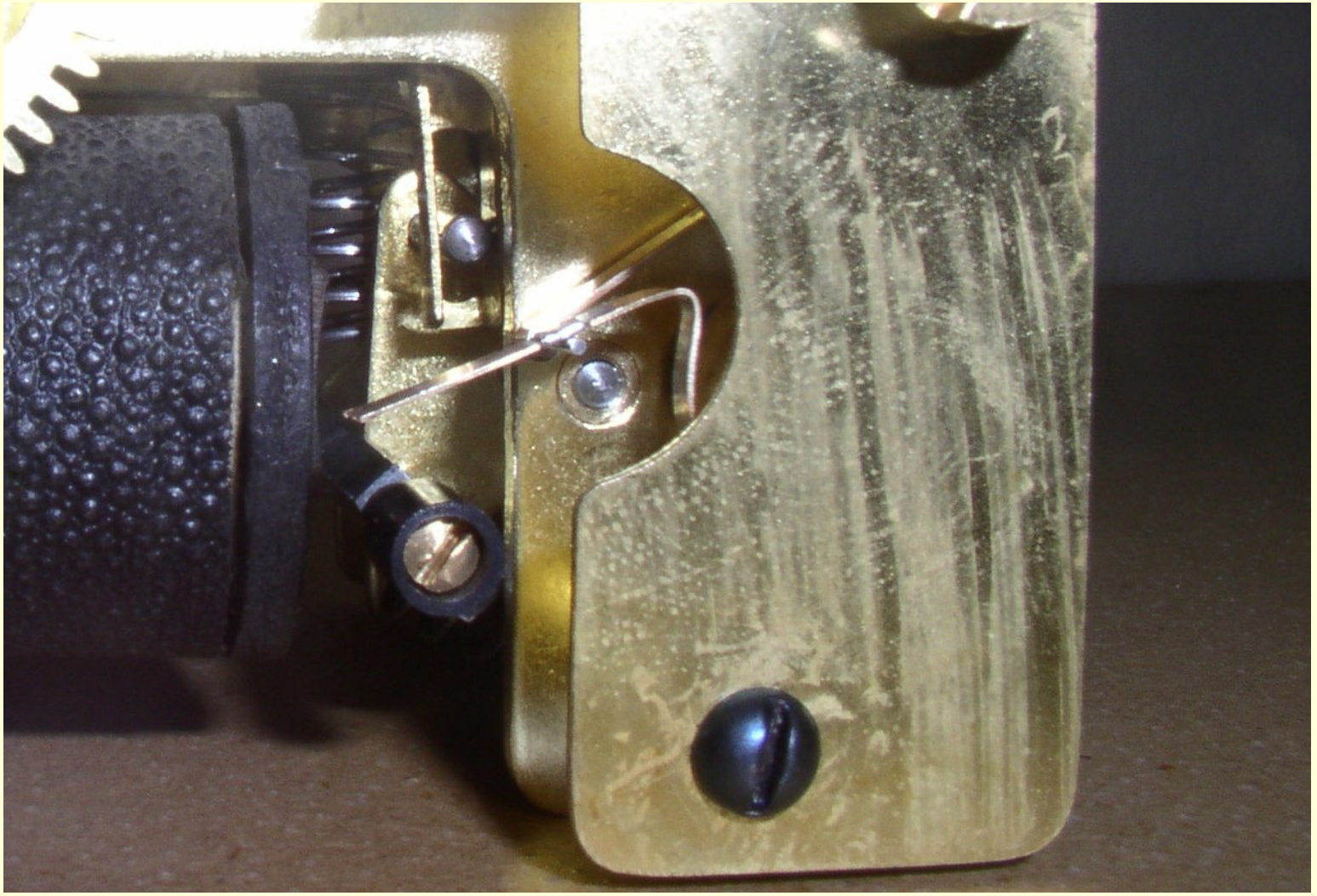
Repaired Hourly Contactor



Motor Contact: Wrong side of pin AND broken winding ratchet!

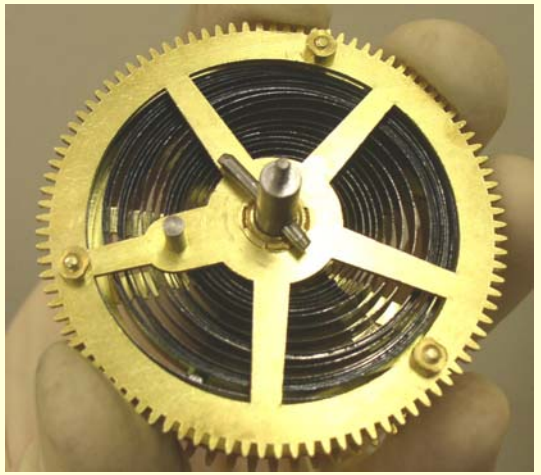


Corrected Contact and Ratchet



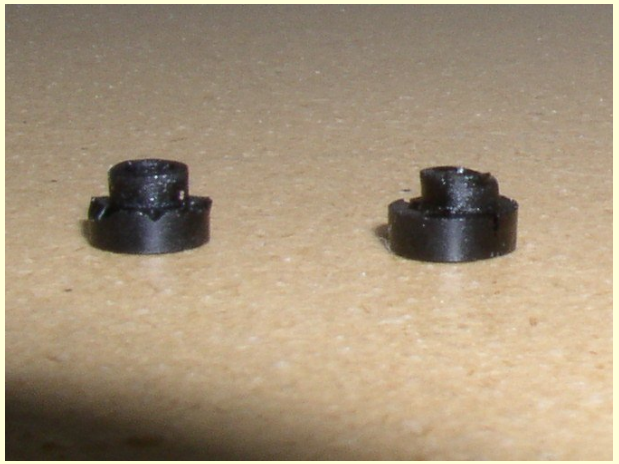
Correct Mainspring Tension

- Clean and lubricate spring and barrel
- Wind up 3-4 turns
- Install detent and hourly cam



Broken or Missing Shoulder Washers

- Broken washers should be replaced
- Use 0.25” black Acetal (Delrin)
- Readily available from:
  - www.onlinemetals.com
  - www.interstateplastics.com
  - Costs about $.70/ft and works well

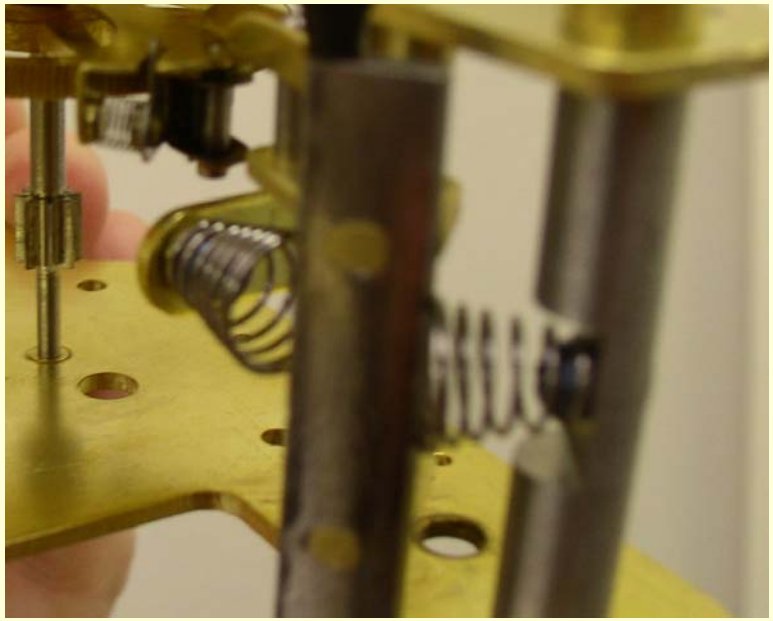


Center Wheel Hub Loose

- Accompanied by other problems
  - Erratic timekeeping (runs fast and slow)
- Requires movement tear down to correct
  - DON'T solder in situ
  - Inspect on every restoration

Recoil Springs Lost or Misadjusted

- Lower spring lost or misadjusted:
  - Clock may not wind at all
- Upper spring lost or misadjusted:
  - Poor battery life, slow wind, or motor noisy

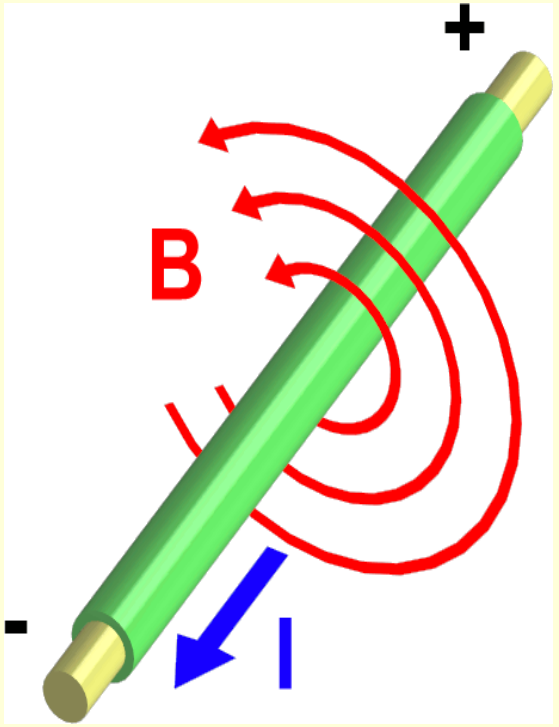


More Battery Killers

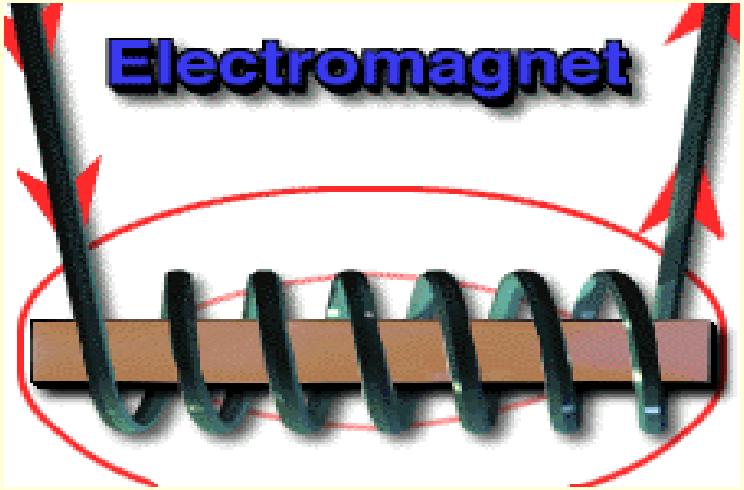
- Worn winding wheel holes and pivots
- Wiring Sync Light to indicate winding
  - Knocks battery life in half
- Winding Coils rewound with wrong wire
  - Mic bare wire and use www.wiretron.com wire table

