Capacitors in your Old Radios

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January 2023

This is a Huge Topic.
There are many kinds of capacitors.
They have many functions.
Their failure can cause many different symptoms.
I'll do my best, but please help me if I forget something.

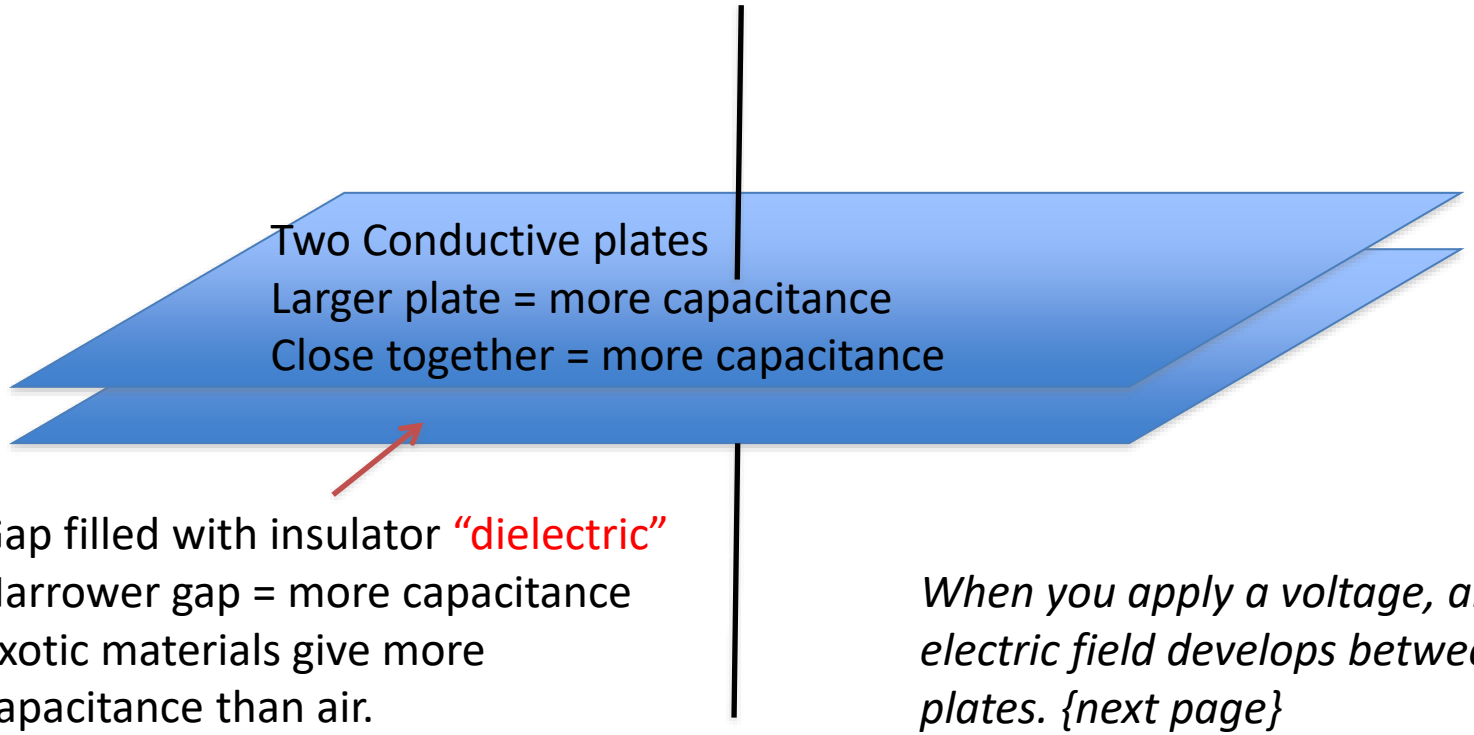
Overview

- Physical Description
- What they do, ways to describe them
- How to test them
- Capacitor types
  - Reforming Electrolytics
- How they fail
- Capacitors "*in their element*"
  - What matters ?
  - Symptoms of a failed cap.
- Where to buy them
- Hiding Capacitors
- To Recap or not to Recap?


.47 MFD.
400 V.D.C.
MADE IN
TYPE GT

PHYSICAL DESCRIPTION

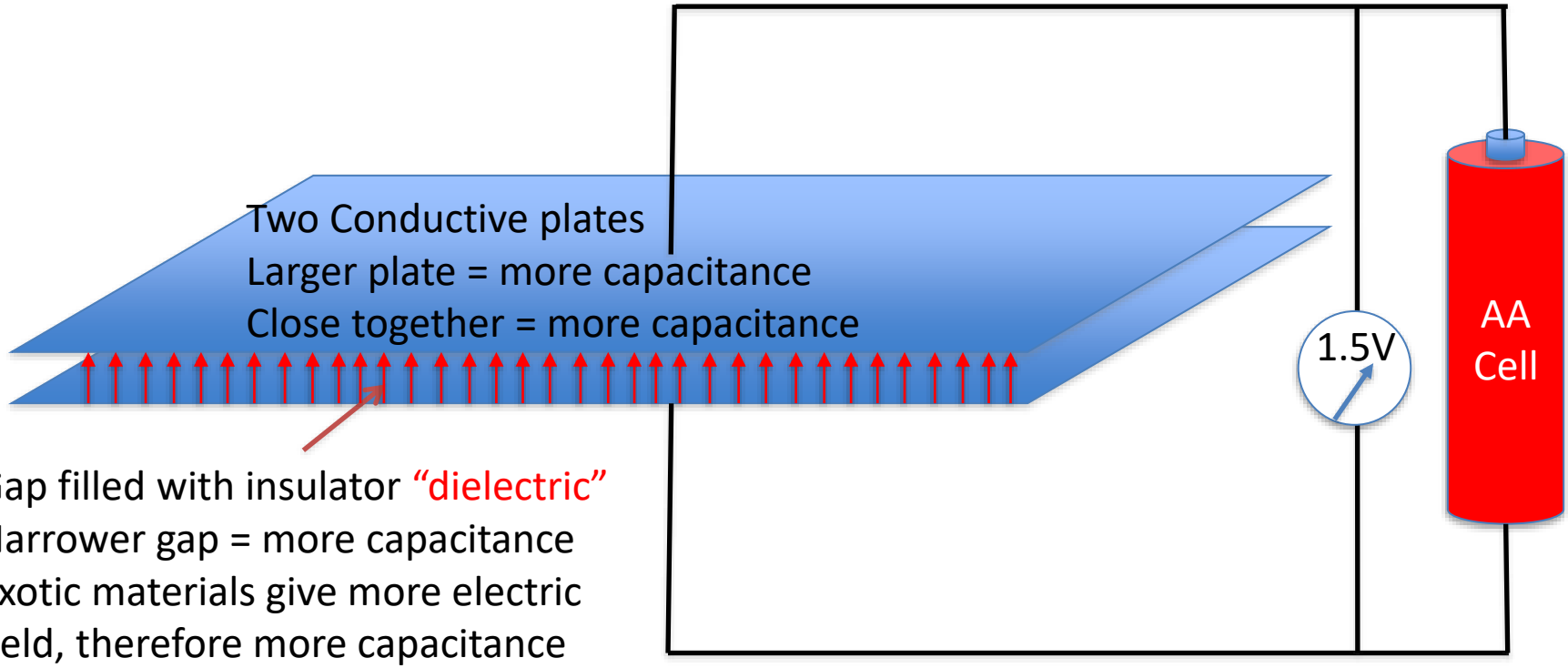
A Basic Capacitor



Gap filled with insulator "dielectric"
Narrower gap = more capacitance
Exotic materials give more capacitance than air.

When you apply a voltage, an electric field develops between the plates. {next page}

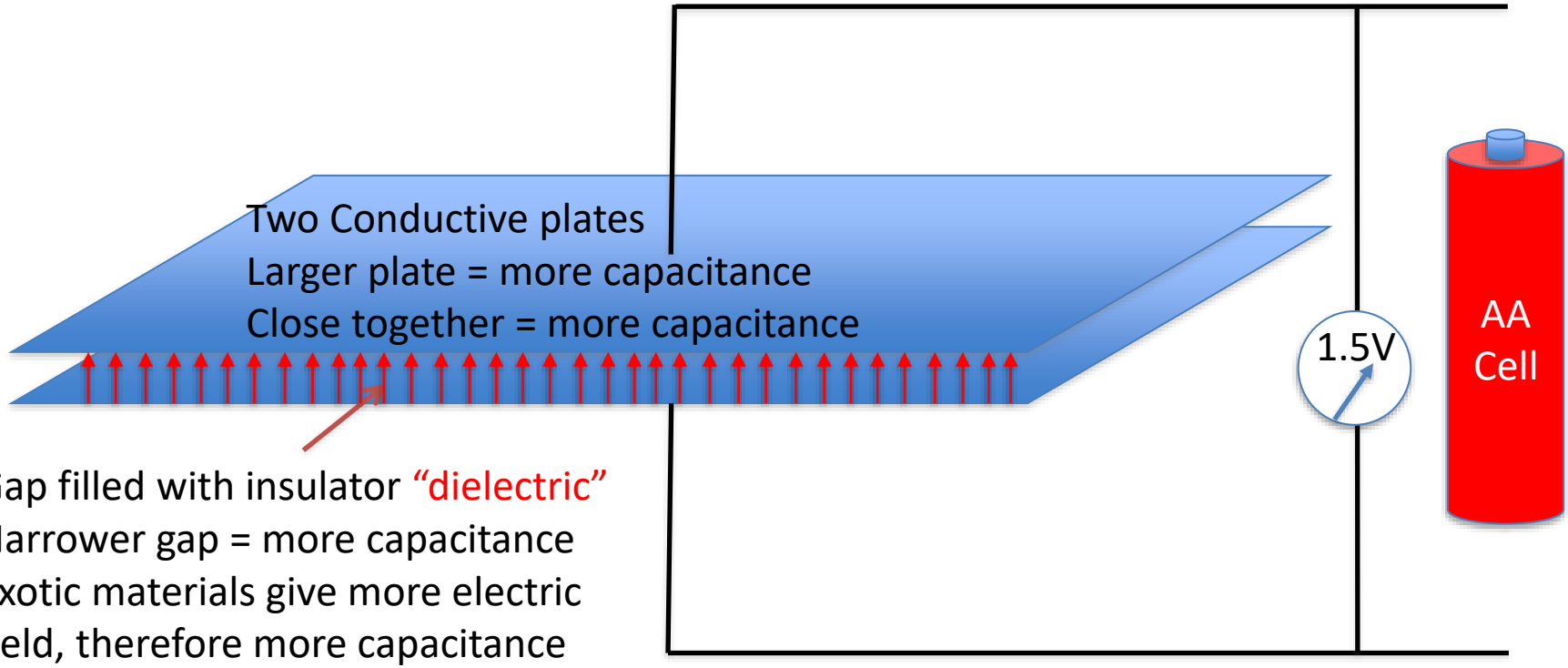
A Basic Capacitor



Gap filled with insulator "dielectric"
Narrower gap = more capacitance
Exotic materials give more electric field, therefore more capacitance than air.

When you disconnect the voltage, the electric field remains between so the voltage remains too.

A Basic Capacitor



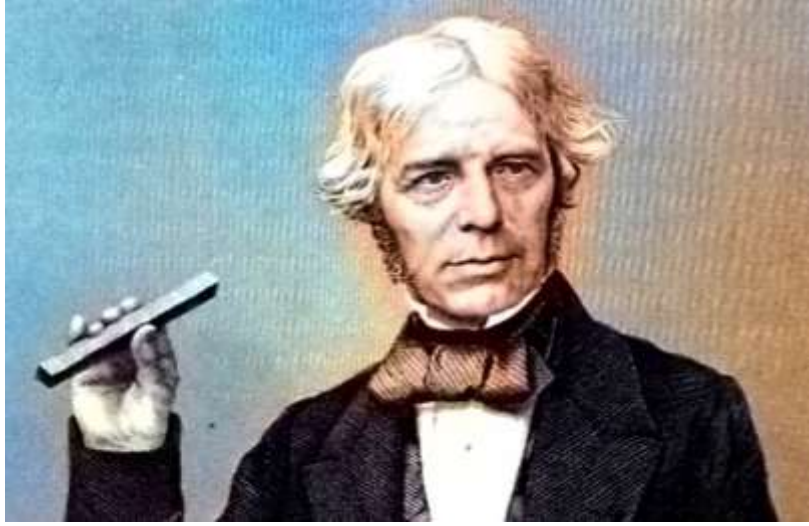
Gap filled with insulator "dielectric"
Narrower gap = more capacitance
Exotic materials give more electric field, therefore more capacitance than air.

When you disconnect the voltage, the electric field remains so the voltage remains too.

THEREFORE: *CAPACITORS CAN BE A SHOCK HAZARD.*

CHARGE ONE UP AND THE CHARGE CAN REMAIN. FOR HOURS OR DAYS.

Farads



- One of the basic descript-tions of a capacitor is that it is like a rechargeable battery.
- The amount of current that it can retain is measured by its capacitance, measured in Farad. (named after scientist Michael Faraday)
- A Farad is huge, so we usually use:
  - 1,000,000µF (micro Farad) = 1F;
  - 1,000,000,000nF (nano Farad) = 1F;
  - 1,000,000,000,000pF (pico Farad, or “puff”) = 1F.

Or, in the old days, Micro micro farad, µµF

A Basic Capacitor

The dielectric's ability to "support an electric field", or provide capacitance is called *permittivity*. High permittivity = more capacitance per unit area.

Air=vacuum=1

Plastic=2-3

Paper=2-4

Mica=3-6

Aluminum oxide=10

Tantalum pentoxide=27

Barium Titanate = 200-14000

*Capacitance (pF) = (8.854*permittivity*area)/gap (metres)*,

so a 0.1uF paper (3mil dielectric) capacitor is about the size of a piece of printing paper (before it is wound up).

Main Capacitor Characteristics

- Capacitance (in Farads, etc…)
- Tolerance (allowable capacitance range in percent)
- Maximum Working Voltage (in maximum Volts, usually DC, sometimes AC)
- Capacitors are sometimes referred to as *Condensers* in old literature.

  Capacitor = Condenser

Capacitor Characteristics

- Capacitance (in Farads, etc…)
- Maximum Working Voltage (in Volts)
- Tolerance (in percent)
- Leakage
- Series Resistance
- Inductance
- Temperature Coefficient
- Safety (how do they fail)
- Size and shape
- Polarity?

Q (function of frequency

Measures of their imperfections

There are others like dielectric absorption, microphonics, linearity that I won't go into.

Capacitor Characteristics

- Usually, you'll only find the **capacitance** and **voltage**, **polarization** (+ end and – end on electrolytic caps) maybe **tolerance**, written on the capacitor.
- In purchasing new capacitors, most of the time you do not need to worry about the other characteristics.

ELECTRICAL DESCRIPTION OF A CAPACITOR

What does a Capacitor do?

- A capacitor offers high “resistance” at low frequency and low “resistance” at high frequency.
- A series capacitor: Lets through RF, blocks audio & DC. Or lets through audio, blocks DC. ← *Blocking or DC Block capacitor*
- A shunt capacitor: Shorts AC (Audio/RF) to ground, but allows DC ← *Decoupling or bypass capacitor*

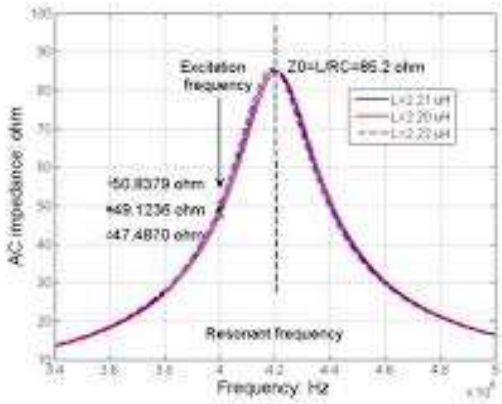
What does a Capacitor do?

- A capacitor “fights” a change in voltage across it.
- A capacitor can store a voltage for a short time, like a rechargeable battery. ← *power supply filter capacitor,* which sustains voltage between the 60Hz bumps from the rectifier.

What does a Capacitor do?

- A capacitor can work with a coil to make a sharp frequency-selective filter.
- Resonant capacitor.
- With the coils in an IF transformer, makes a frequency-selective filter.
- A variable capacitor + a coil makes a variable frequency-selective filter.