Coils and Electromagnets

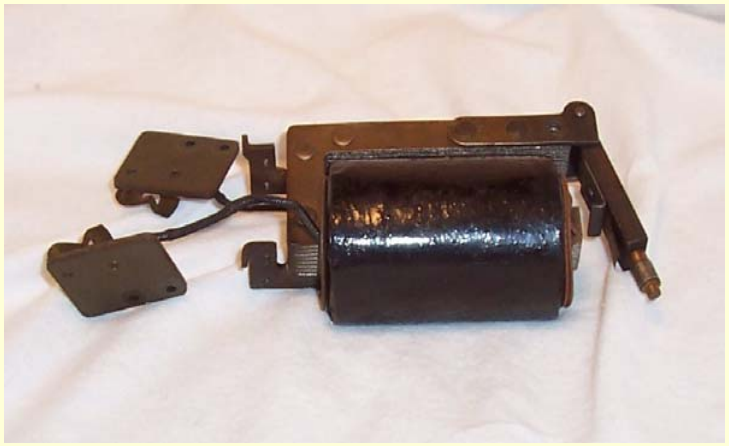
- If a current is passed through a wire, a magnetic field results
- This magnetic field encircles the wire as shown.
- The magnetic field will form around magnetic materials if we let it



Coils and Electromagnets



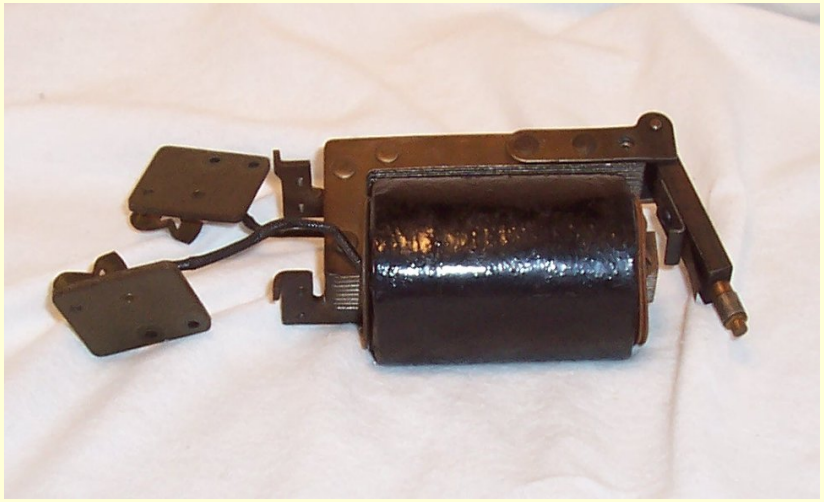
- Winding multiple turns around a core will concentrate the magnetic field as shown.
- All coils have some winding resistance resulting from the copper
- Amps = V/(coil R)

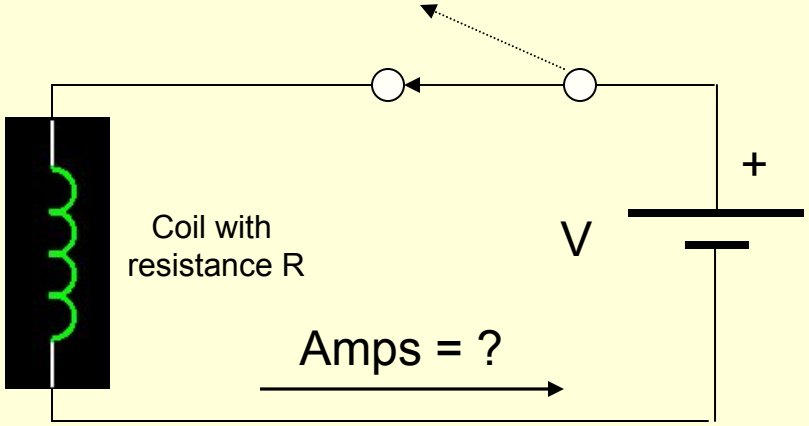


Challenges with Coils

- What happens when I energize this synchronizer coil?
- Current will flow through the coil
- Amps = V/(coil R)
- Example: If V =3 volts and R is 6 Ω, then:

  Amps = 3V/6Ω = 0.5 Amp

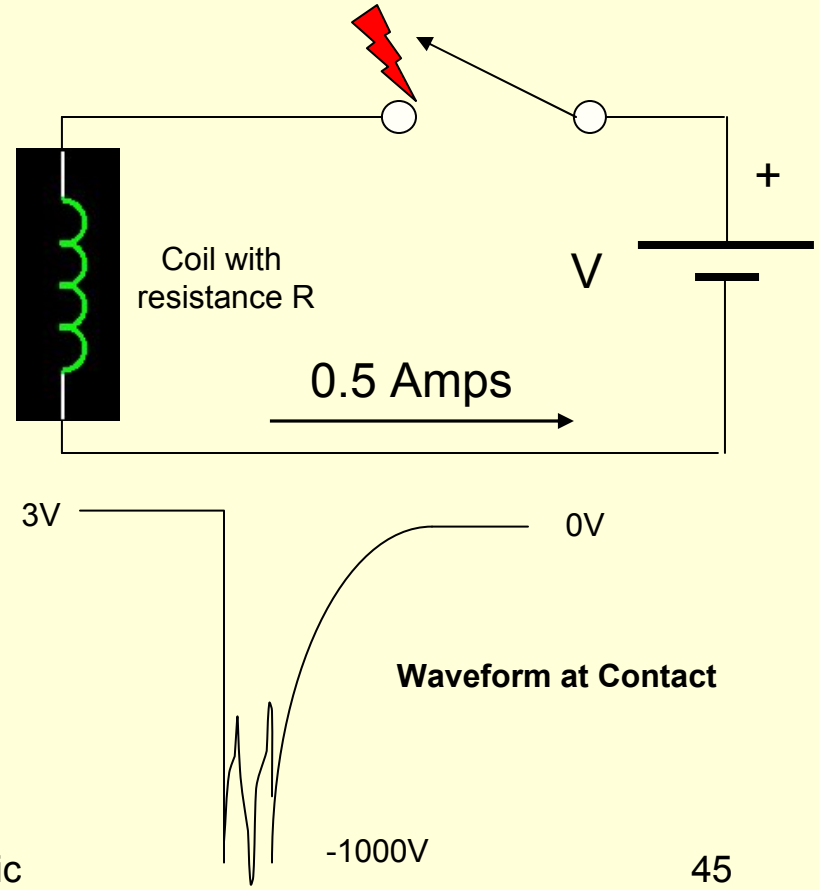




Challenges with Coils

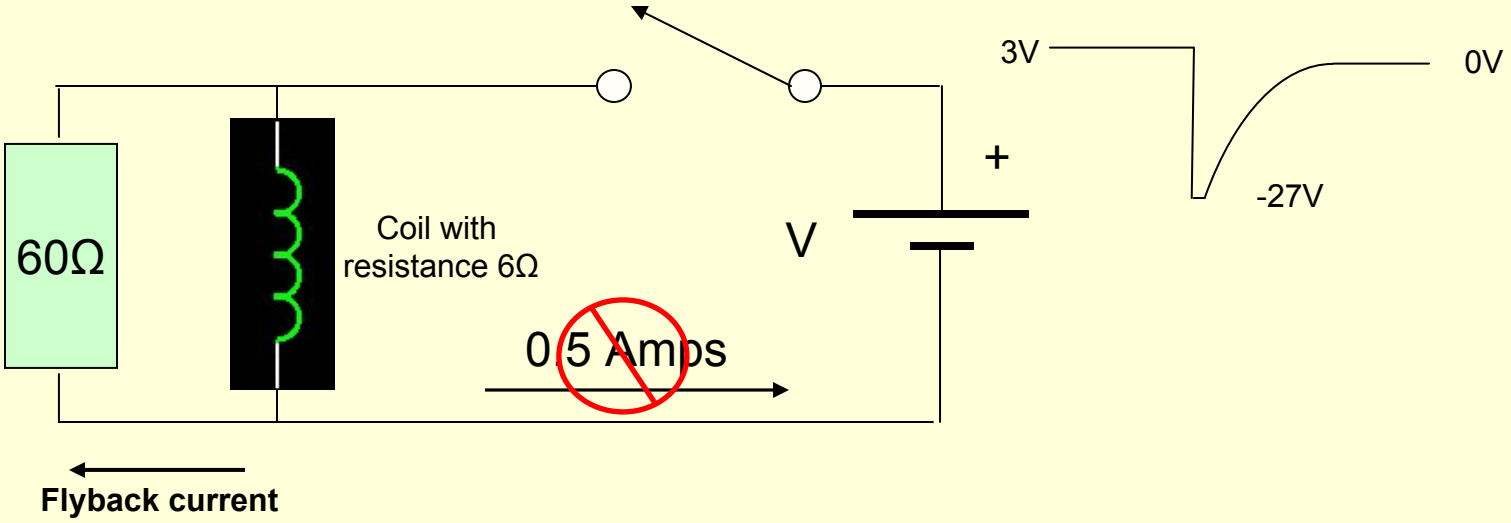
- What happens when we disconnect the coil?