(a)



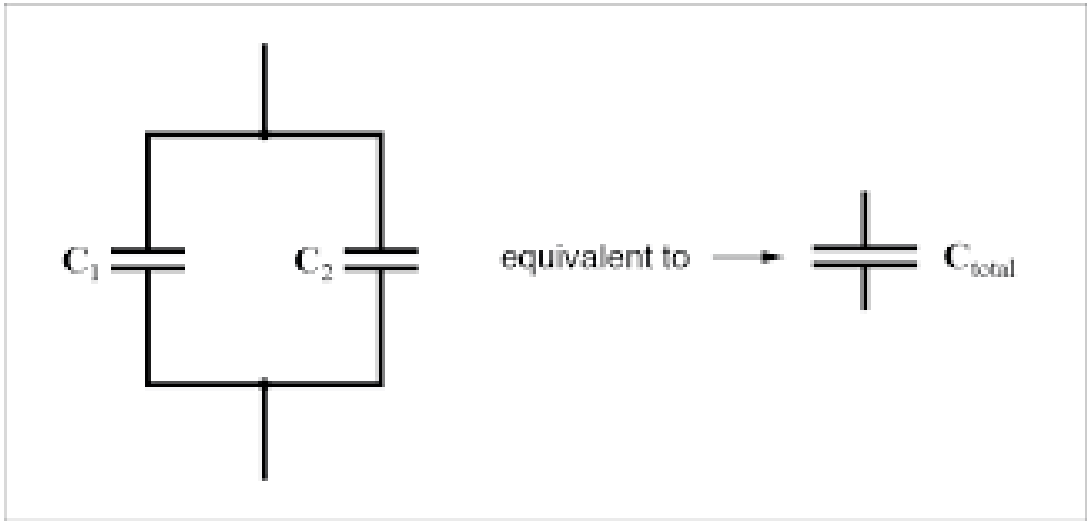
(b)

What does a Capacitor do?

- Filters out some specific frequencies. Tone control circuits.
- Prevents damaging voltage spikes. ← *vibrator buffer capacitor.*
- Controls EMI (Electromagnetic Interference). → *Line filter capacitors.*

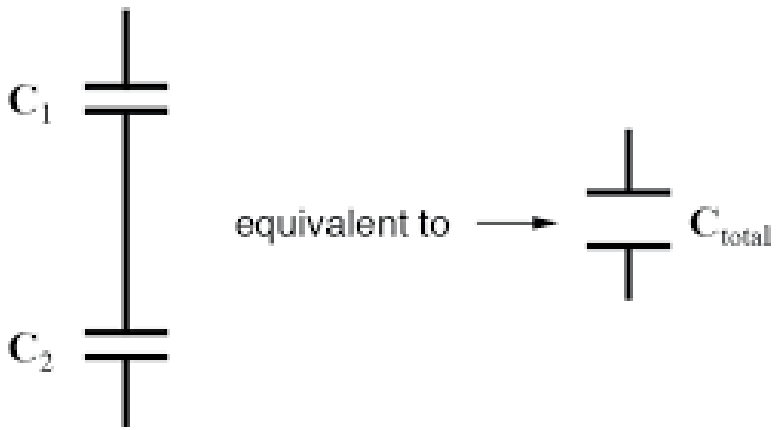
Capacitors in Parallel

- If you put two capacitors in parallel: Total capacitance is the sum of their capacitances.
- Overall voltage rating is the rating of the lowest voltage capacitor.
- So: parallel a
  - 0.1uF 200V cap &
  - 0.05uF 400V cap
  - You get a 0.15uF 200V capacitor



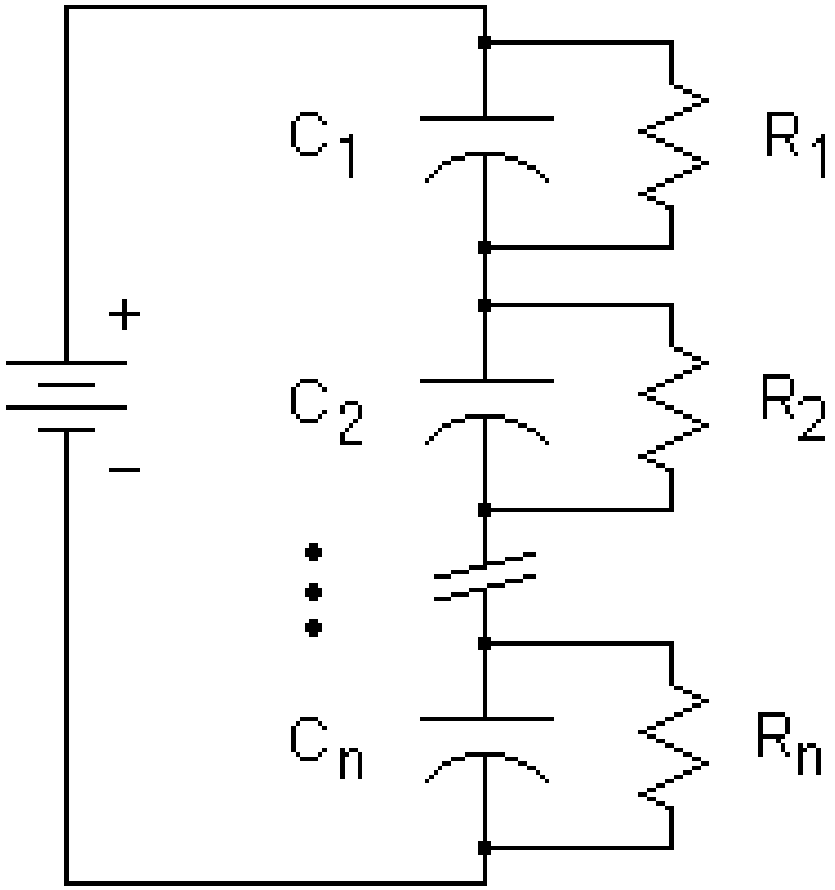
Capacitors in Series

- If you put two capacitors in series: Total capacitance is $C_{Tot} = \frac{C_1 C_2}{C_1 + C_2}$ or $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$
- Overall DC voltage rating is ambiguous, because if one capacitor is slightly leaky, then the other capacitor takes all the DC voltage.
- So: two caps in series
  - 0.1uF 200V cap &
  - 0.05uF 400V cap
  - You get a 0.0333uF 200V



Capacitors in Series

- If you need a **high voltage capacitor**, you can put 2 or more low voltage capacitors in series, but you must add leakage resistors to equalize the DC voltage across the capacitors.
- R must draw 10X more current than worst-case capacitor leakage current



HOW TO TEST A CAPACITOR

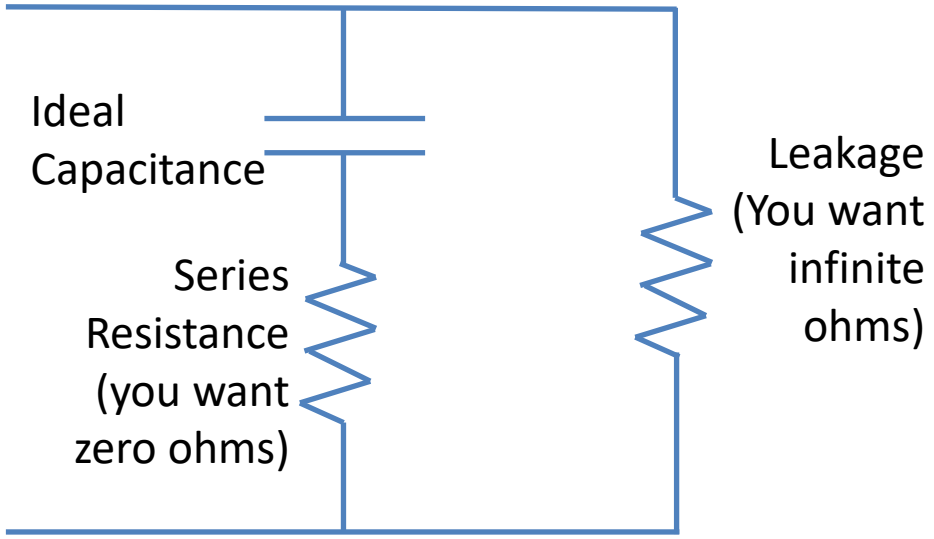
Golden Rule for Capacitors

- If a capacitor gets hot REPLACE IT. IT IS BAD.
- A good capacitor should never self-heat. (at least, not in an old radio)
- BUT some things will cause a capacitor to overheat. LIKE a shorted rectifier that places AC across an electrolytic capacitor. If a power supply filter cap is getting warm, make sure the rectifier is not shorted!
- By they way, if you can, it is best to install capacitors in cool places: away from power resistors and tubes. They'll last longer and leak less.
- Resistors can get hot. But if a resistor is getting *too* hot, the problem might be a capacitor.

3 Capacitor Tests

- Leakage (resistance, or current at a certain voltage). Ideally should be zero leakage.
  - Paper caps and electrolytics.
- ESR (Equivalent Series Resistance) Is there some resistance in the way?
  - Most relevant for electrolytics.
- Value (how many Farads)
  - Value of caps usually doesn’t change much unless it is catastrophic.

Real Capacitor Model



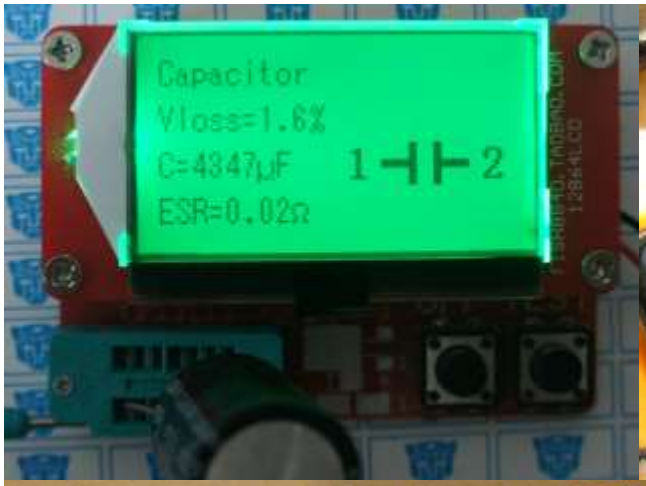
Testing Capacitors

- Capacitor tester will determine value, maybe leakage.
- ESR tester will determine series resistance. (Mainly relevant to electrolytics)
- Ohmmeter can determine if the capacitor is leaky, but a high voltage capacitor leakage tester is better. Some capacitors leak much more at high voltages.
- In-circuit: measure leakage current thru the capacitor with an ammeter. (look for under 0.1mA for an electrolytic, but under 1µA for a blocking cap.)
- **Often, an in-circuit test is easier than a capacitor tester.**

Practical: Testing Capacitors

- Look for physical damage. Melted wax, ends popped out, cracks, bloating.
- If you can measure leakage in-circuit, that's the best way. (I'll show you later)
- Or, unsolder one lead and measure current with a high voltage applied.
- Usually, don't worry about measuring capacitance or ESR. Place a known good capacitor in parallel with the suspect capacitor in situ, look for improved performance.

Capacitor Testers



Capacitor Testers

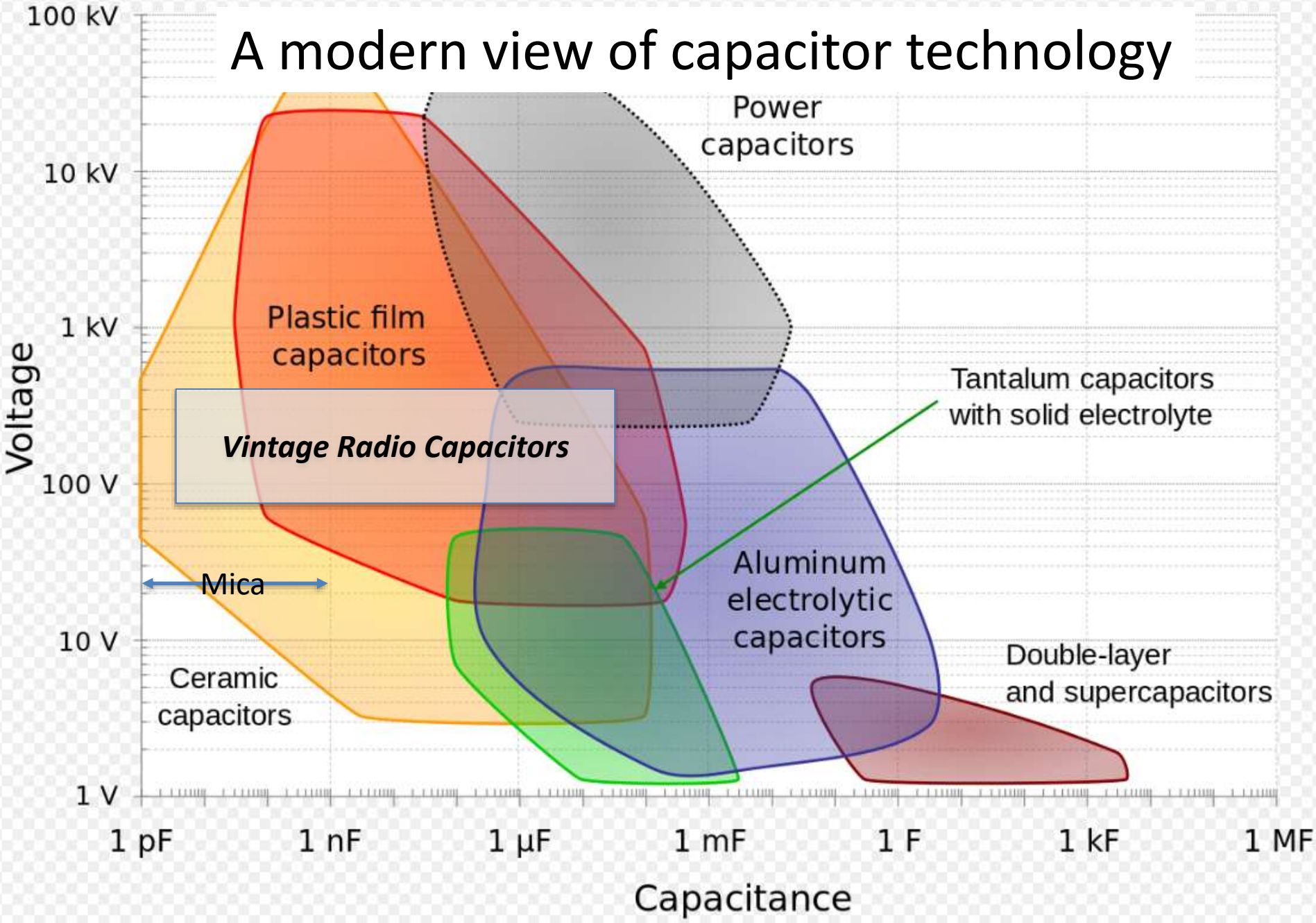
- There are all-in-one digital testers available cheaply on-line from China (but I do not have one!). Club members have had good experience with them. Most also do diodes, resistors transistors, inductors, etc.
- Some DMMs have a capacitance function.
- Capacitor bridges can measure value accurately.
- Eye-tube leakage testers.
- Many ESR testers available on-line
  (I made my own see: http://rabjohn.ca/data/documents/A-simple-ESR-meter-short.pdf).
- Peak Electronics (UK) has a nice one.

TYPES OF CAPACITORS

Types of capacitors

- Air-dielectric variable (usually under 0.001µF)
- Trimmer (variable with screwdriver)
- Mica (usually under 0.001µF)
- Paper (usually 0.001µF to 1µF) ← Obsolete, but very common in our radios!
- "Plastic film" (usually <1µF)
- Ceramic
- Electrolytic (usually >1µF)
  - Wet; "Dry"; Tantalum

A modern view of capacitor technology

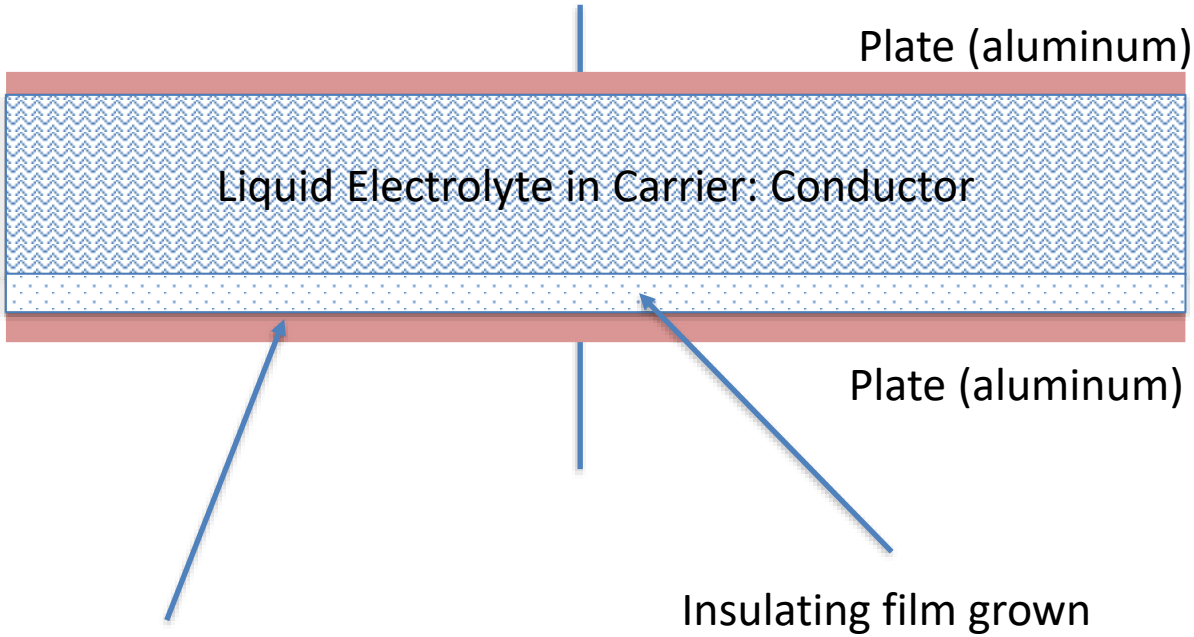


A “**Crap**acitor”

Electrolytic

- High value (# of microFarads), high density (Farads per pound). Generally >1µF.
- Polarized (polarity of DC voltage across them matters, must be correct, otherwise they explode!)
- Usually power supply filter capacitors. Also cathode resistor decoupling.
- Wet, “Dry” (which is not really dry), Solid Aluminum, Tantalum (Niobium)

Electrolytic Capacitor



Surface may be roughened up to increase surface area and therefore density.

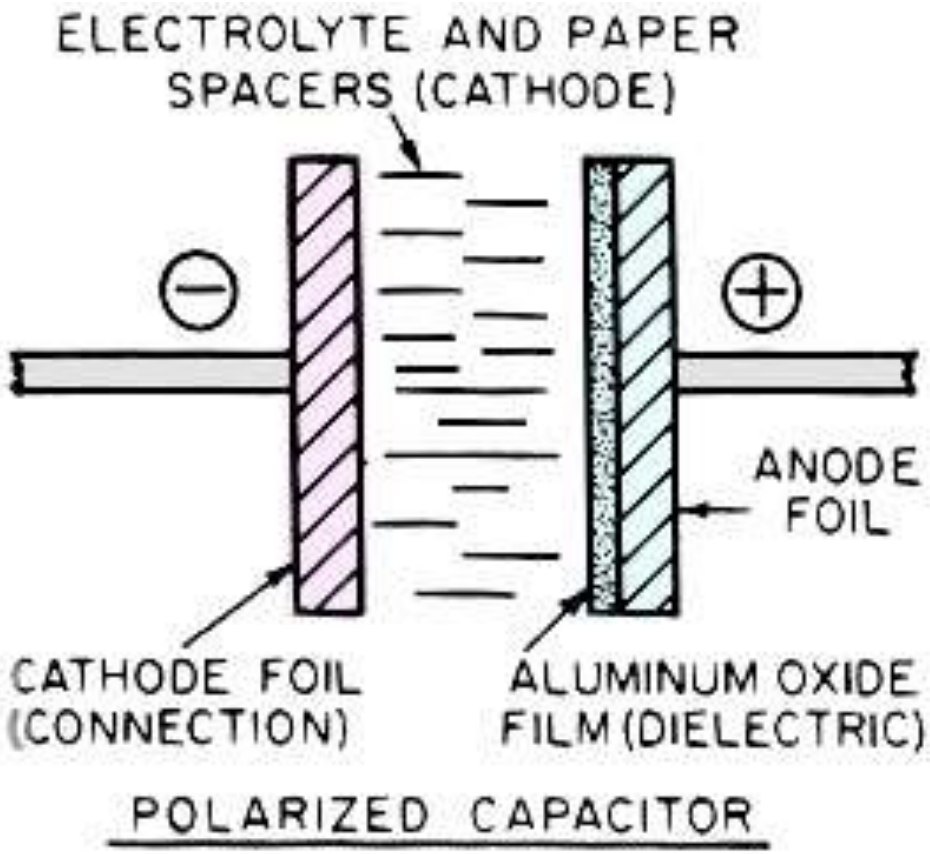
Insulating film grown on electrode. THIS is the insulator.

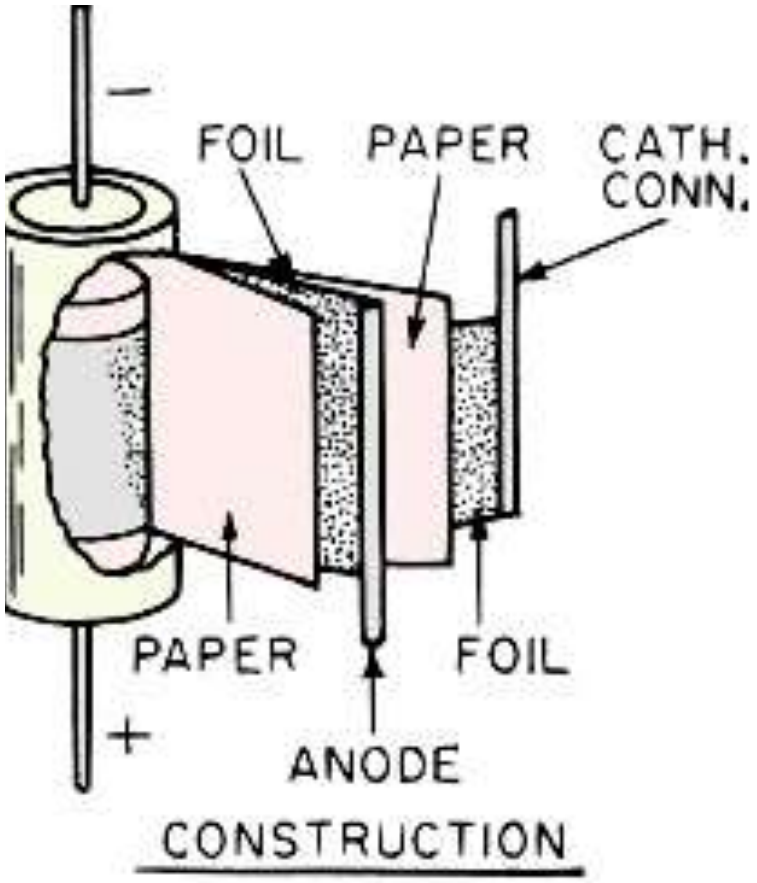
Wet Electrolytic

Entirely unreliable.
Entirely obsolete.
1-20uF, high voltage, for power supplies.

Leyden jar:
Circa 1745

“Dry” Electrolytic





“Dry” Electrolytic

Not very reliable. Tend to dry out and lose capacitance. Large value capacitors, polarized. Mostly used in power supplies.

Can sometimes be rejuvenated.

Not really “Dry”

“Modern” Dry Electrolytic

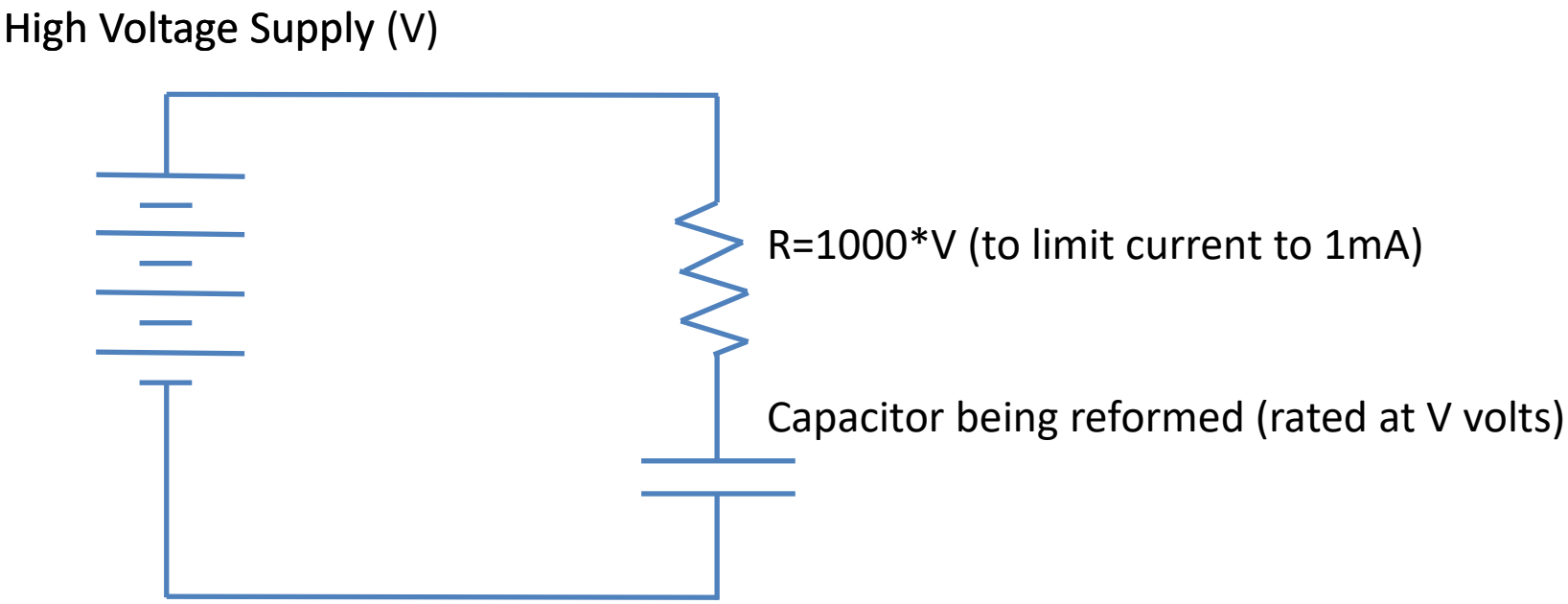
Still not very reliable, especially when warm. Often rated for 1000 hours (just over 1 month) at 85C. Can lose capacitance. Can corrode other nearby parts.

Can sometimes be rejuvenated.

Not really “Dry”

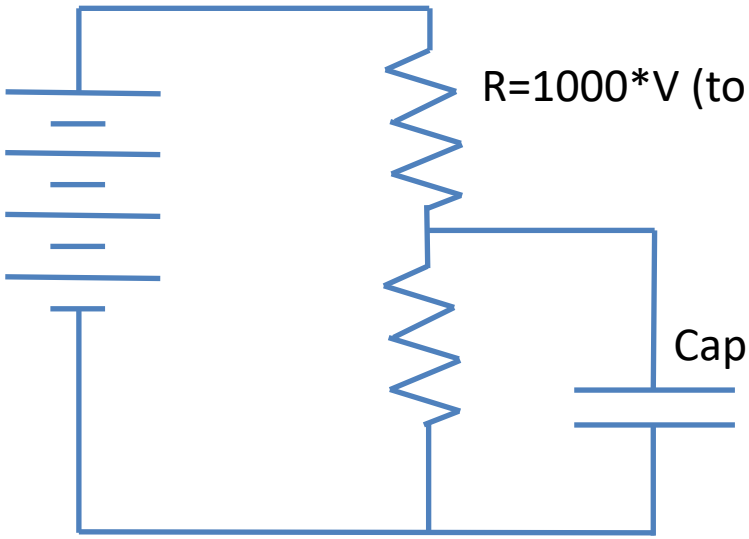
Reforming Electrolytic Capacitors

You may be able to “fix” a leaky electrolytic capacitor. (It will not fix ESR or capacitance loss!)
You are doing this when powering on an old radio slowly (variac)



Reforming Electrolytic Capacitors

High Voltage Supply (V)



R=1000*V (to limit current to 1mA)

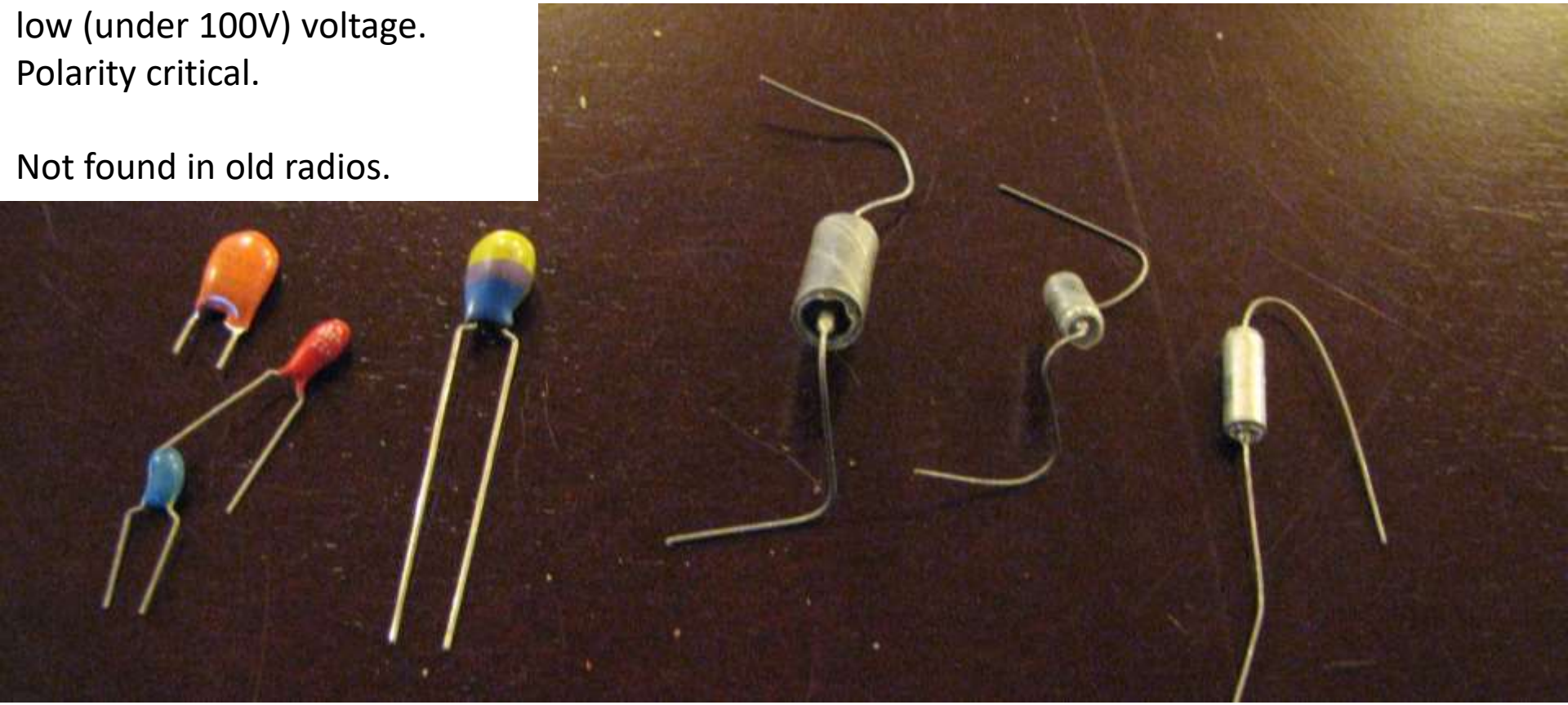
Capacitor being reformed (rated at VC volts)

R=1000*V*(VC/(V-VC))

Tantalum (truly dry)

Variable reliability. Glass sealed units are quite reliable. Tear-drops are not. Tend to fail to a short circuit. 1-100uF, generally low (under 100V) voltage. Polarity critical.

Not found in old radios.



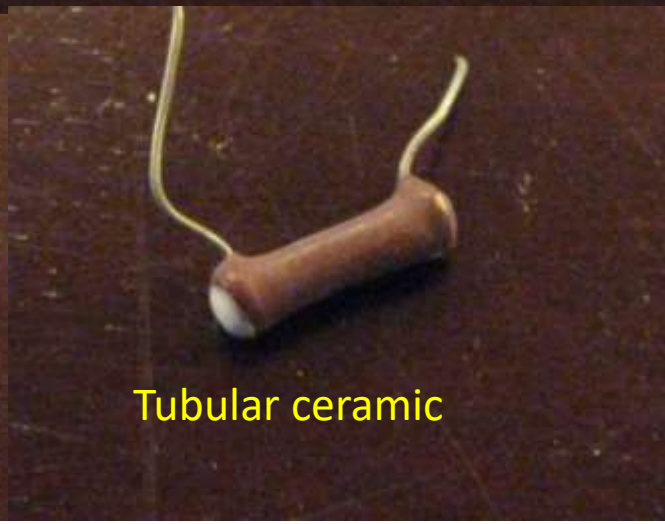
Ceramic Capacitors

- Handles soldering temperatures very well, so are widely used in chip form on circuit boards.
- Simple dielectrics (Aluminum oxide and related compounds) can make very good capacitors.
- Exotic dielectrics (Barium Titanate and related materials) can make very dense, high value capacitors.
- Exotic materials have quirky characteristics. Capacitance depends on voltage, on temperature, and can be microphonic.