1. **Energy is stored in the coil as an electromagnetic field. That's the nature of a coil's "inductance."**
2. **So, when the switch is opened, the current will want to keep flowing in the coil.**
3. **It will increase its voltage until the contact arcs over (100's or 1000's of volts).**
4. **The "spot" temperature from this arc is hot enough to melt metal, thus pitting and damaging the contacts.**



Challenges with Coils

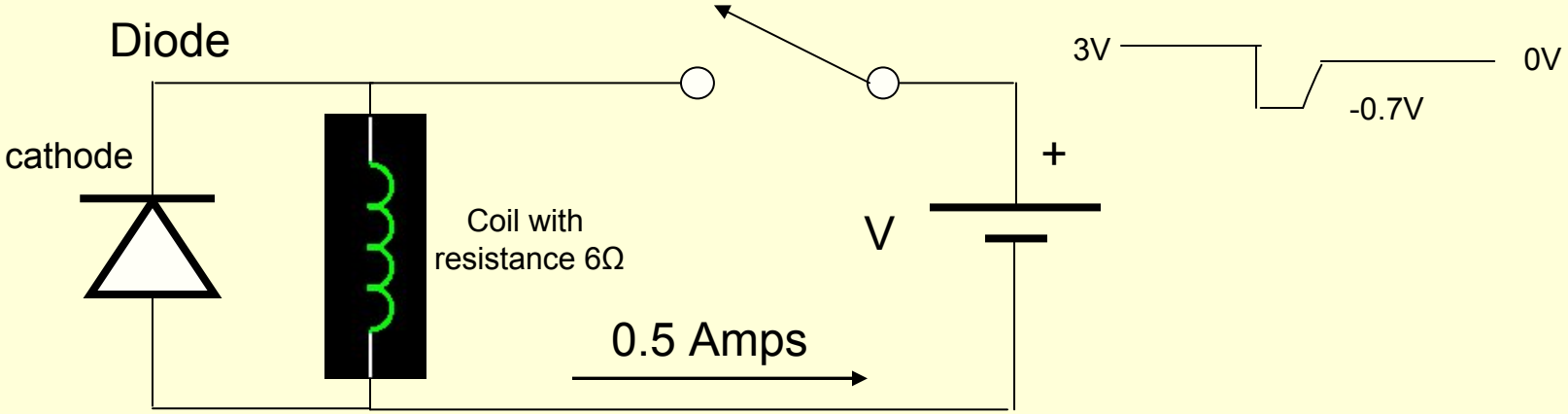
- Question: How do I prevent this?
- Answer: Create somewhere else for the coil current to go when the contact opens.
- Most common option is a Damping resistor, usually selected to be ~10x the value of the coil resistance.



Challenges with Coils

- Most common option is a Damping resistor, usually selected to be ~10x the value of the coil resistance.

- Another option is a diode, but this was obviously not used in vintage days.

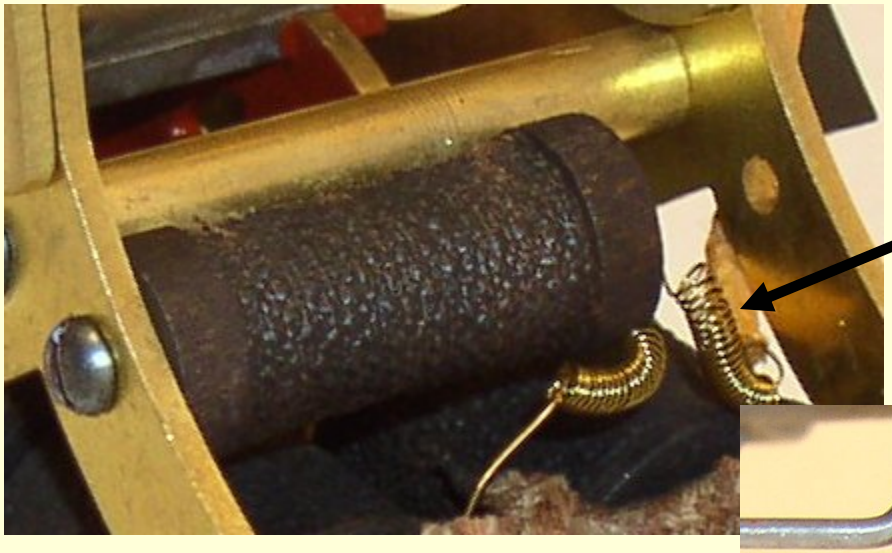


Inductance of 3 Volt SWCC Coils

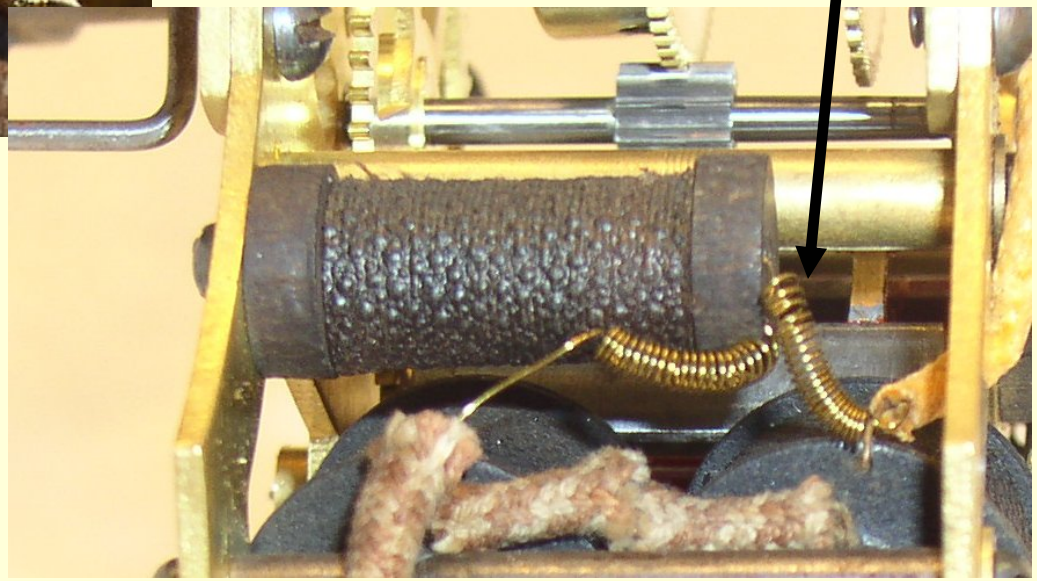
- Winding Coils: 32 mHy
- Dual Synchronizing Coils: 87 mHy
- WU Single Synchronizing Coil: 200 mHy

- mHy is an abbreviation for millihenry or .001 Henry

SWCC Damping Resistors



Note strain relief on lead wires



Tips on Damping Resistors

- As a general rule, the Damping Resistor is 8-12x the value of the coil resistance
- Always check to be sure the lead wires are not broken and the wires are not touching metal or each other
- Check motor contacts for blue arcs (in the dark) while winding

Tips on Damping Resistors (cont'd)

- NEVER remove them from clock permanently
- Don't put a cheap Radio Shack resistor in a 100 year old clock
- They can be restored
  - Use 7ft of #32 NiCr wire wound non-inductively on the original wood spool (yields ~68Ω)
    - Available from WireTronic, Inc
      - www.wiretron.com
  - Make a new wood spool in about 5 minutes from 0.5" dowel rod if missing

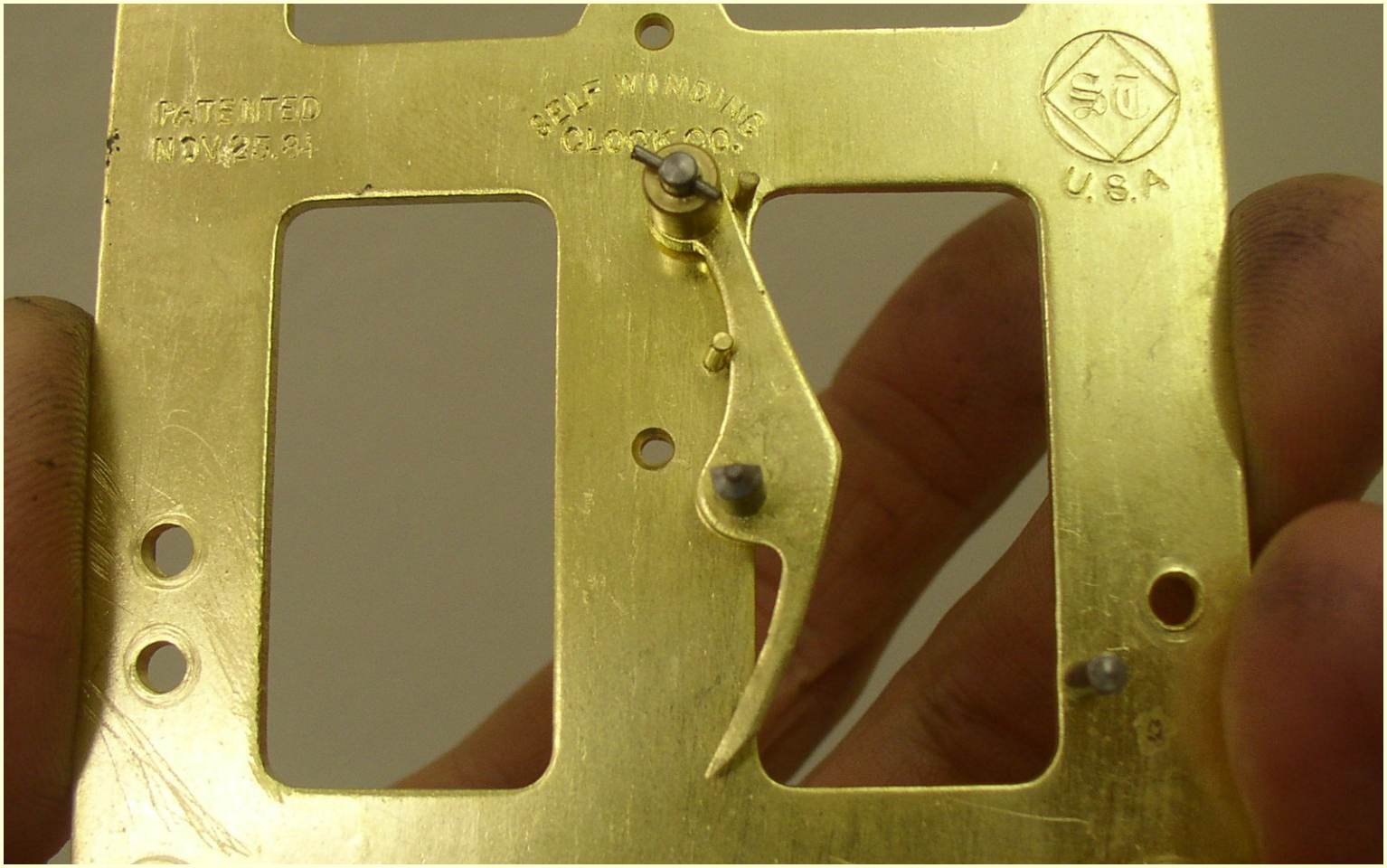
Non-inductive winding

- Damping resistors MUST be wound non-inductively
- To do this:
  - Fold the wire back over itself (3.5ft long)
  - Wind double wire over spool
  - Run two leads out through holes in spool (should be about 10 inches of lead wire for each)
  - Coil each lead individually around 3/32” brass rod for strain relief (looks like spring about .5” long)
  - Put thin black paper over coil when done

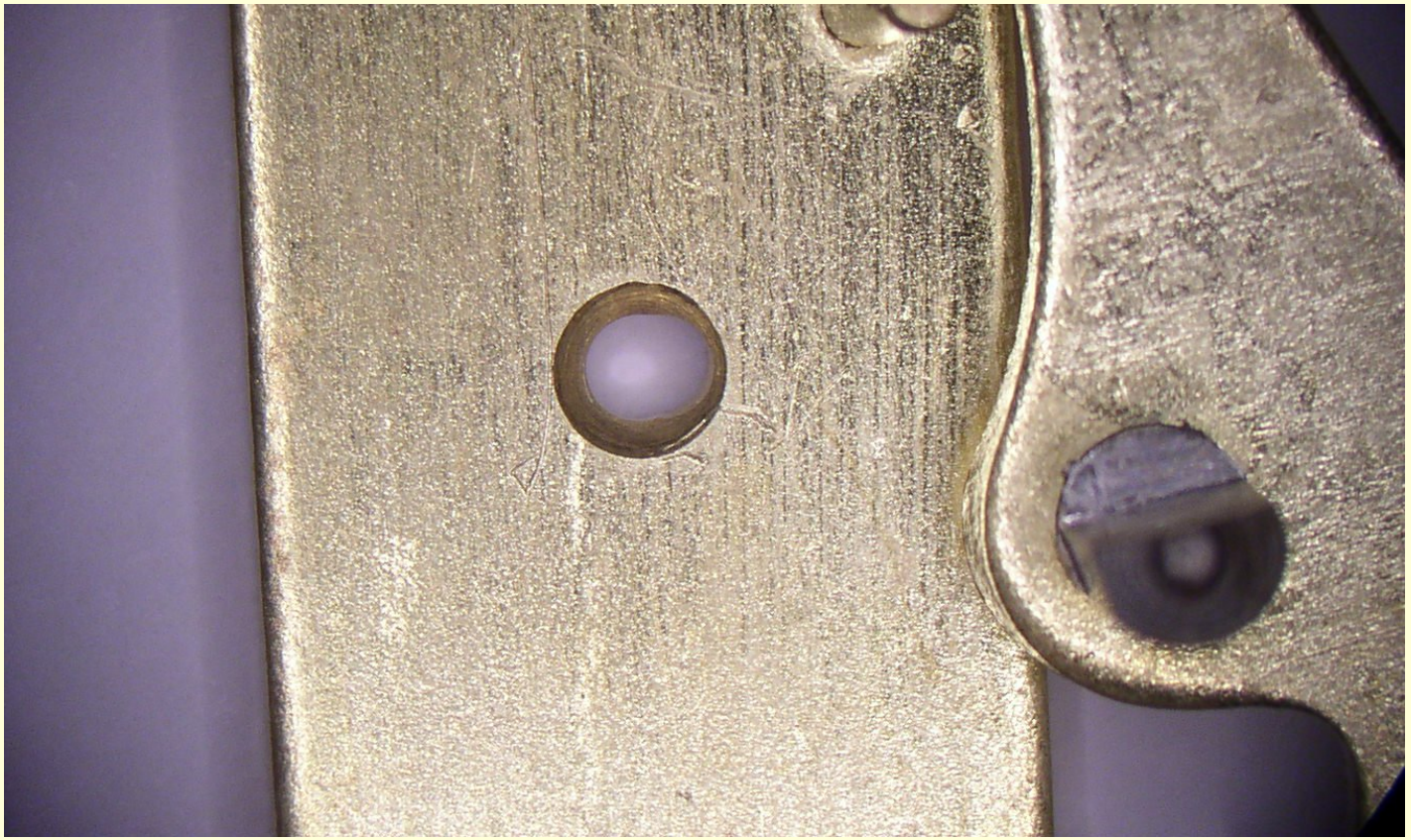
SWCC Bushings

- Movements are fairly high quality
  - Style A and C movements are uncommon
- We use and recommend flush bushing
  - Provides cosmetically excellent repair
  - Work hardens hole
  - Bushing is firmly held in place
  - Replicates original oil sink
  - Reflects Seth Thomas Standard of Craftsmanship

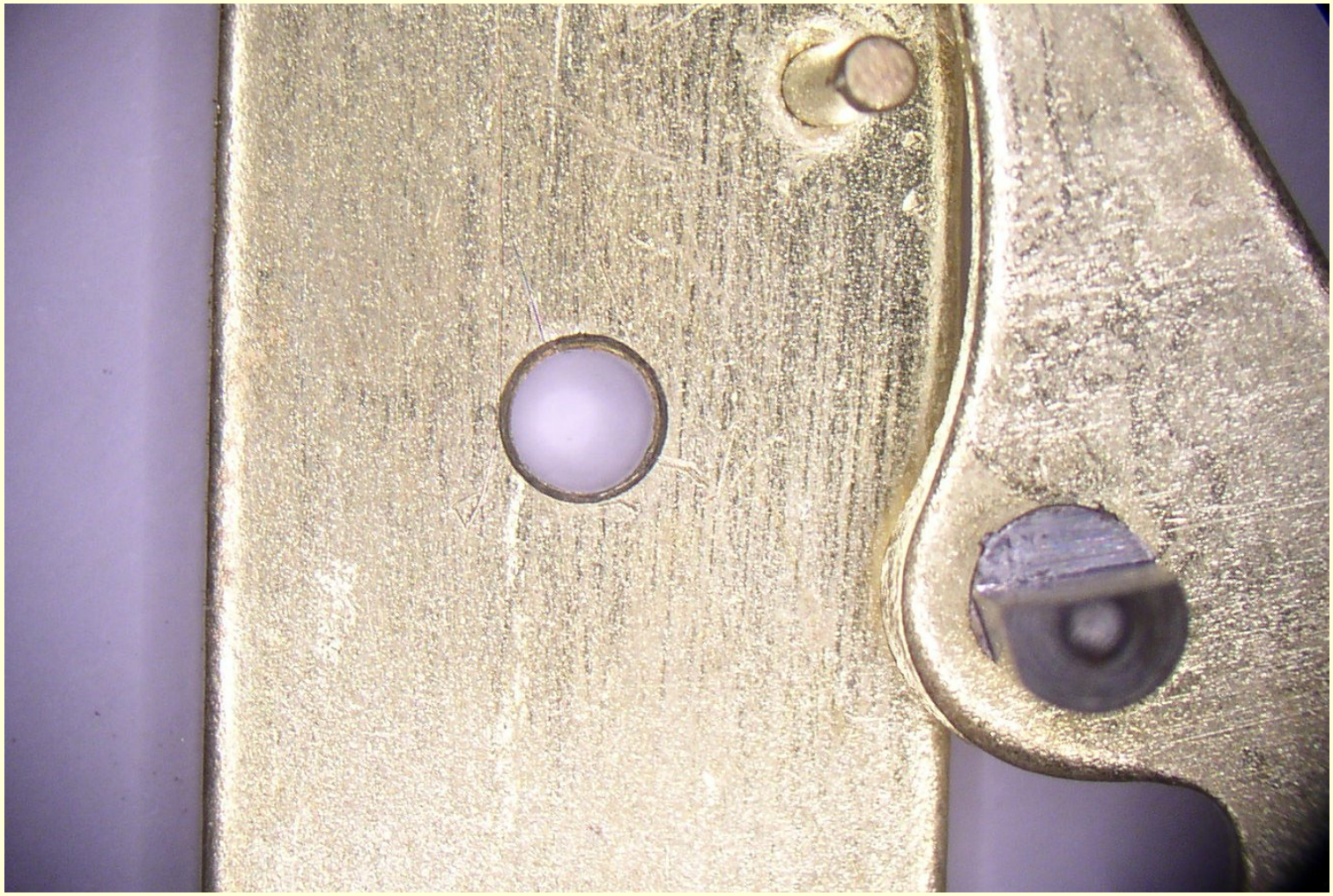
Bushing Second Wheel Front Hole Style A movement