Induce audio noise into your circuit when vibrated

Disc Ceramic

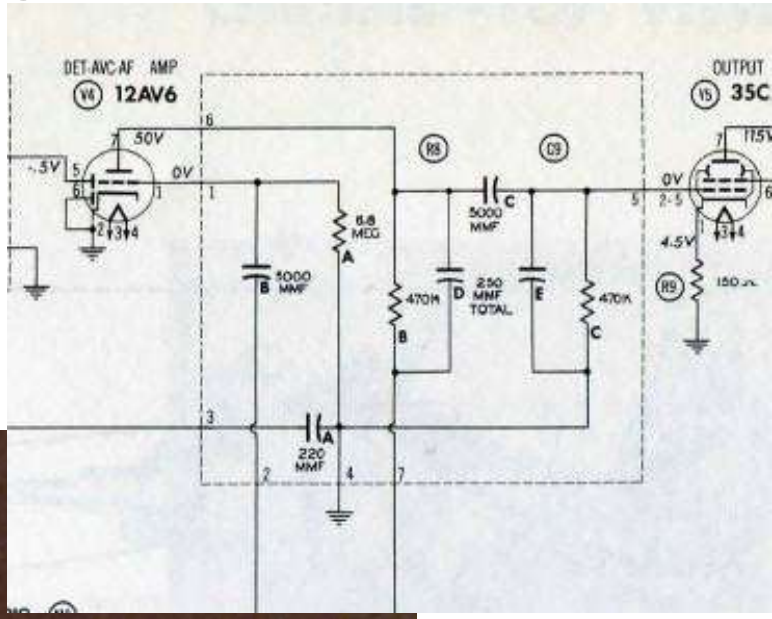
Reliable, mainly under 0.1µF. Often used in RF circuits. Can handle high voltage. Low values are good capacitors, high values can have odd characteristics.

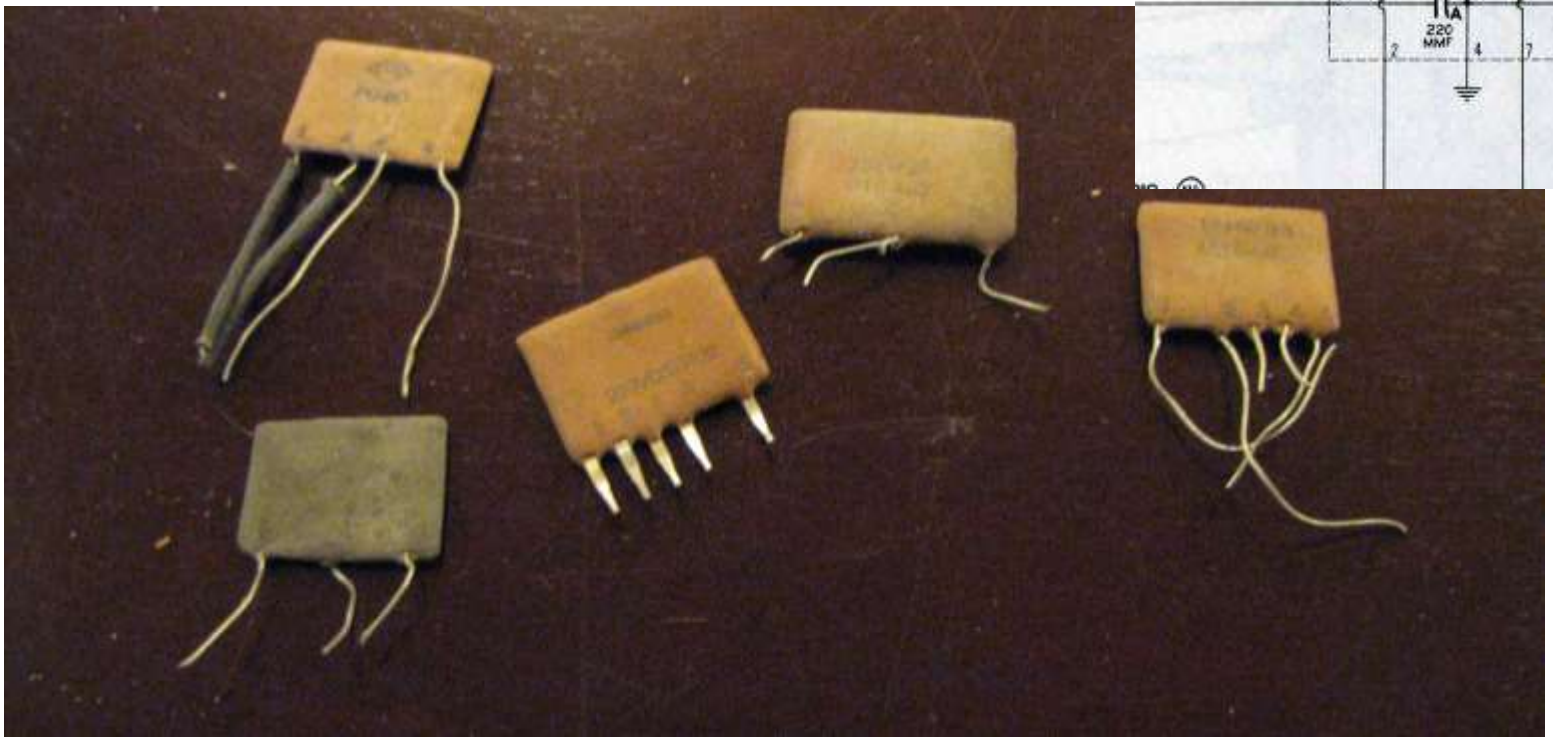


Tubular ceramic

Couplates

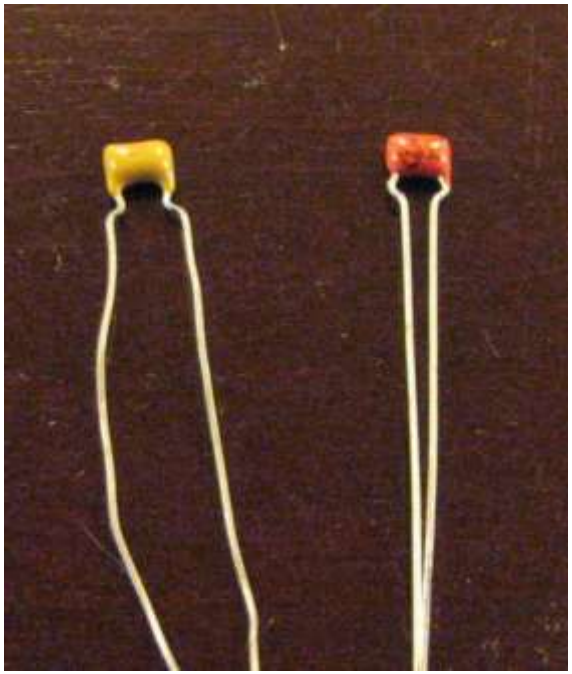
Capacitor (ceramic) and resistor networks on thick-film substrates. Reliable. Can be found in AC-DC sets from the 50's.

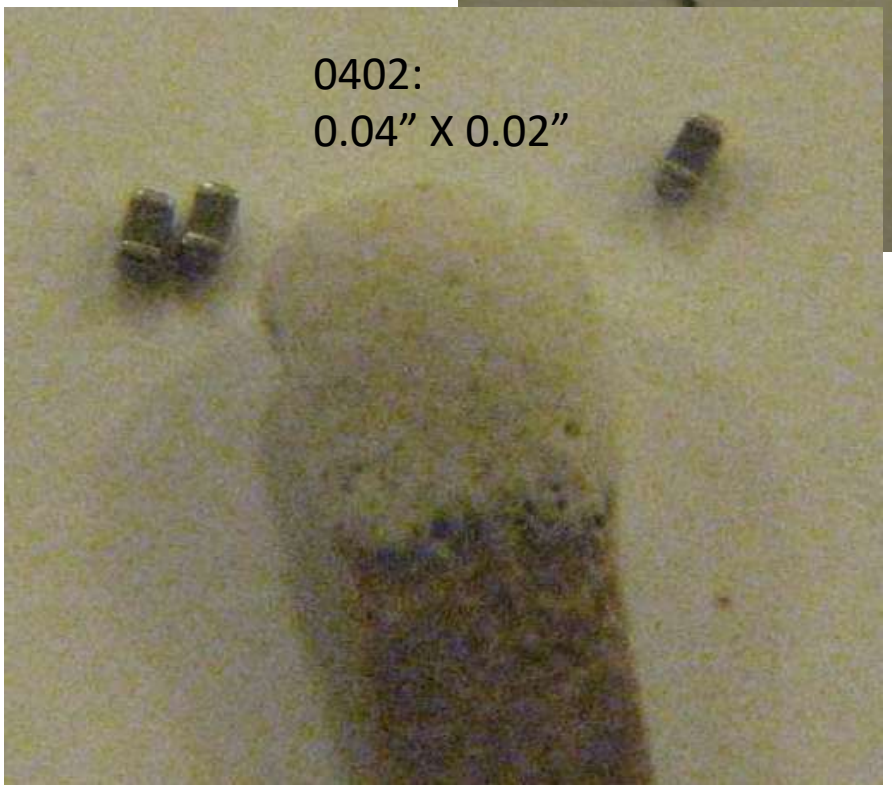




Multilayer Ceramic

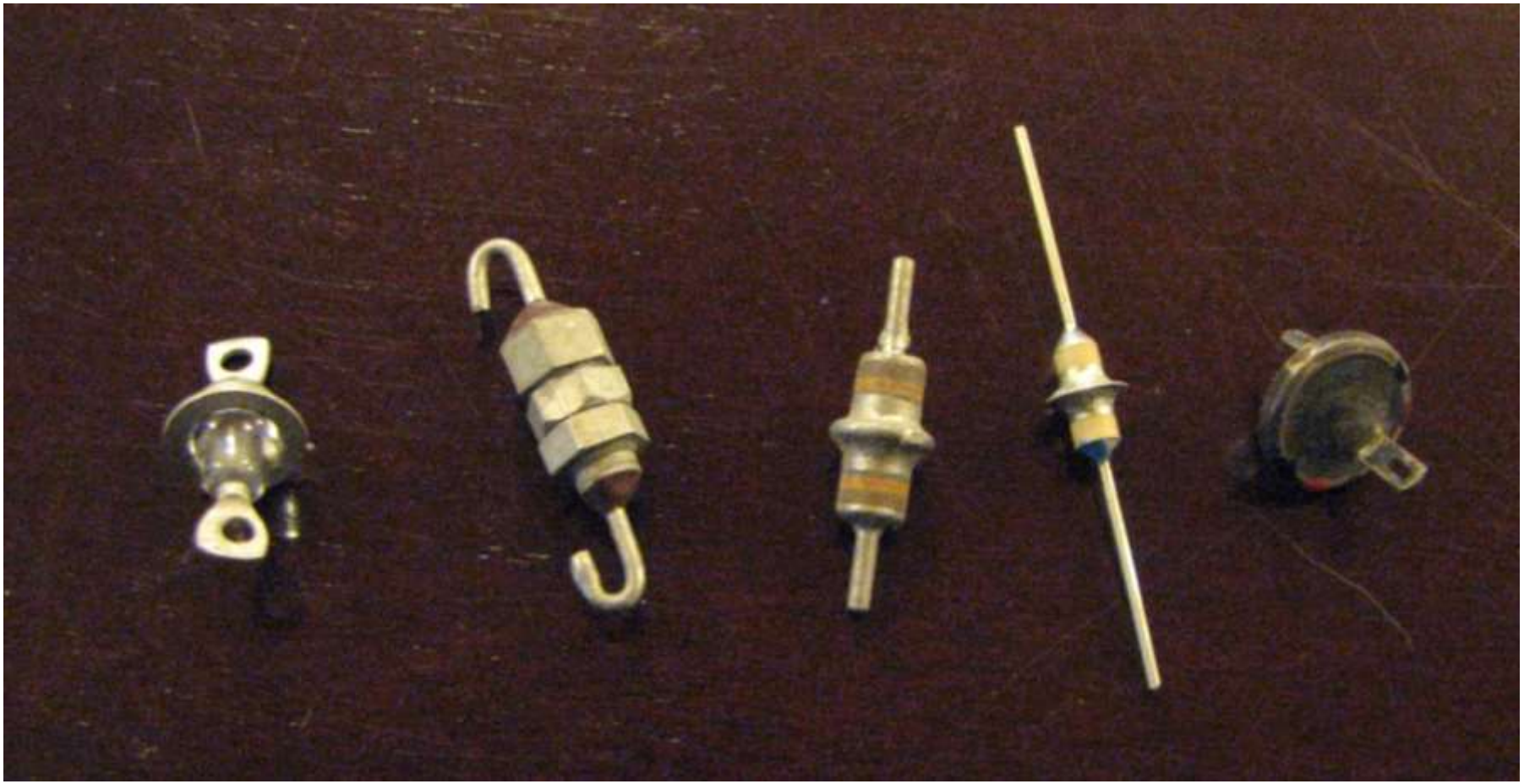
Reliable, modern. Very dense, the most common type of capacitor in today's electronics.





Feed-through Capacitors

Reliable, usually ceramic.
Provides a capacitance to ground. Decoupling.
Part of a RF shielding strategy.

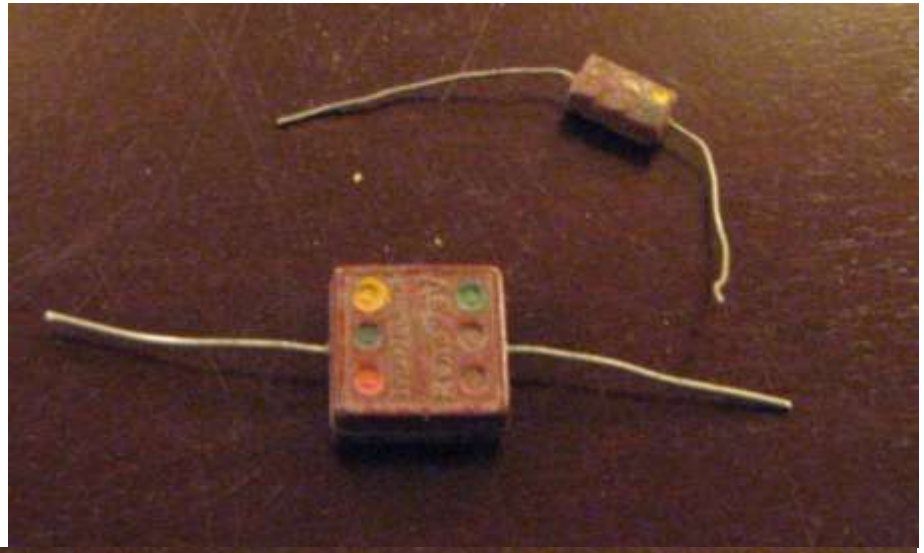


RF Capacitors

- Mica
- Air dielectric (usually variable)
- Trimmer
- Ceramic capacitors can also be excellent at RF. Can have specific temperature coefficients.
- Generally very reliable. (Mechanical problems)

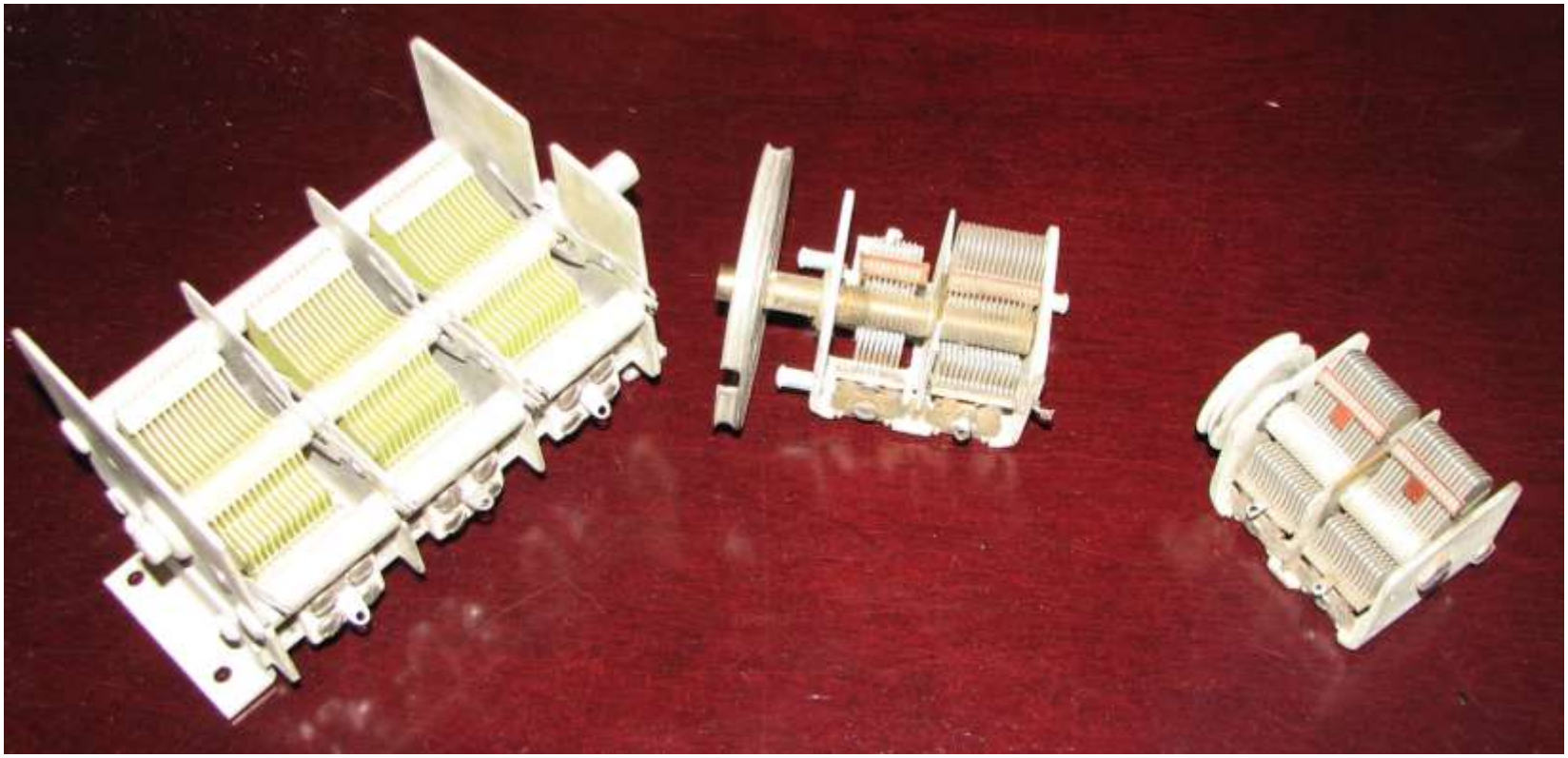
Mica, Silvered Mica

Reliable, mostly low value (under 1000pF, though larger ones are available). Good tolerance, used for RF circuits.