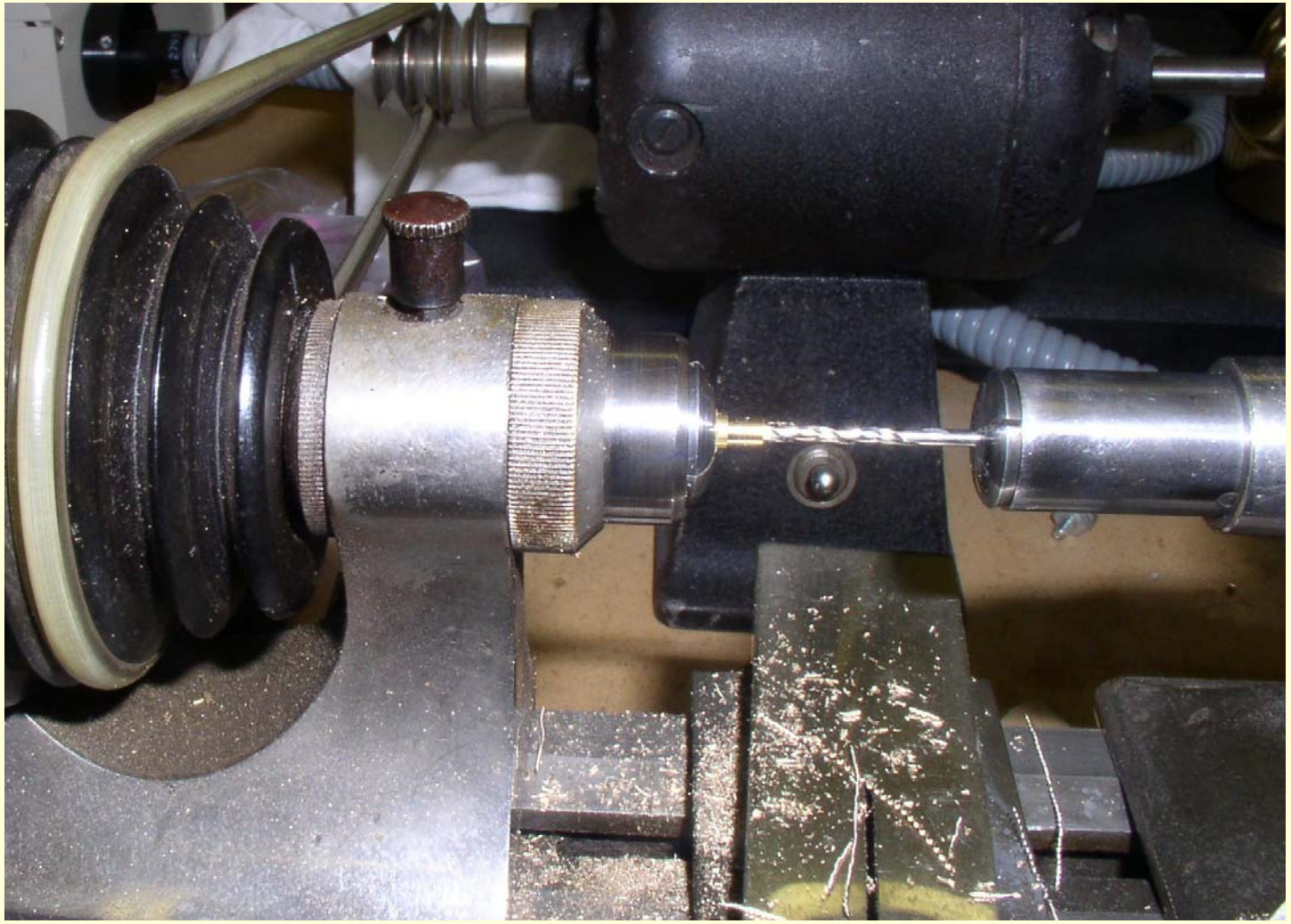
Bushing Second Wheel Front Hole Style A movement