Variable

Usually under 1000pF



Variable: Trimmer

Under 1000pF

Air Variable Trimmer

Ceramic Trimmers

Compression Trimmers

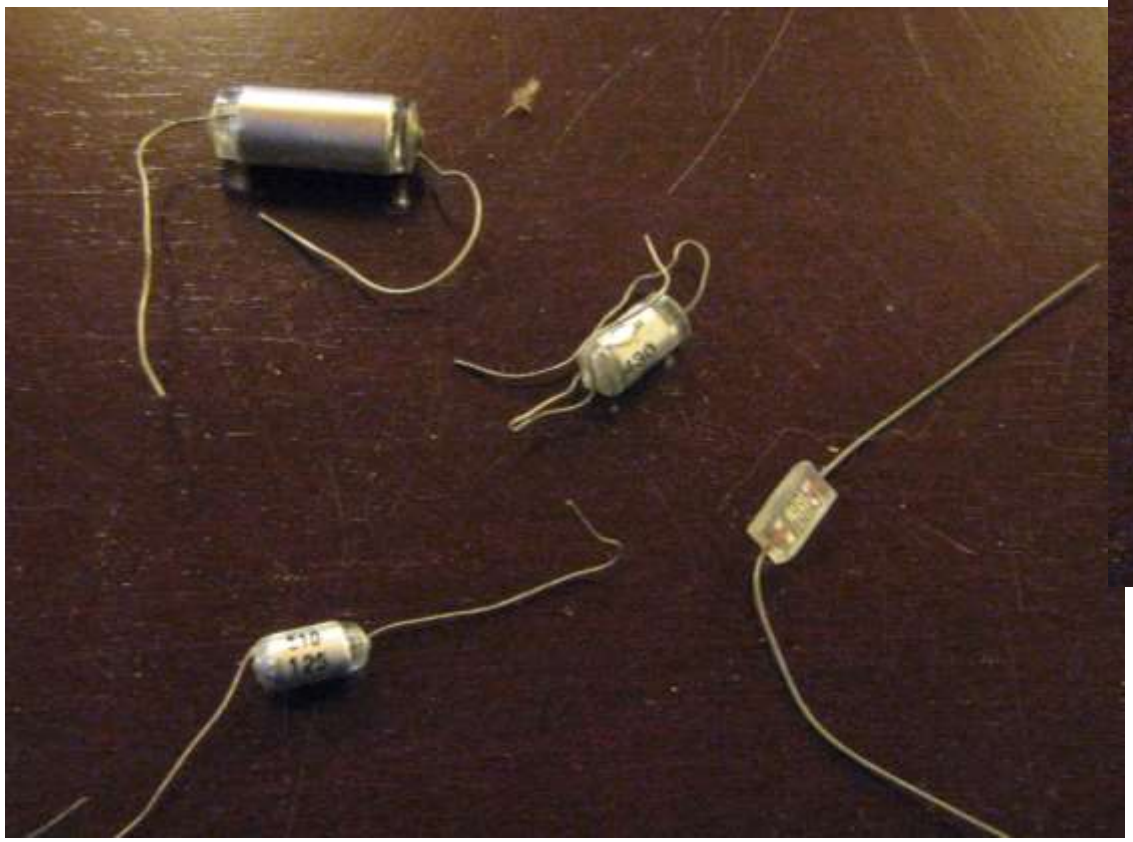
“Plastic” Film (polymer) Capacitors

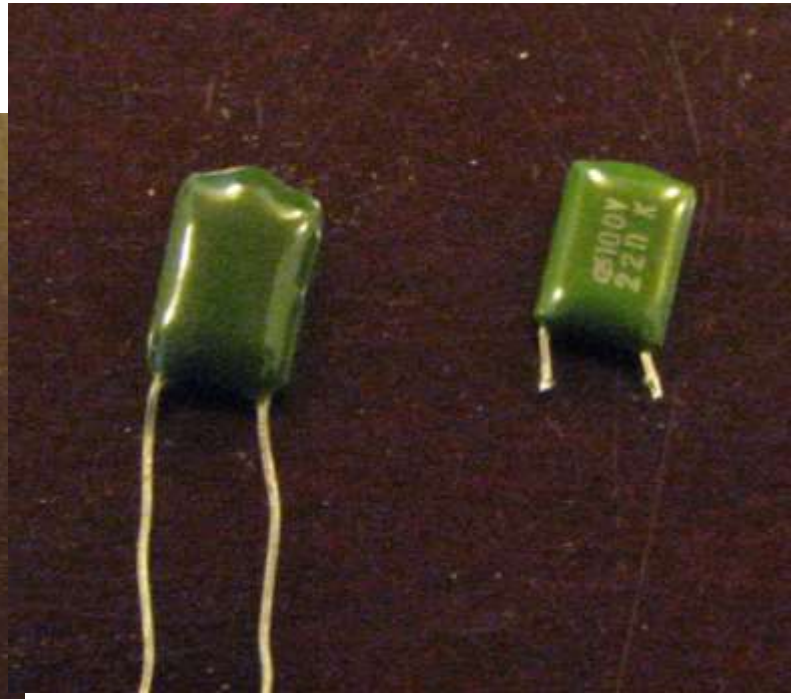
- Reliable. Excellent replacement for a paper cap.
- Polyester (a general term)
  - Polyethylene
  - Mylar=a polyester of Polyethylene
- Polycarbonate
- Polypropylene
- Polystyrene
- Preferred by audiophiles!
- Teflon (actually a fluoropolymer) ←$

Film

Reliable, modern, a variety of voltages and sizes. Good characteristics. Ceramic better for soldering temperatures.

Polystyrene





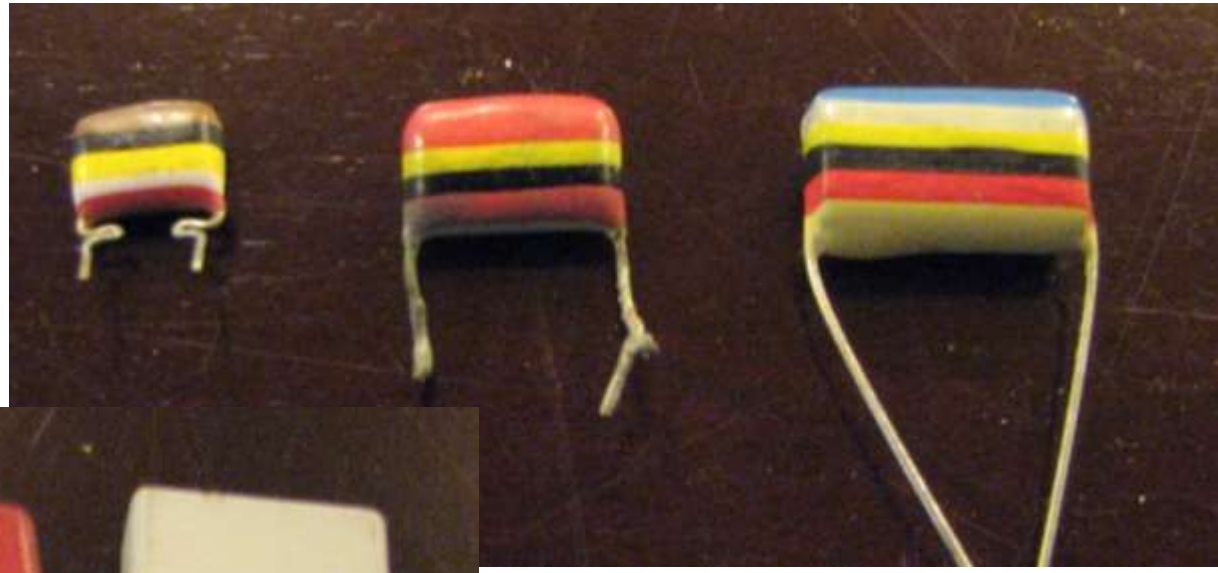
Mylar

Film Capacitors

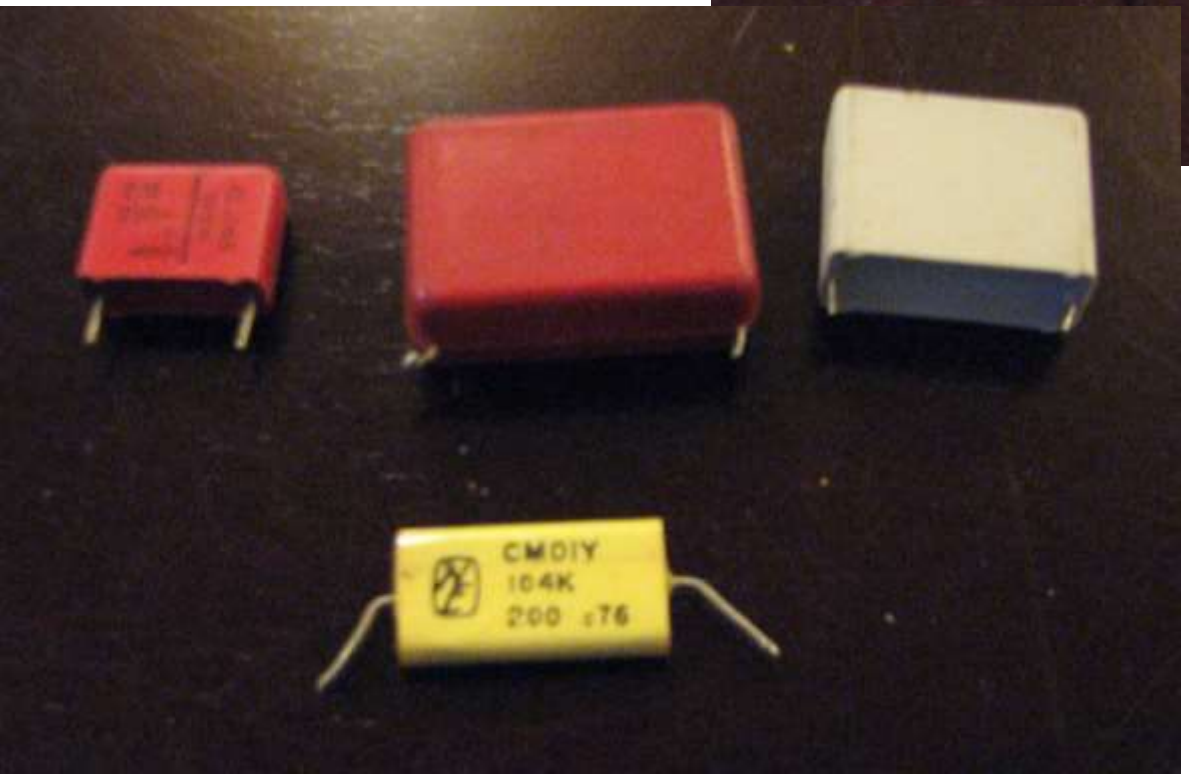
- Polyester Film
- Polypropylene (PP) Film
- PTFE/Teflon Film
- Polystyrene Film

Film Capacitors

Reliable, modern, a variety of voltages and sizes. High values with good temperature characteristics.



Metalized Polyester Film



Metallized Polyester or Polycarbonate Film

Paper Capacitors

- Wax or oil impregnated paper forms the dielectric.
- Obsolete
- Poor tolerance
- Poor reliability
- Wax or tar sealed are the worst. Plastic or glass sealed are better.

Paper Capacitors

Not reliable.
Air pockets can cause local discharges that can result in a short or leakage. Mechanical problems can cause opens.

Bathtub Capacitors

Usually paper (or oiled paper) inside
Generally higher voltage.

Shi-shi Capacitors

- Black Beauty (paper, but well sealed)
- Bumblebee (same as black beauty)
- Not Reliable!
- Orange Drop (polyester)
- Are sought after by audiophiles and guitar amplifier enthusiasts. More later…

Outside Foil

Some capacitors have a marking that tells you which terminal connects to the “outside foil”. This is not a polarity (+, -) marker; polarity does not matter for paper capacitors.

Outside Foil

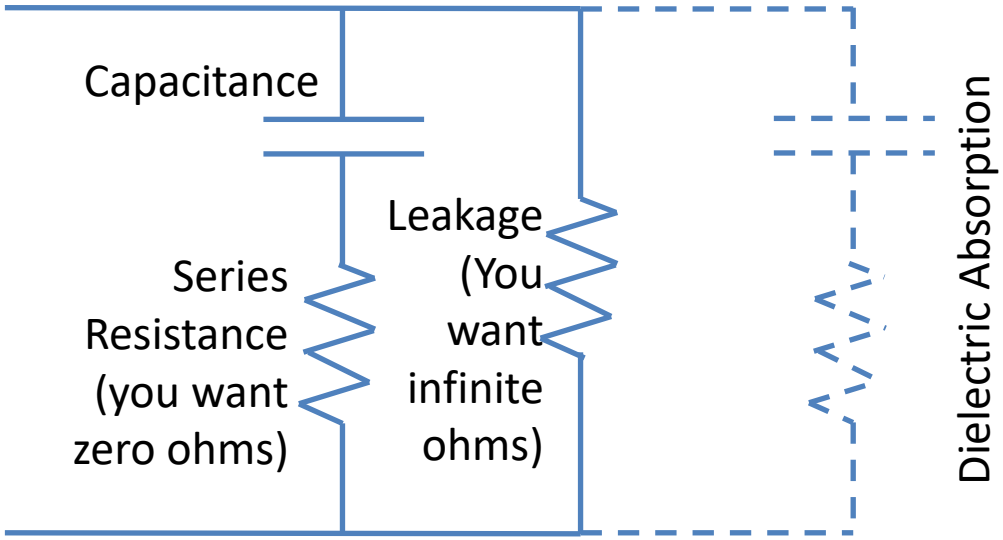
- The outside foil (external plate), being on the outside of the capacitor, can couple to other circuits unintentionally. The inside foil is shielded from the outside world by the outside foil.
- If one terminal of the capacitor is grounded, ground the outside foil.
- If one terminal “sees” a higher impedance than the other, the lower impedance terminal should be connected to outside foil.
- Usually does not matter very much.