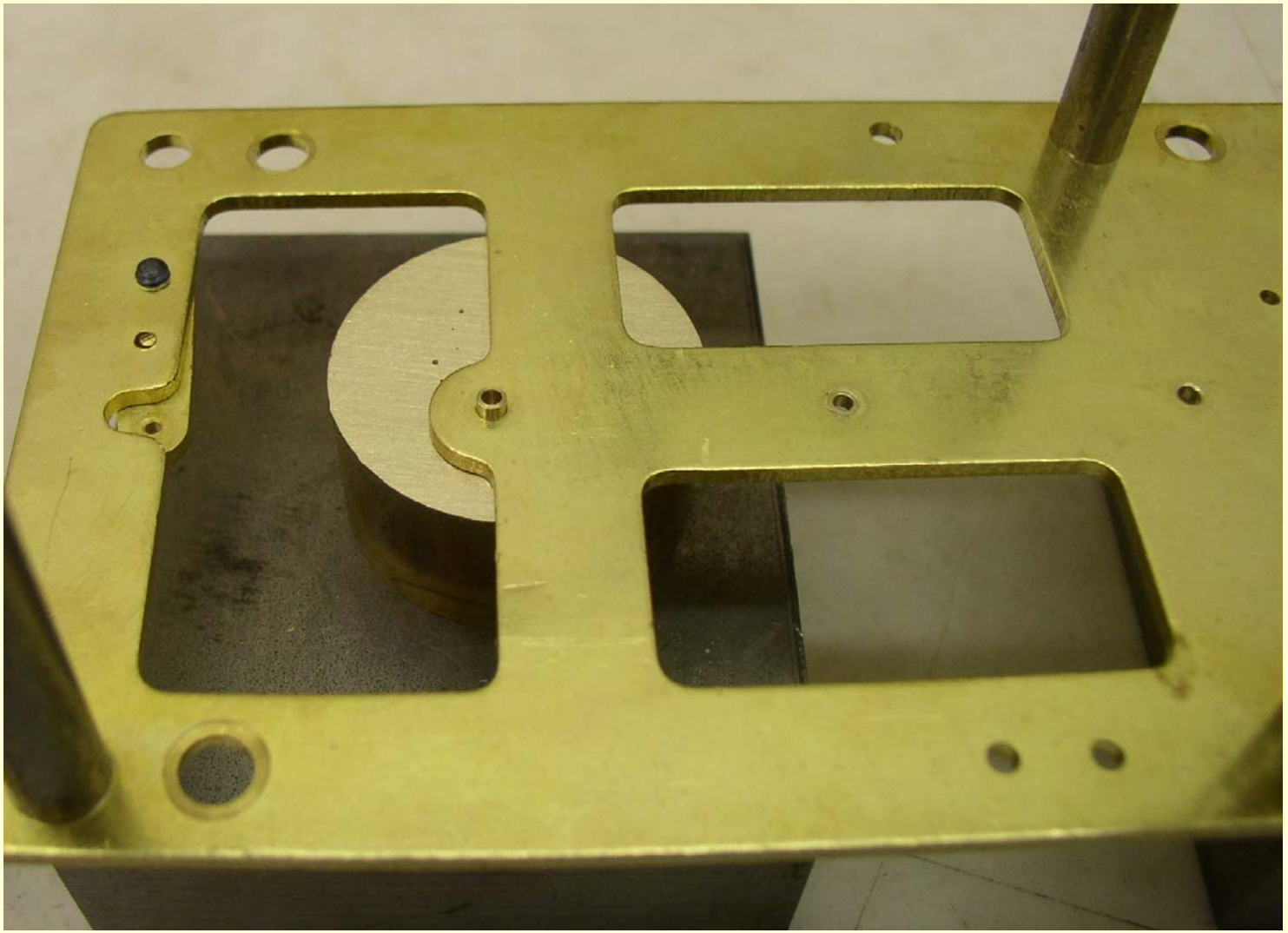
Hole Filed to Center and Broached



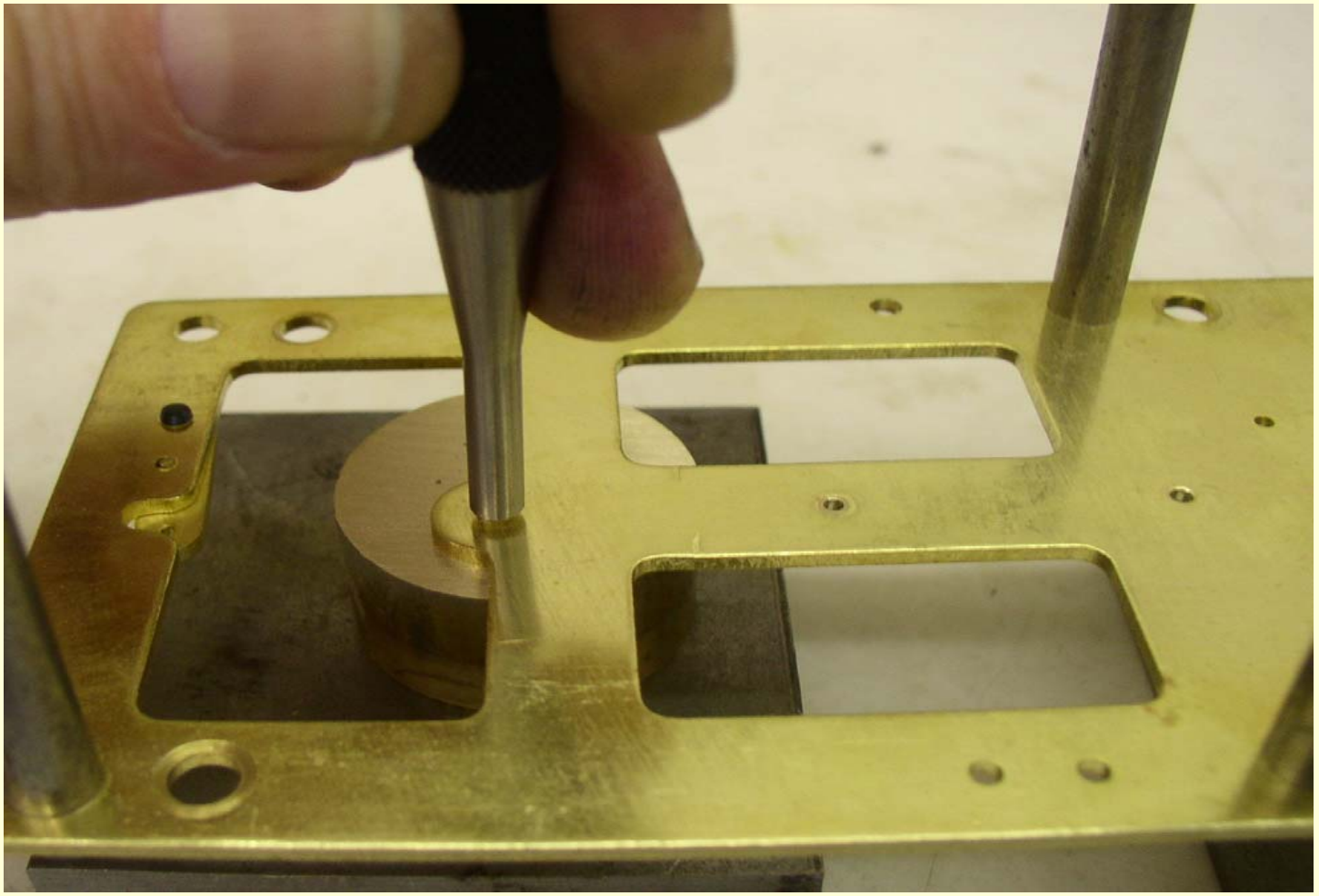
Turning up Bushing on Lathe



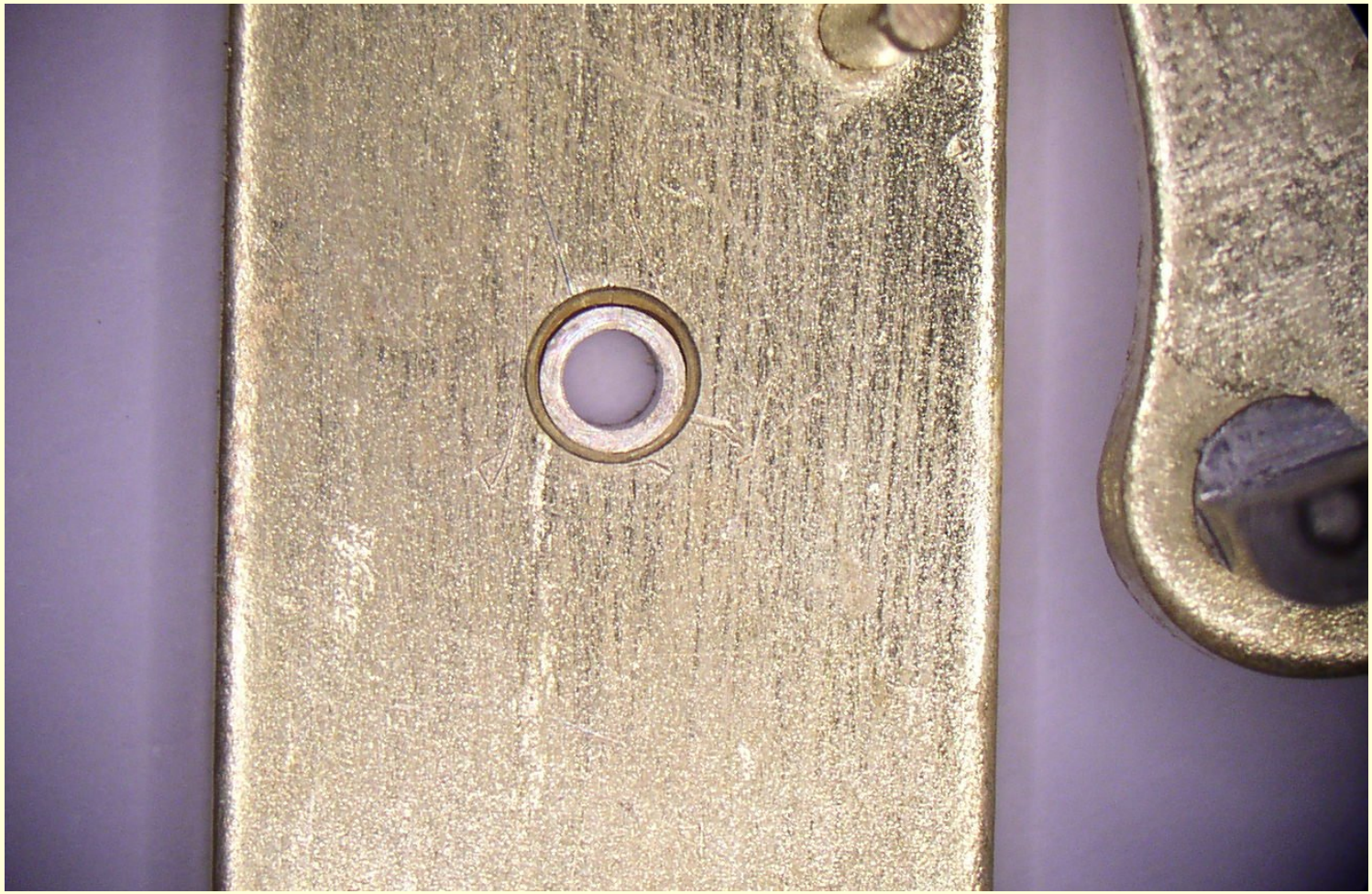
Installing Bushing



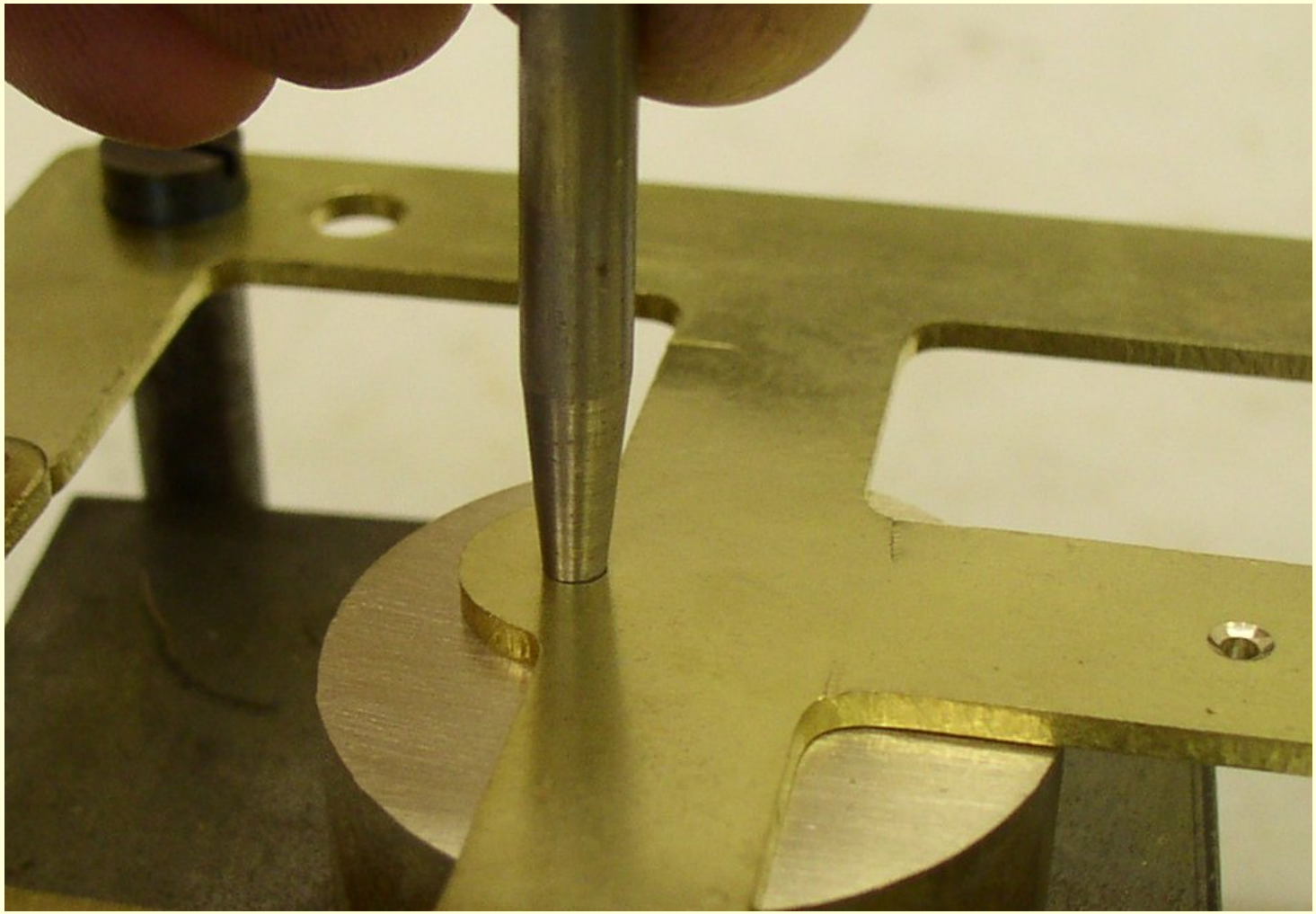
Driving Home Bushing



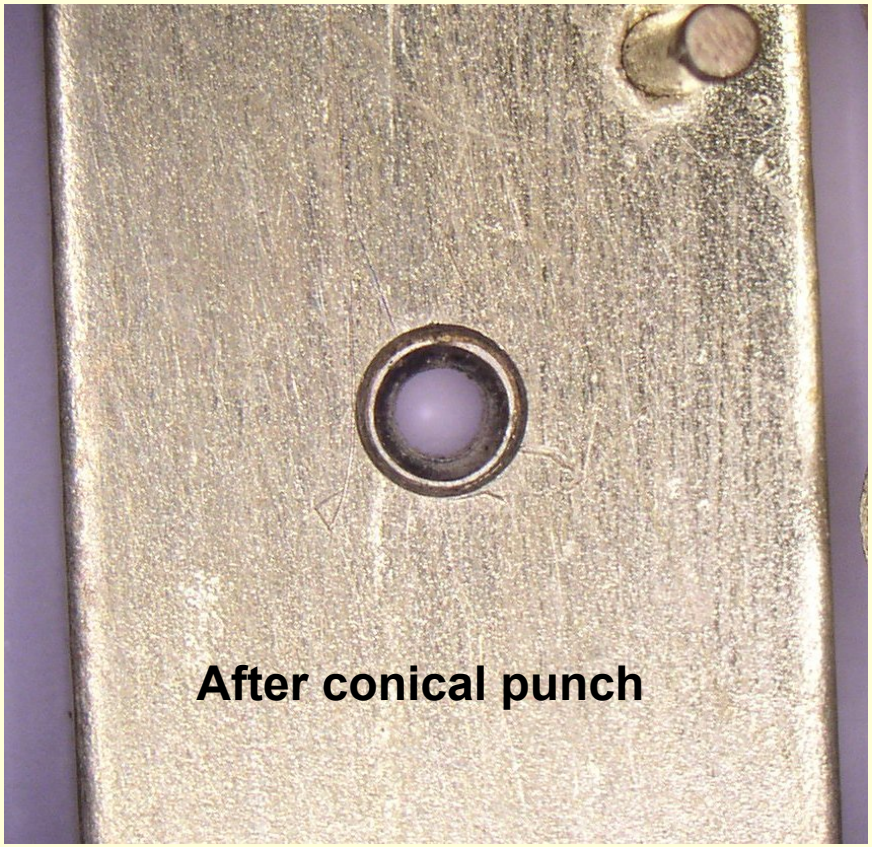
Front View of Installed Bushing

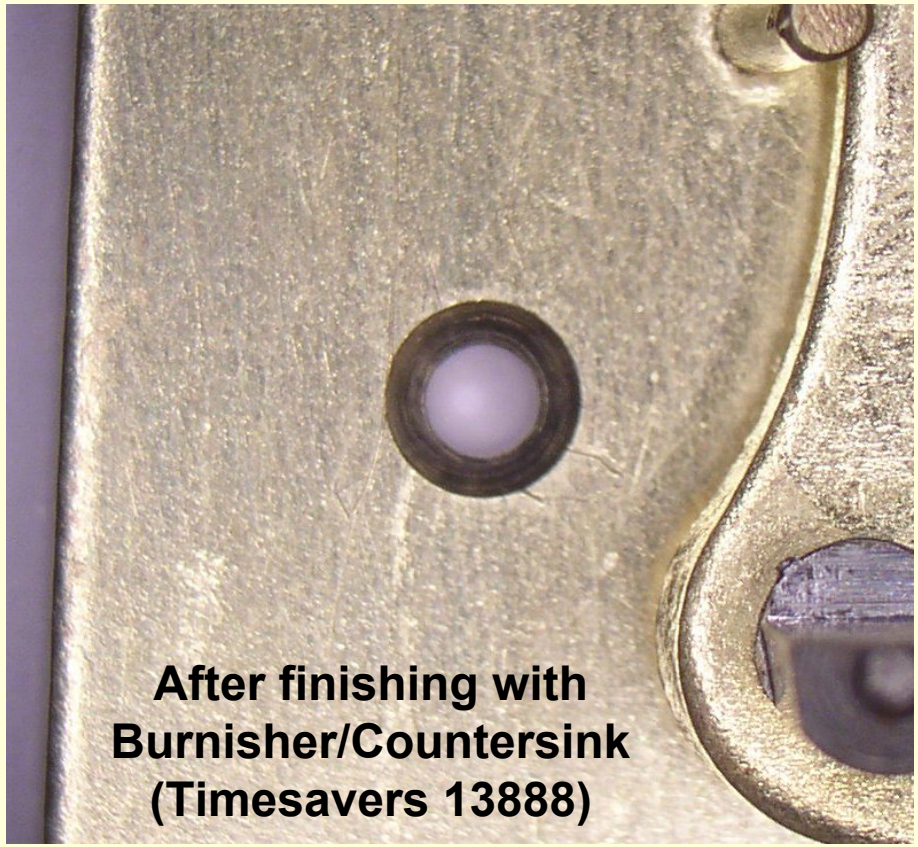


Shaping Oil Sink

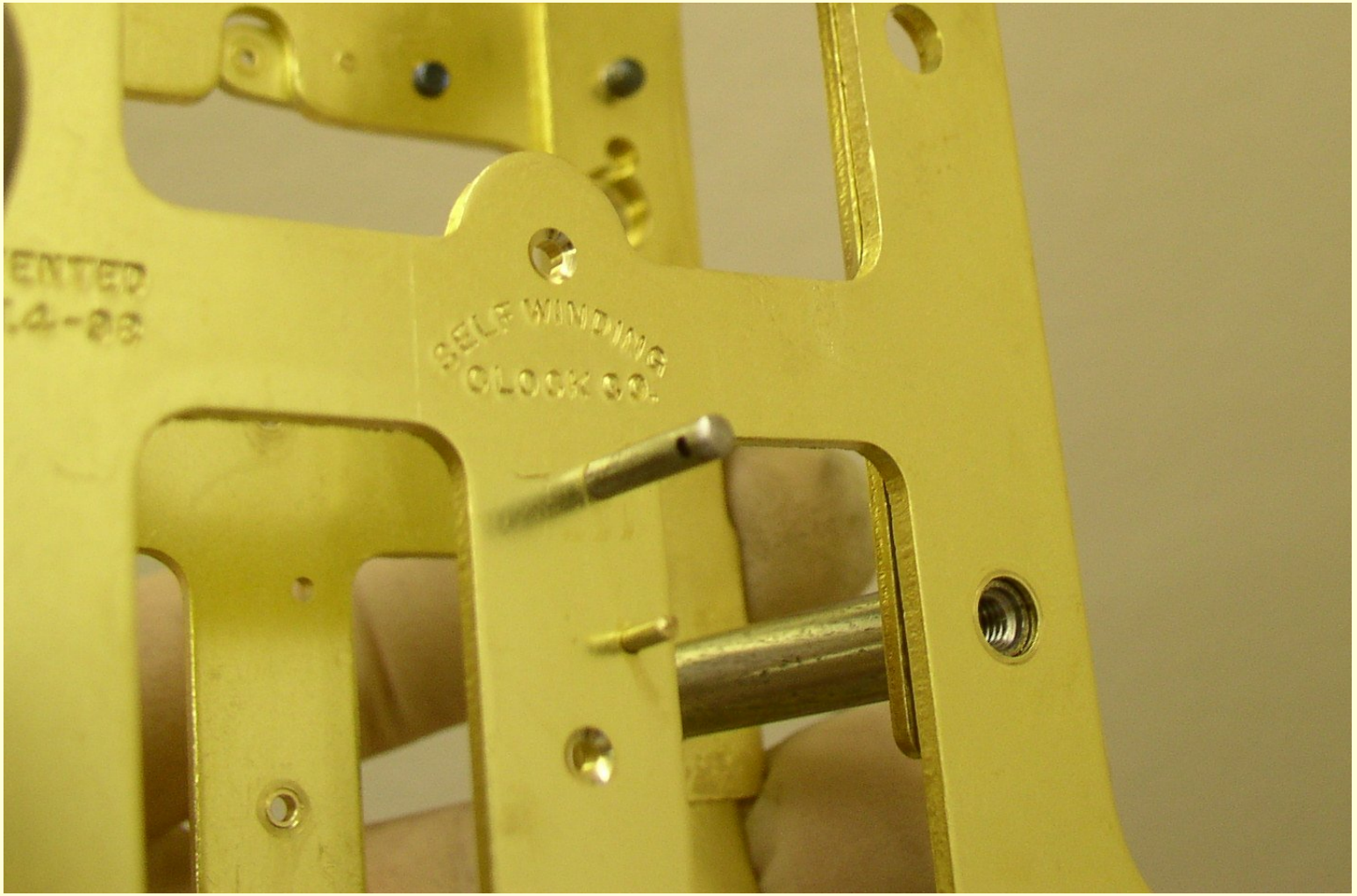


Finishing the Job

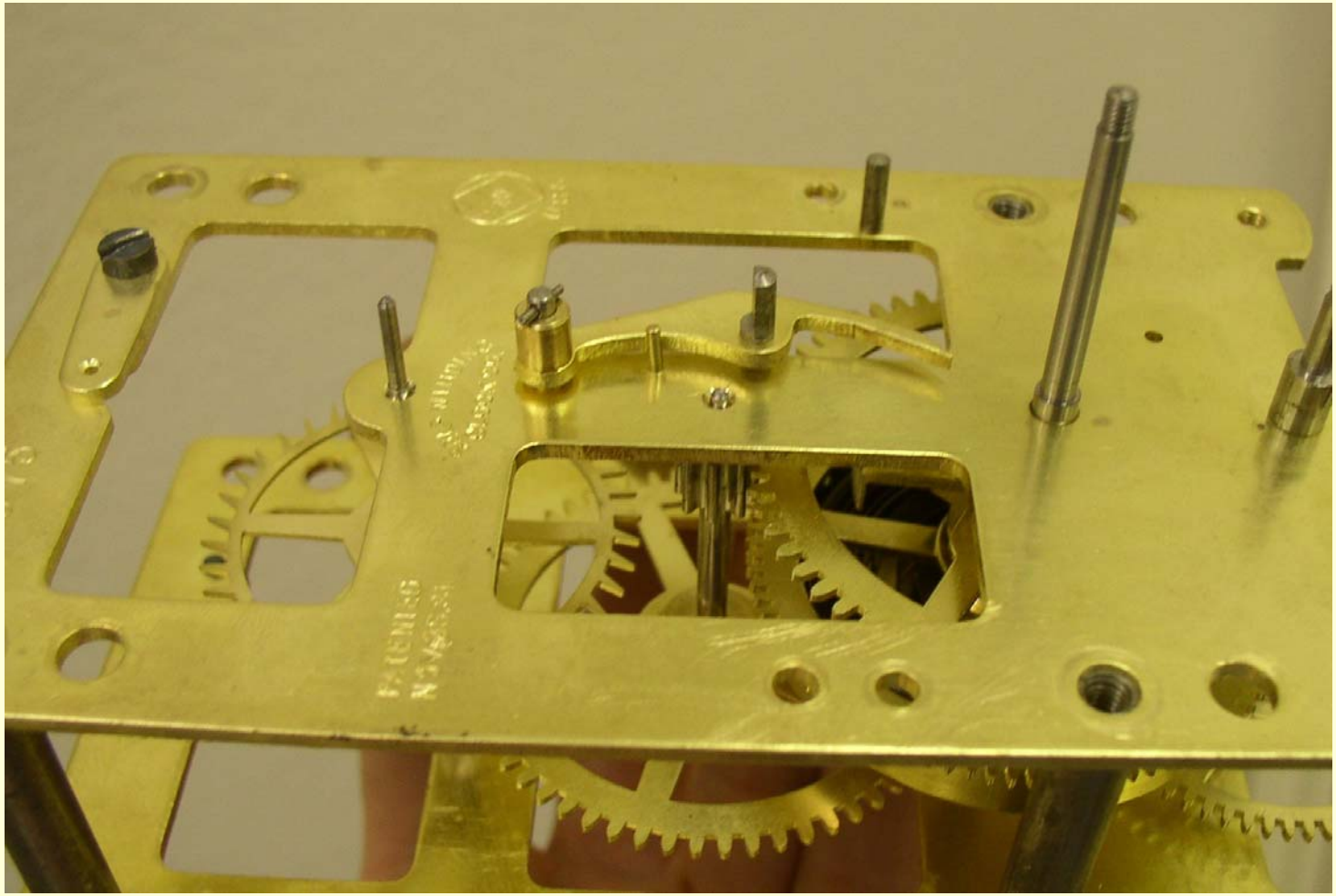




Another View of New Bushing



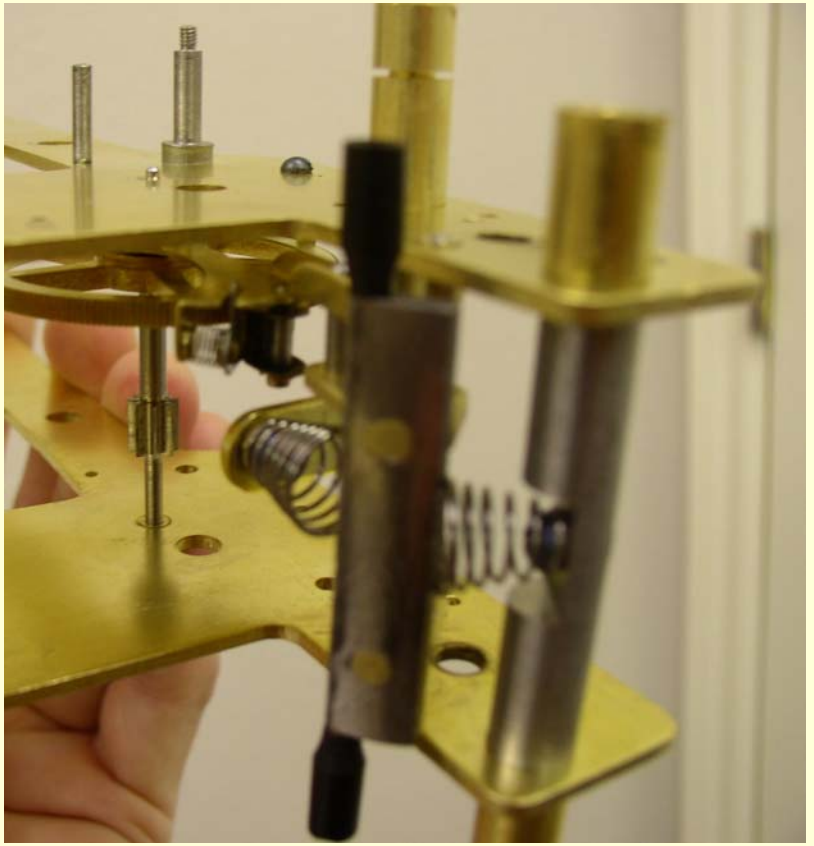
Style A Front Plate, Bushed



Motor Restoration Tips

Common Problems:

1. Winding Wheel Pivots/Holes
   - Arbor also worn badly
2. Ratchet arm broken
3. Ratchet arm hub
4. Armature Pivots/Holes
5. Ratchets worn
6. Springs missing

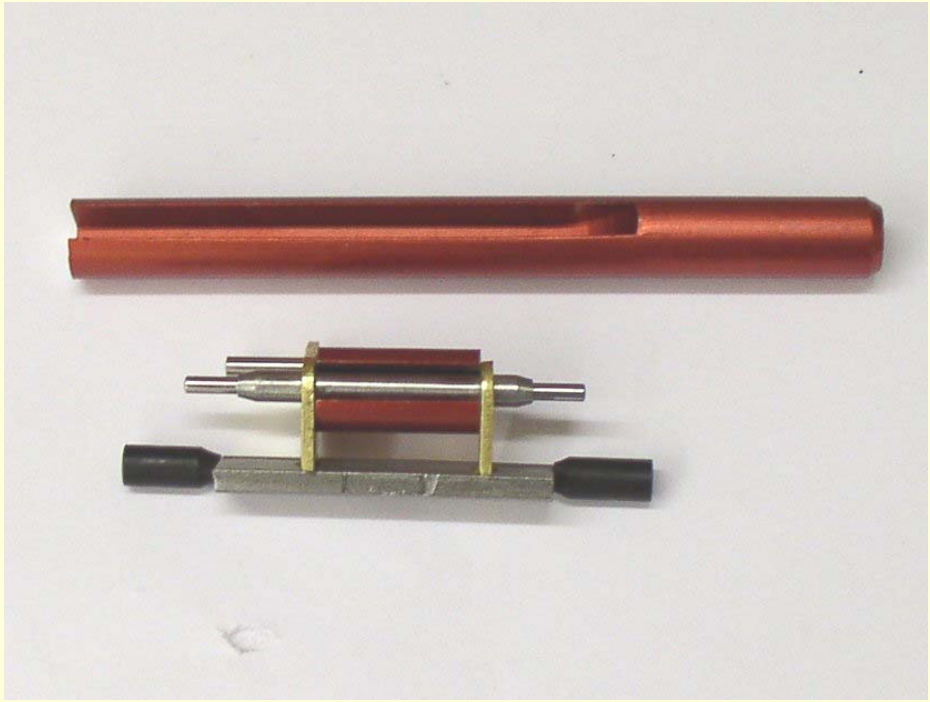


Motor Armature

- Pivot wear is serious
  - Bushing will quickly wear once pivot is scored
  - Must be addressed
- Pivot is difficult to access

Accessing Pivots

- Must remove arbor
- Make tool from Cannon Pinion punch (Timesavers 20879)
- Acts as spacer as you drive out arbor



Ratchet Wheel Arbor and Hub

- Polish upper arbor like a pivot
- Replace Hub if worn (or rebush)
- Inspect opening for cracks
- Clean up ratchet
- Inspect springs
- Adjust

Screws

- Keep an eye on threads
  - Years of heavy tightening damages them
  - Rethread or clean up per table
- Be careful of screw sizes
  - Many different types on these clocks
- Use washers where used originally
  - Coil yoke mounts
  - Wherever wires attach
  - Make new ones if missing

Screw Sizes Style A, C, F

Location	OD (inch)	Thread (TPI)	Screw Size
Hand Nut	0.097	56	3-56
Sync & Minute	0.085	56	2-56
Dial Screws, Electrical Connections	0.110	40	4-40
Bosses, Pillars	0.138	40	6-40
Motor Coils	0.136	32	6-32
Sync Second Bit Escape Arbor	0.047	130 (est)	000-120

Synchronizing Components

- Don’t remove them
  - Destroys the heritage (and value) of the clock
  - They are cool to put back in service!
- Future class on restoring and adjusting them
- Many SWCC models are only fair timekeepers w/o synchronization
- We have a nice kit that will power and synchronize your clock to seconds/month
  - Looks like a pair of No. 6 cells

1900S Synchronizer Kit

Optional Labs

- Basic Electrical Measurements
- Experiments

Basic Electrical Measurements

- The standard instrument for basic electrical measurements is the DMM (**D**igital **M**ulti**M**eter)
- Multi Function
  - Volts
  - Ohms
  - Amps
  - Continuity
  - Diode Test
- Accuracy ~1%
  - Good enough for most if not all clock work

Important Aspects of DMM Measurements

- Know your DMM