FAILURE MODES

Electrical Failure Modes

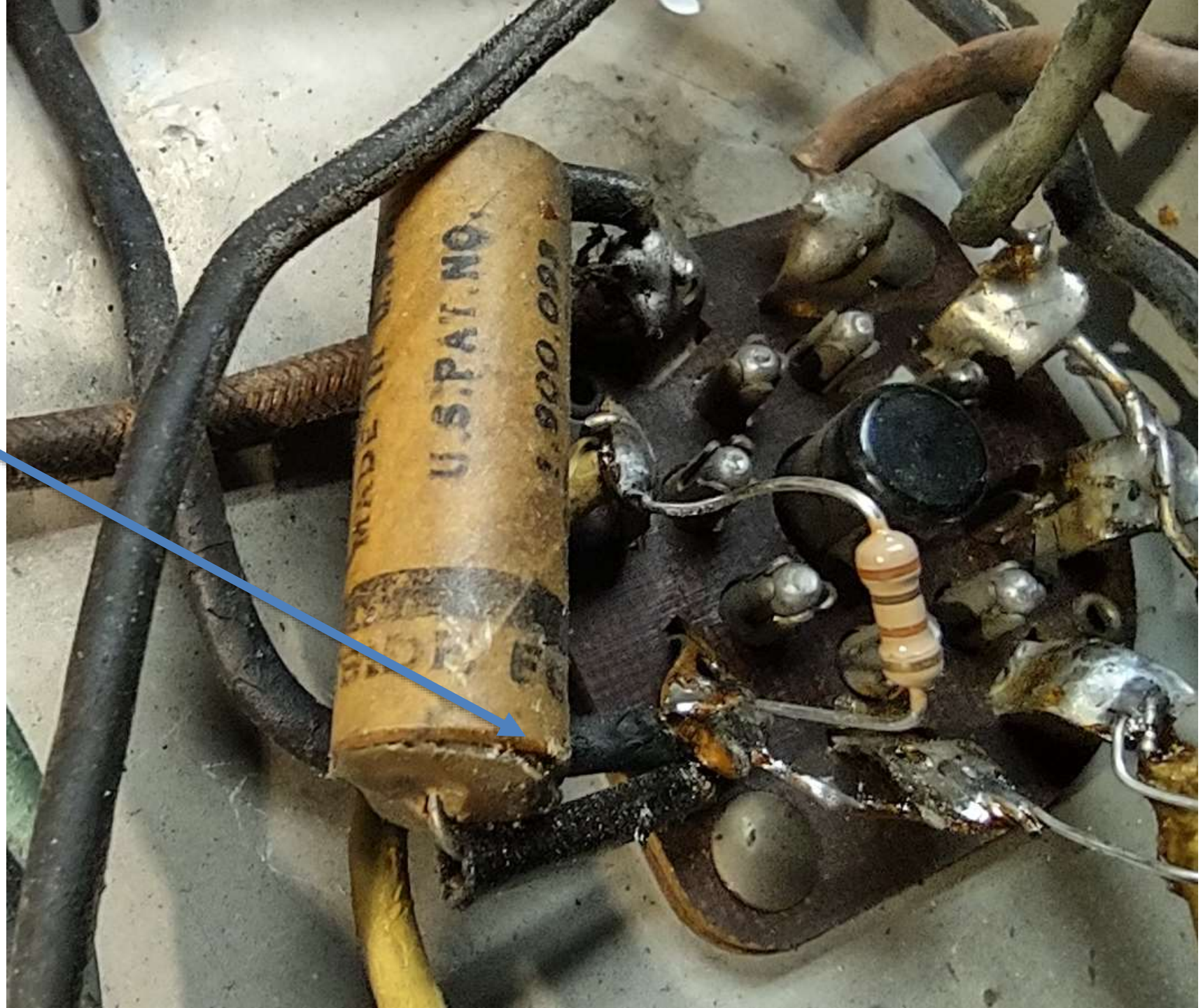
- Electrical Loss (Energy Dissipation)
  - Effective Series Resistance (ESR) increase (looks like an increase in resistance in **series** with the capacitor). ← mainly electrolytics.
  - Leakage current increase (looks like a resistance in **parallel** with the capacitor).
- Loss of capacitance.
- Depressed breakdown voltage. Leakage may appear only at high voltage.
- Noise

Electrical Failure Modes



Electrical Failure Modes

- Generally, the dielectric (insulator) is the problem.
- Paper dielectric is not uniform; locations with high field could damage paper.
- If moisture gets into the capacitor, leakage can occur in the dielectric. This leakage can carry ions with it, eventually causing a metallic path to be “electroplated” thru the dielectric.
- Connection to the plates can open up.


U.S.PAT.NO.

Noise

- A leaky capacitor can induce a crackling noise.
- An intermittent capacitor can be difficult to find.
- Capacitors can self-heal (high current through a shorted section causes the metal to vaporize), but that can result in a noisy capacitor.

Variable Capacitor Failure Modes

- Bent plates cause intermittent shorts
- Dirt in plates cause intermittent shorts
- To diagnose: place a high voltage (with a current limit, like a light bulb) across the capacitor and rotate it, look for sparks where the plates are shorting.
- Fixing a short in the middle of a stack may be tough. Try sliding stiff plastic into the gap.
- Dirt in bearings/sliders cause variable ESR.

Electrolytic Capacitor Failure Modes

- In a good capacitor, the dielectric is formed by an oxide grown on one of the electrodes. This oxide can degrade with time but can also be rejuvenated.
- Electrolyte dries up, causing increased ESR

CAPACITORS IN THEIR ELEMENT

- I’ll try to answer:
  - What symptoms are caused by a bad capacitor
  - What to look for in a replacement
  - How to test in-circuit
- It all depends on where the capacitor is used

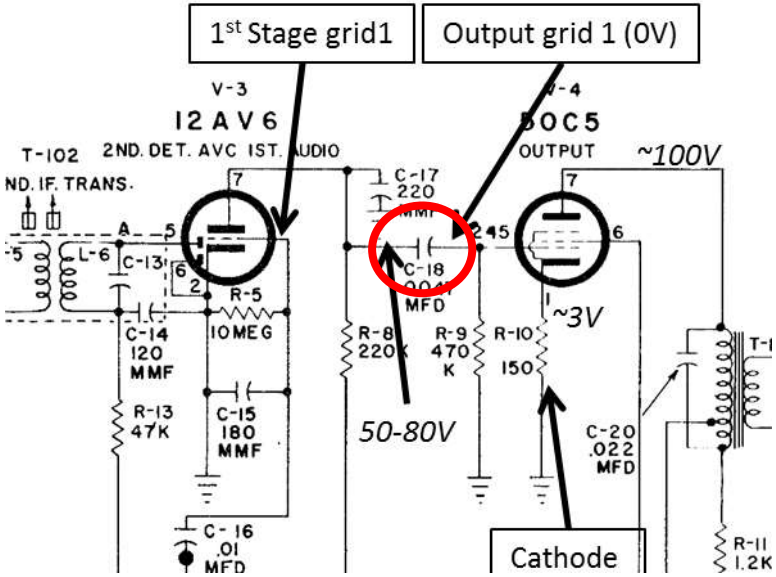
- **DANGER HIGH VOLTAGE. CAN BE LETHAL.**

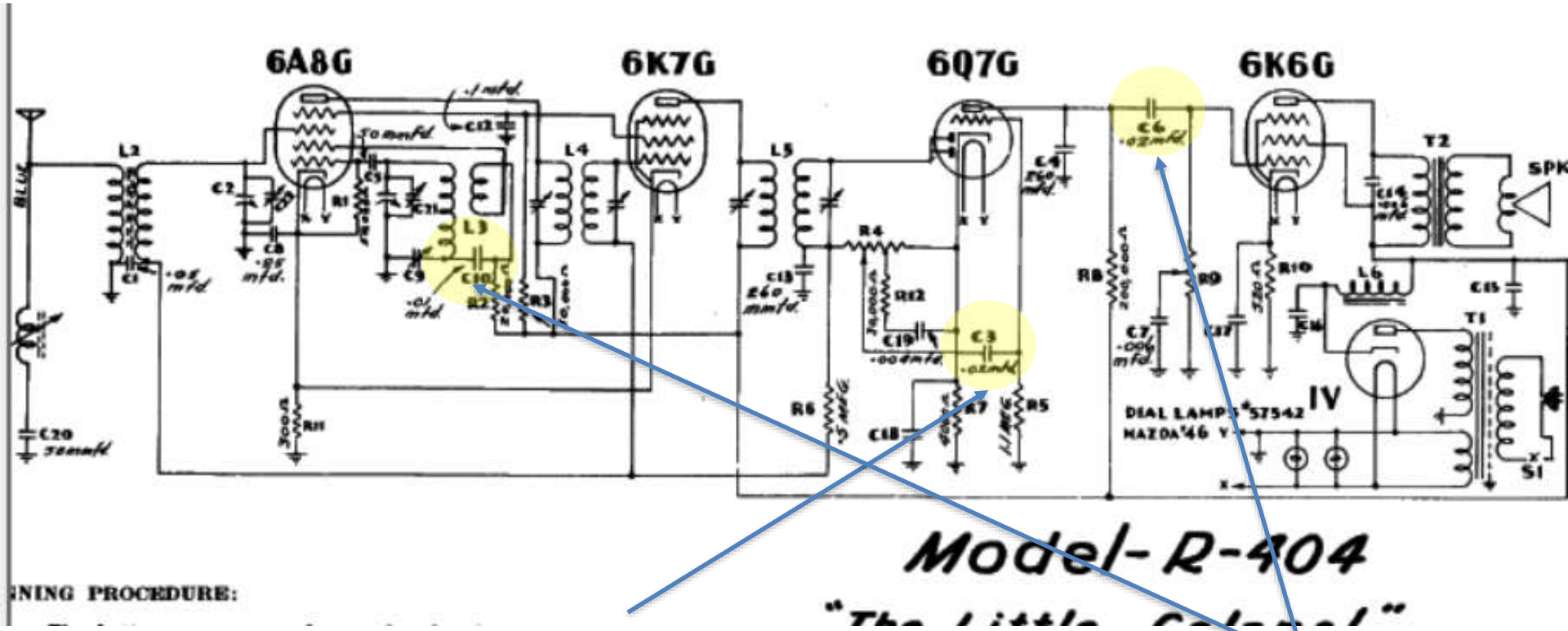
DC Block

- If the capacitor goes open or loses value, then audio will not get through or be very weak.
- If the capacitor is leaky, the power output tube will be biased too high, take too much current and get too hot, and audio may be distorted.
- Can often be tested for leakage in-circuit
- Replace with a film capacitor of a similar or greater value. Value not critical. Watch voltage.

Blocking Capacitors

- Blocking Capacitors
  - Measure voltage across R-9 Must be under 1V.
  - Value generally not critical. Doubling the cap is OK.
  - If it is open: no Audio. Place a good capacitor in parallel to see if audio returns.

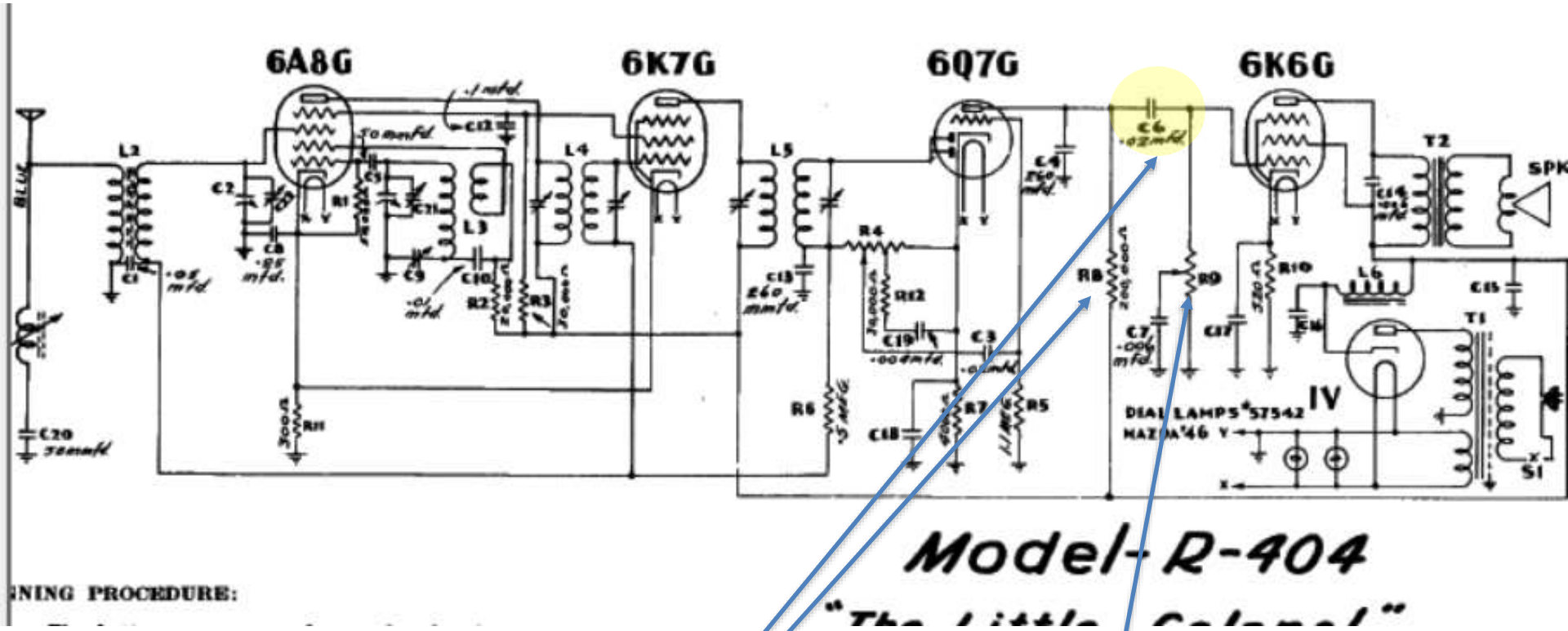




Very low voltage, leakage not a big issue.

This one MUST NOT LEAK.

These are all Blocking Capacitors

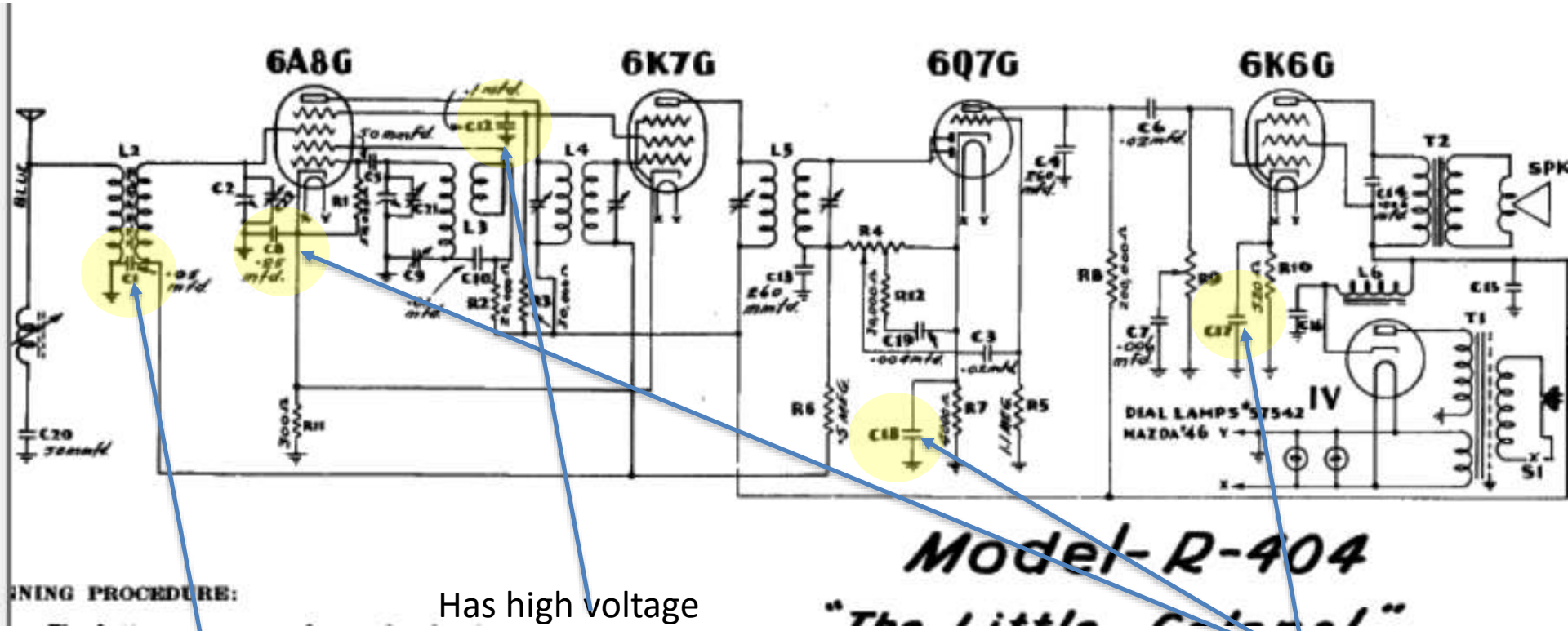


Measure voltage across R8 with the 6Q7G removed. It should be under a half volt. If not, replace C4 and/or C6.

Measure voltage across R9. It should be under a half volt. If not replace C6.

Decoupling (Bypass) Capacitors

- Keeps audio or RF (AC) from leaking from stage to stage through the power supply.
- If the capacitor goes open or loses value, then you can get feedback or whistles.
- If the capacitor is leaky, it can drop voltage to tubes, can cause resistor or rectifier overheating.
- Can often be tested for leakage in-circuit. Test for value by shunting it with a good cap.
- Replace with a film capacitor of a similar or greater value. Value not critical. Watch voltage.