  - Make sure the range is appropriate for what you expect to measure!!
  - Make sure the leads are in the right place
  - Make practice measurements before doing anything real

- Make sure you have a good zero
  - If you don't, subtract the offset from your measurement to obtain most accurate reading
  - Especially true with low voltages

Experiment 1:
Measure the resistance of devices

- Set DMM to 200 ohm range

1. Touch both probe tips to a terminal
2. Record “offset”
3. Measure device of interest eg Terminal 3 and Terminal 4
4. Subtract value in Step 2 from value in Step 3.

Experiment 2:
Measuring Voltage

- Set DMM to 20 Volts DC range

1. Measure battery terminal voltage.
2. Now, connect battery to light bulb (Terminals 5 and 6).
3. Measure battery terminal voltage again.
4. Compare result from 2 to result from 4.

Experiment 3:
Stall Current of Motor

- Connect a wire between Terminal 2 and Terminal 6
- Connect battery (with test clips) between Terminal 1 and Terminal 5
- Stop motor with fingers
- What happens??? Why???

Experiment 4:
Coil Arcing

1. Connect one of the battery leads to Terminal 3 using test clip.
2. Touch other test clip to Terminal 4
3. As you do, notice the spark. Why is there a spark there?
4. Now, connect Terminal 3 to Terminal 7
5. Likewise connect Terminal 4 to Terminal 8.
6. Repeat the test in 1-2 above.
   - What happened? Why?