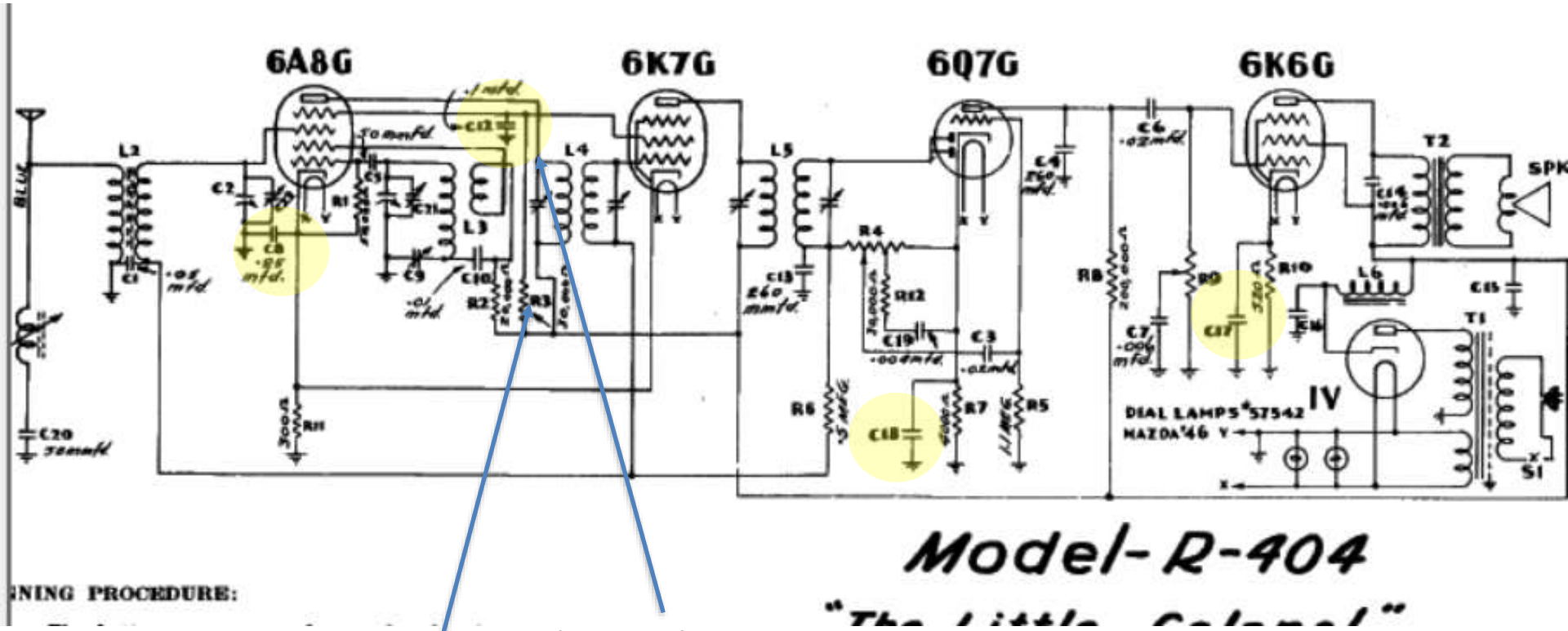


Just has AGC voltage across it, is not stressed much, but if it fails, radio will whistle or “motorboat” (a slow oscillation)

Has high voltage across it, so they tend to fail. If open, expect whistles as you tune.

Shunted by a resistor, so a bit of leakage is not a problem.

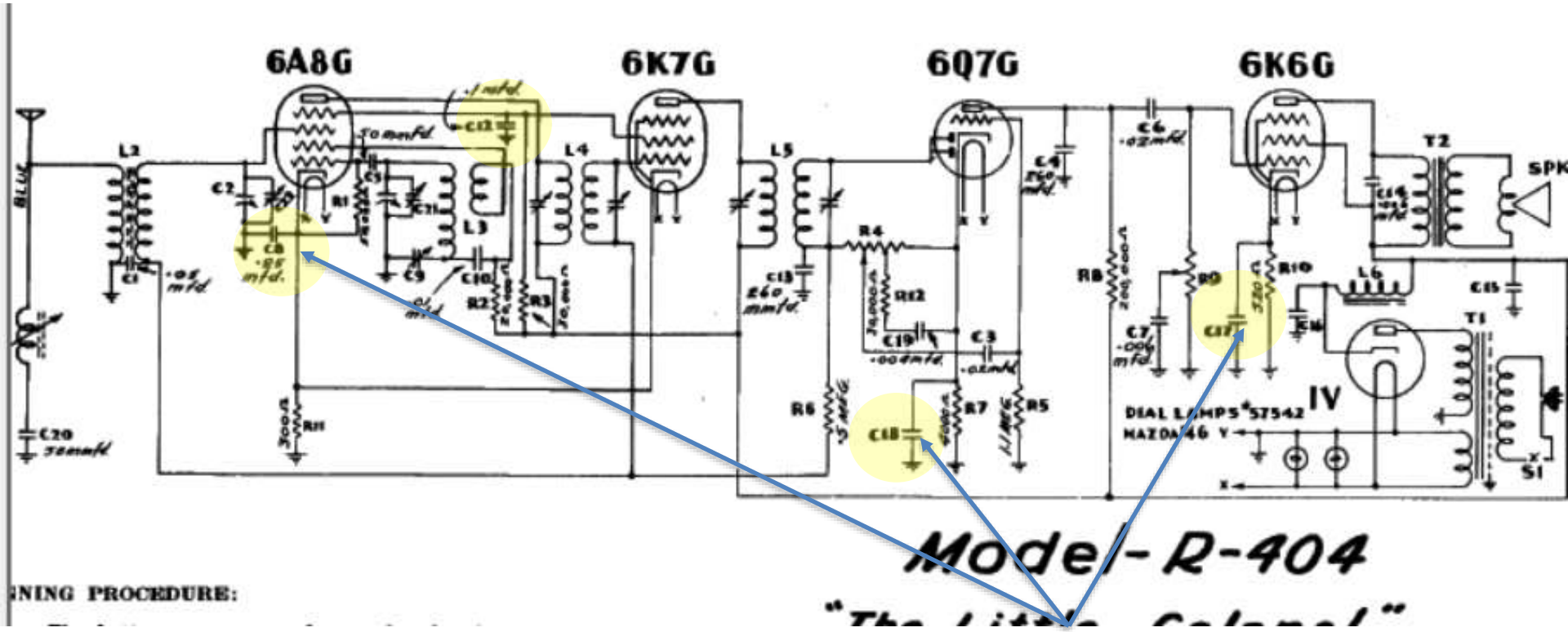
Decoupling/Bypass Capacitors
Value Not Critical. Even double is fine.



TO TEST: take out the 6A8G, 6K7G, and measure the voltage across this resistor. If it's more than ~1V, replace the capacitor.

Decoupling/Bypass Capacitors

Value Not Critical. Even double is fine.

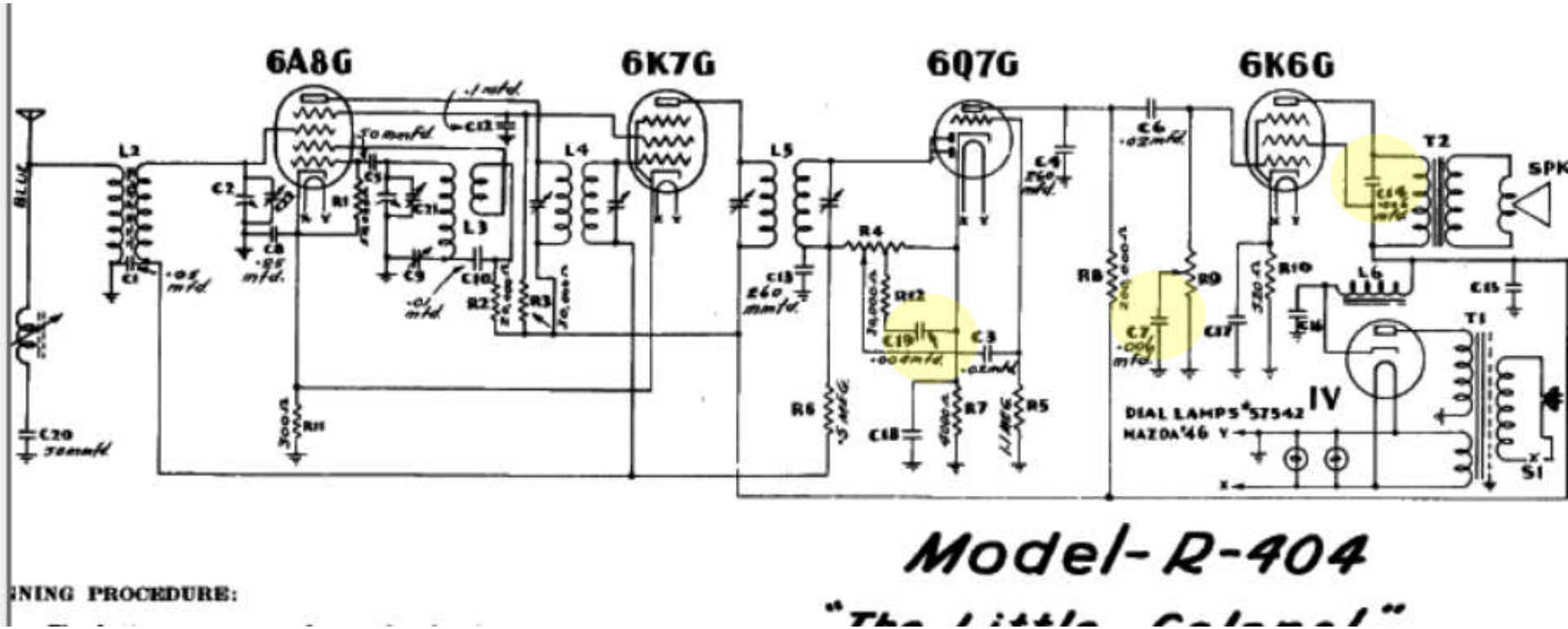


TO TEST: Check cathode voltage of 6A8G, 6Q7G, 6K6G. If it is way off, the capacitor might be shorted.

Decoupling/Bypass Capacitors
Value Not Critical. Even double is fine.

Frequency Response Contouring Caps

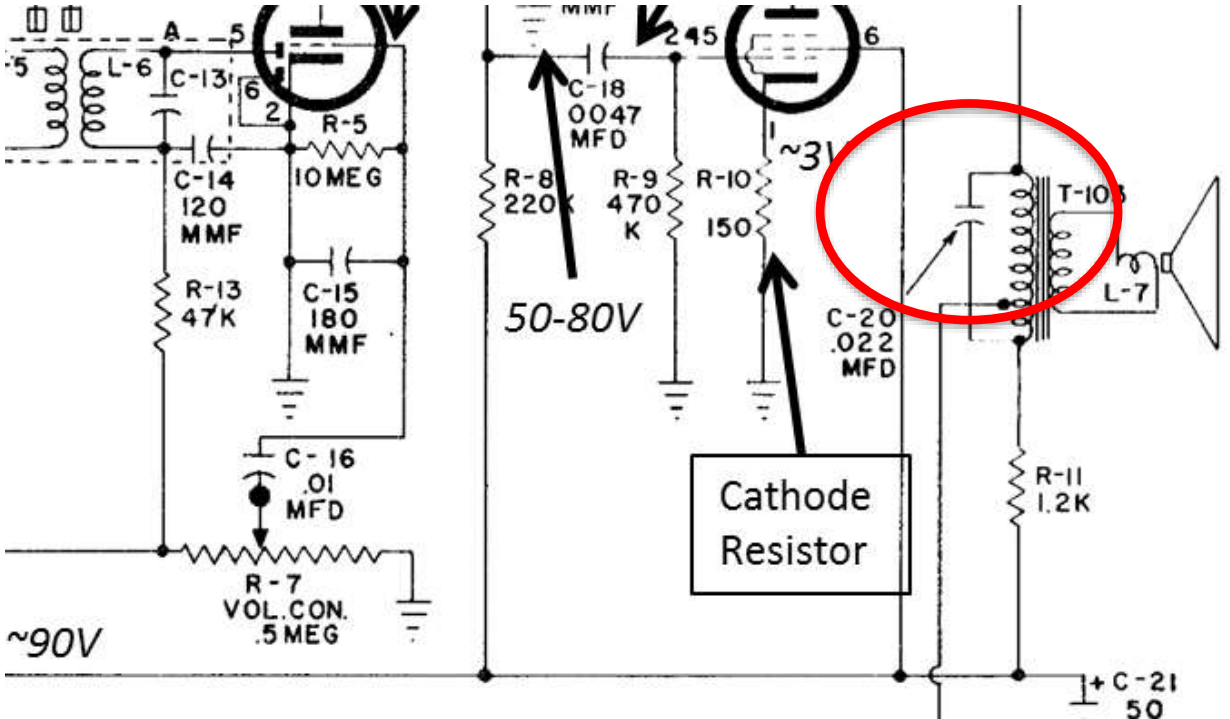
- If the capacitor goes open or loses value, then radio may sound tinny. Tone control might not work.
- If the capacitor is leaky, it may burn out the tone control. Or could cause low audio output.
- Replace with a film capacitor of a similar value, usually within 20%.



Frequency Response Contouring Capacitors

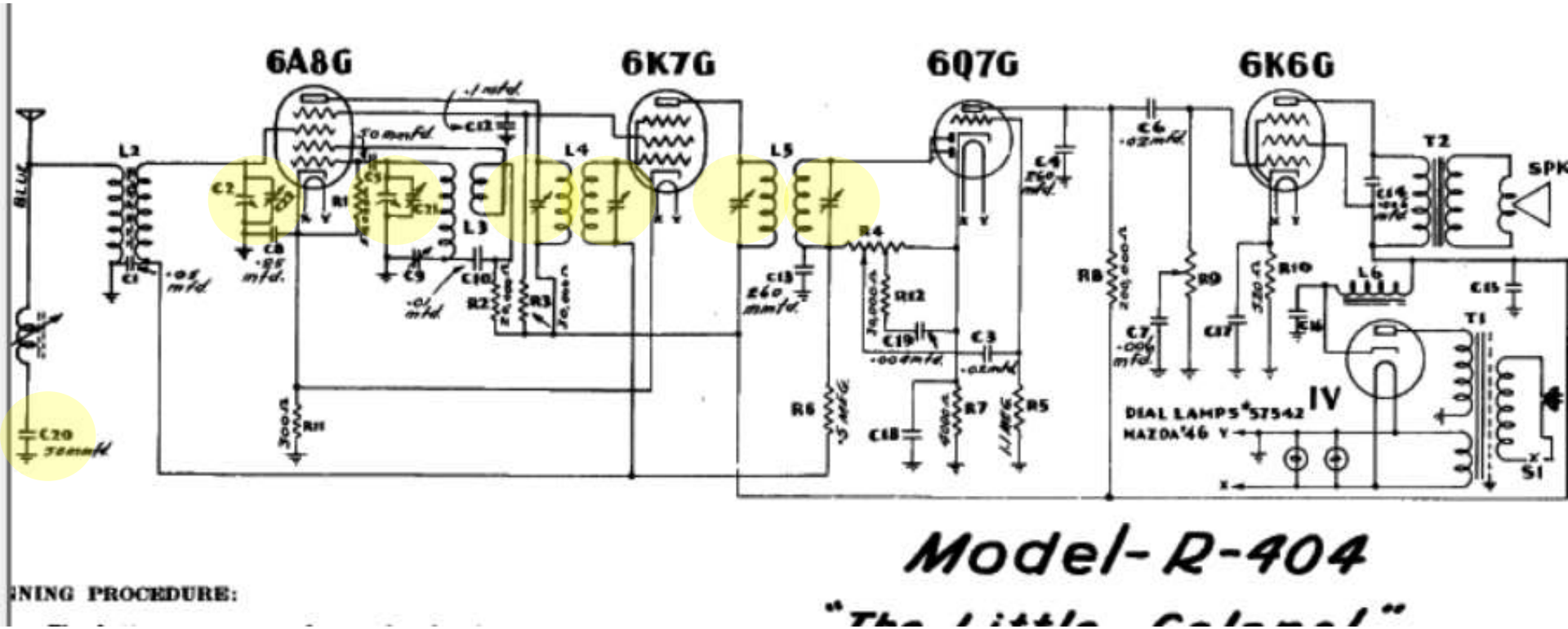
Tone Control Capacitors

- Adjusts contour of the sound, usually attenuating high frequency.
- Certainly, don't make it too big. Keep within 20%



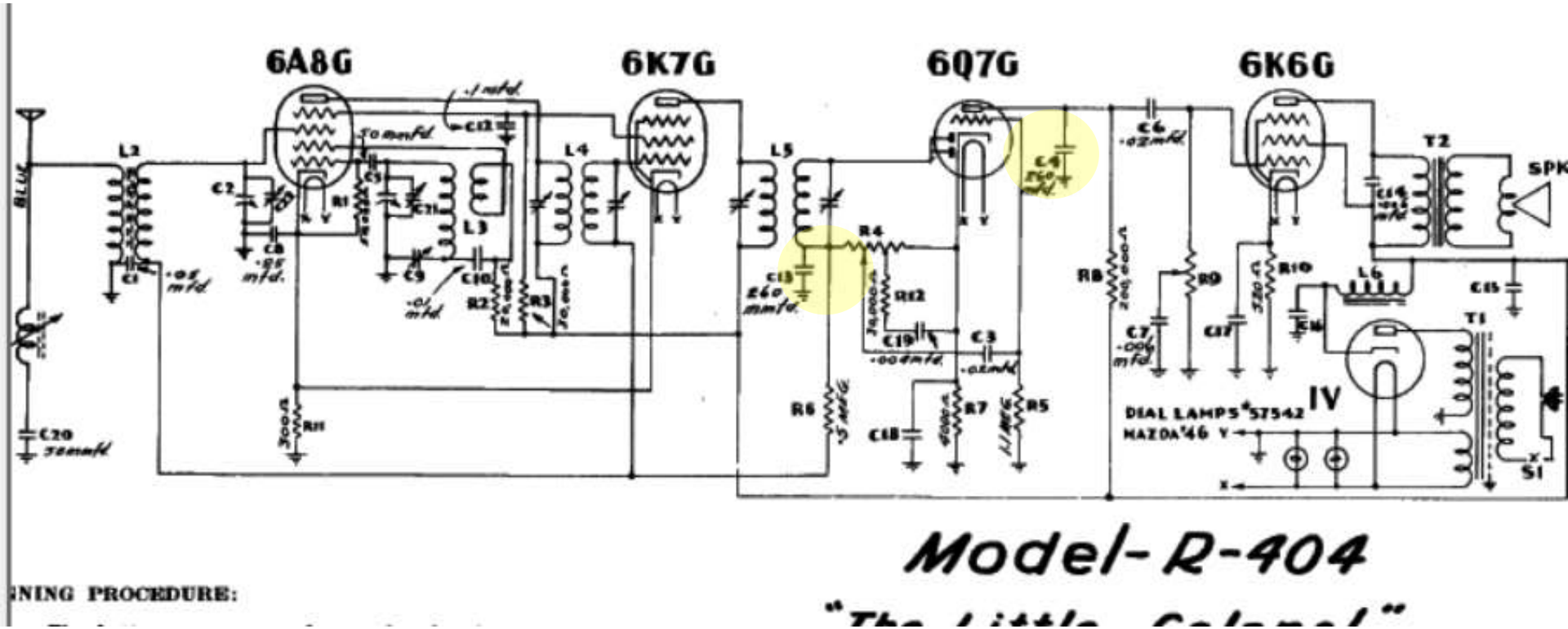
RF Capacitors

- If the capacitor goes open or loses value, then stations may not tune in at the right spot, or radio may lack sensitivity.
- If the capacitor is very leaky, it could kill sensitivity.
- Fortunately, these caps rarely fail.
- Replace with a ceramic or mica capacitor of a the same value. Value is critical. Dress leads to match original. A realignment may be required.



RF Capacitors

Value is critical but fortunately they rarely fail.

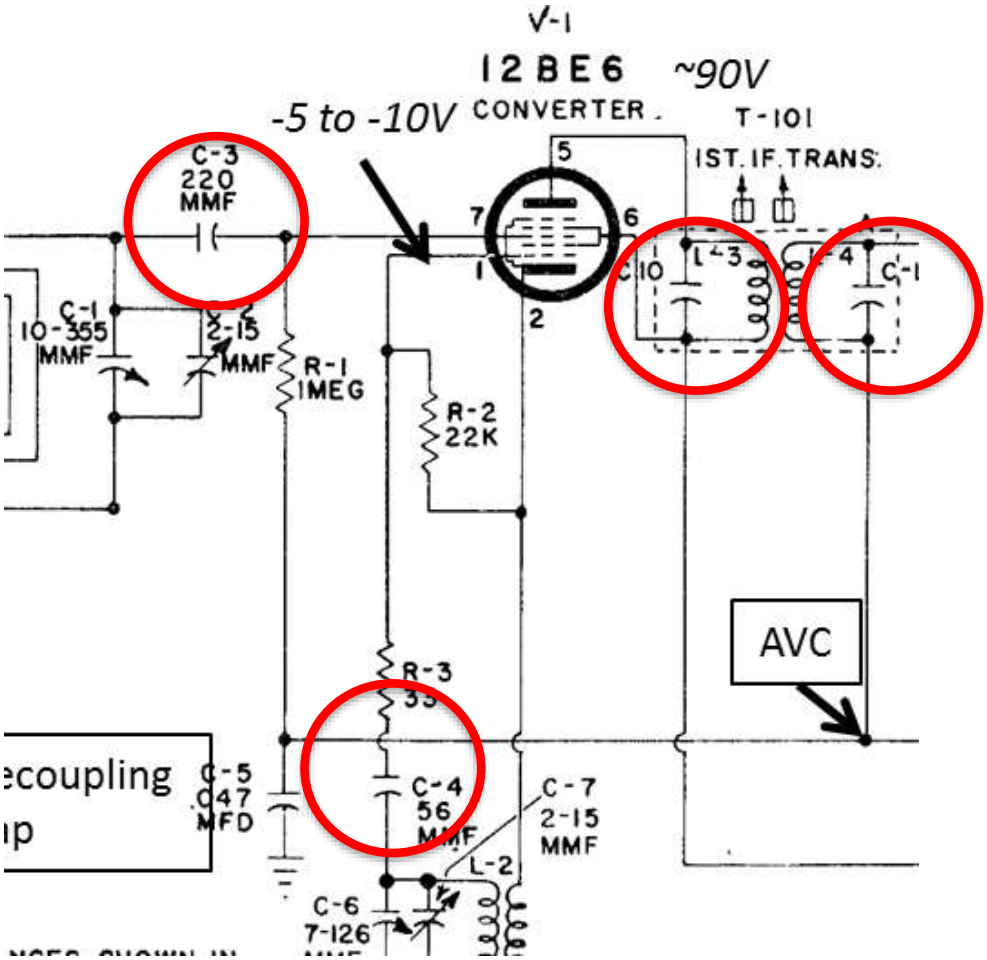


RF Capacitors

Low value, often mica, pretty reliable.

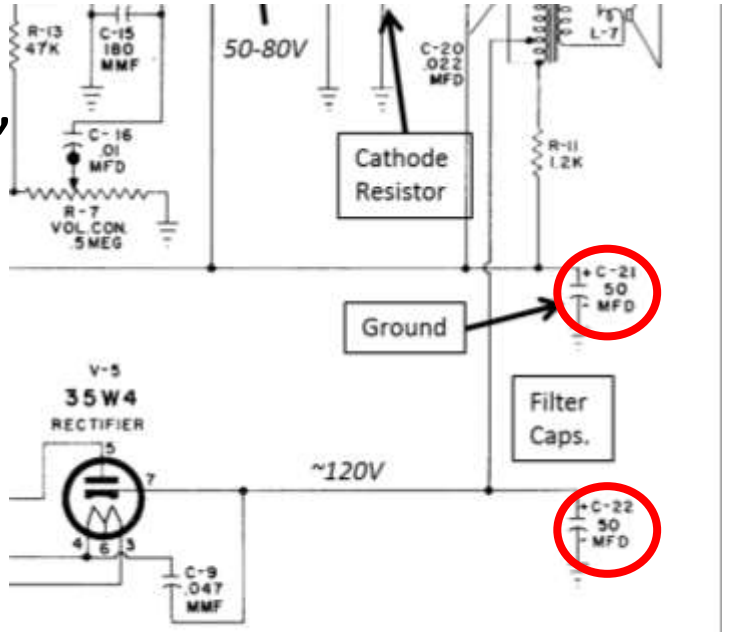
RF Capacitors

- Usually mica. Rarely defective.
- Value can be critical.
- Don’t touch them unless you have a good reason
- Use short lead length.



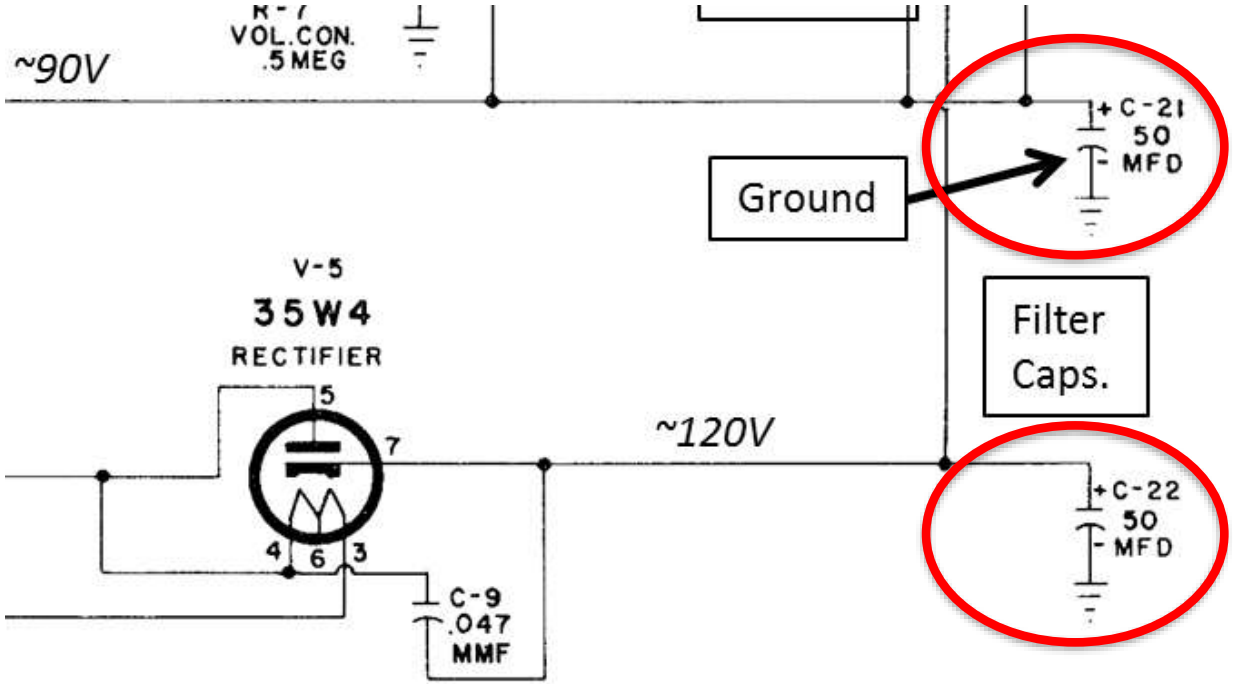
Power Supply Filter Capacitors

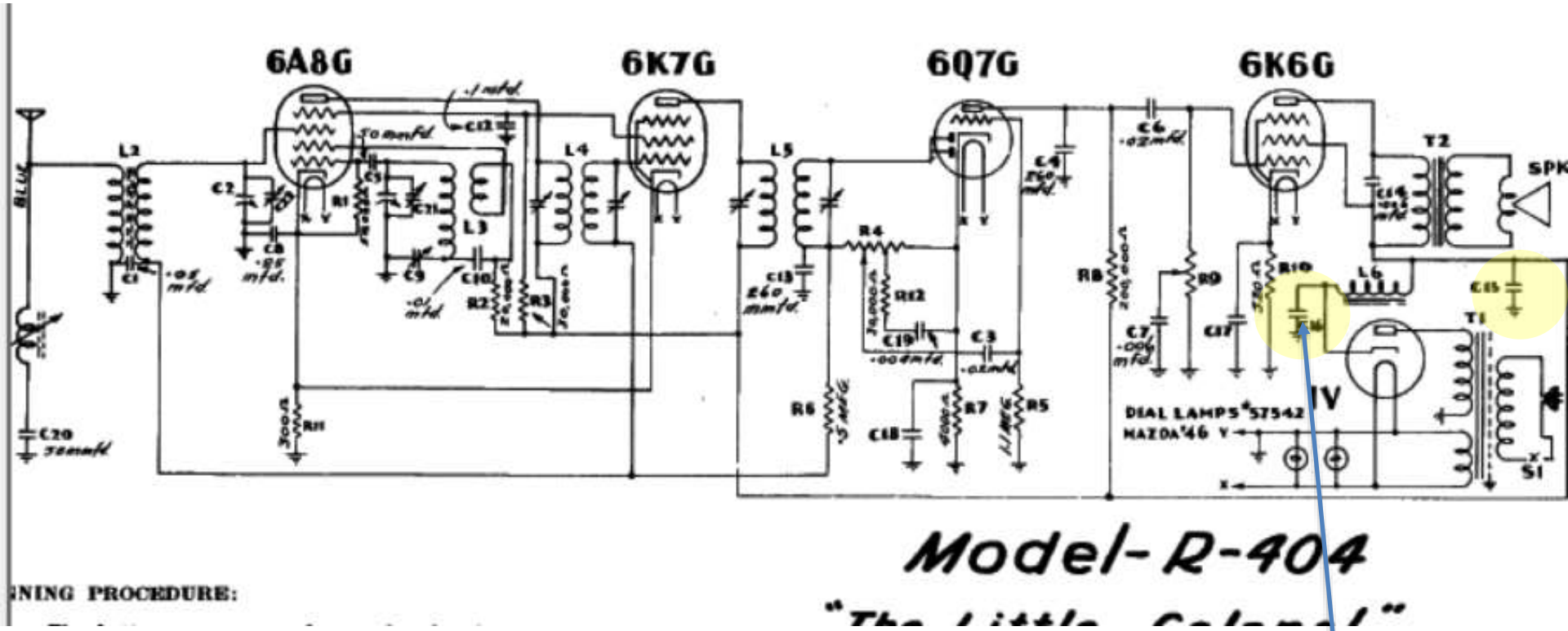
- Very common problem. Degraded capacitor causes hum. Shorted capacitor causes excess line current.
- Try paralleling a known good capacitor. Does that fix the hum problem?
- Value is not critical (sometimes specified as “guaranteed minimum value”), bigger is better, but don’t make first cap too big.
- Watch the voltage.
- Observe polarity.
- New caps are much smaller!
- These capacitors can be “Reformed”.



Filter Capacitors

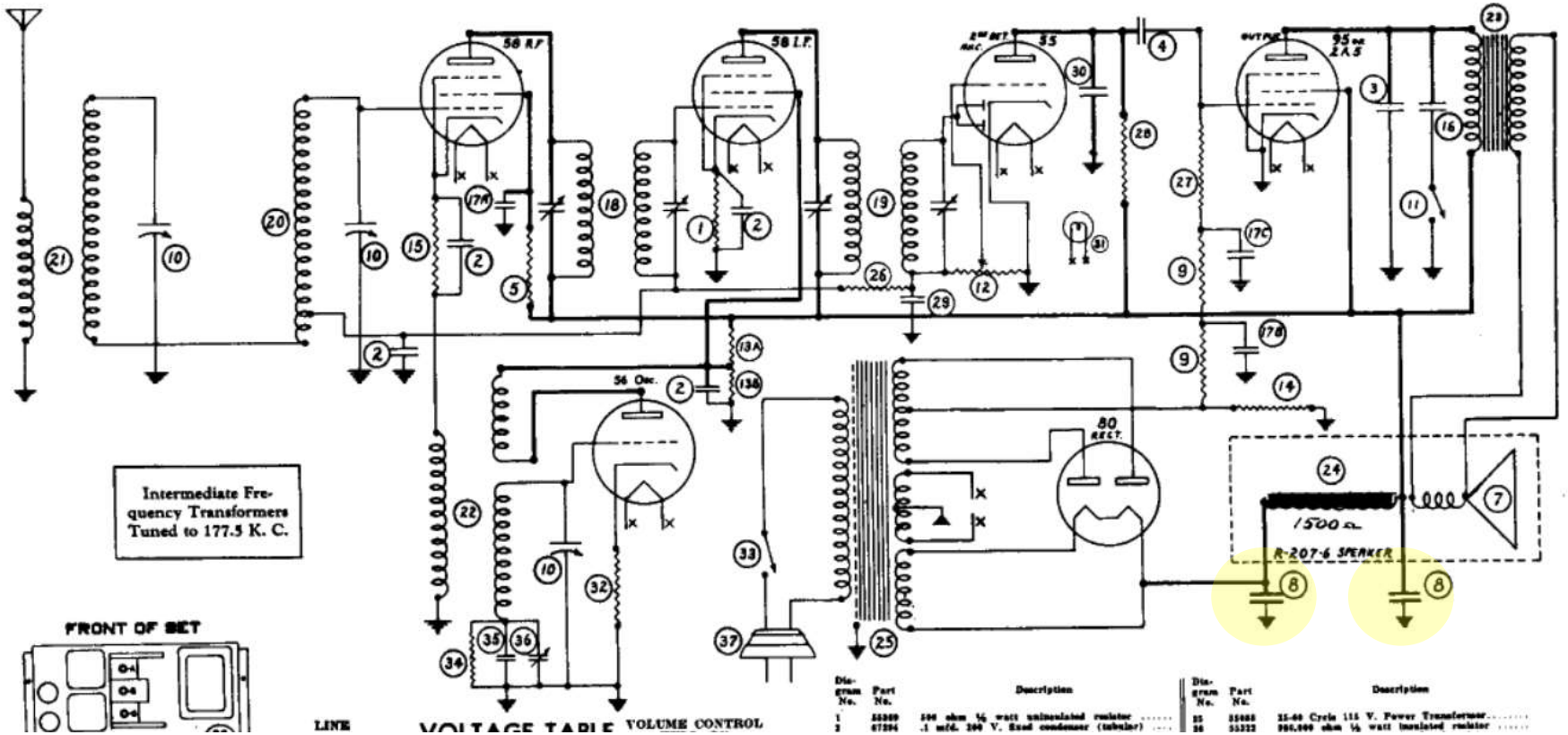
- Smooths out the 60Hz from the power supply.
- Value not critical. Bigger the better. Watch the voltage.
- ESR is important



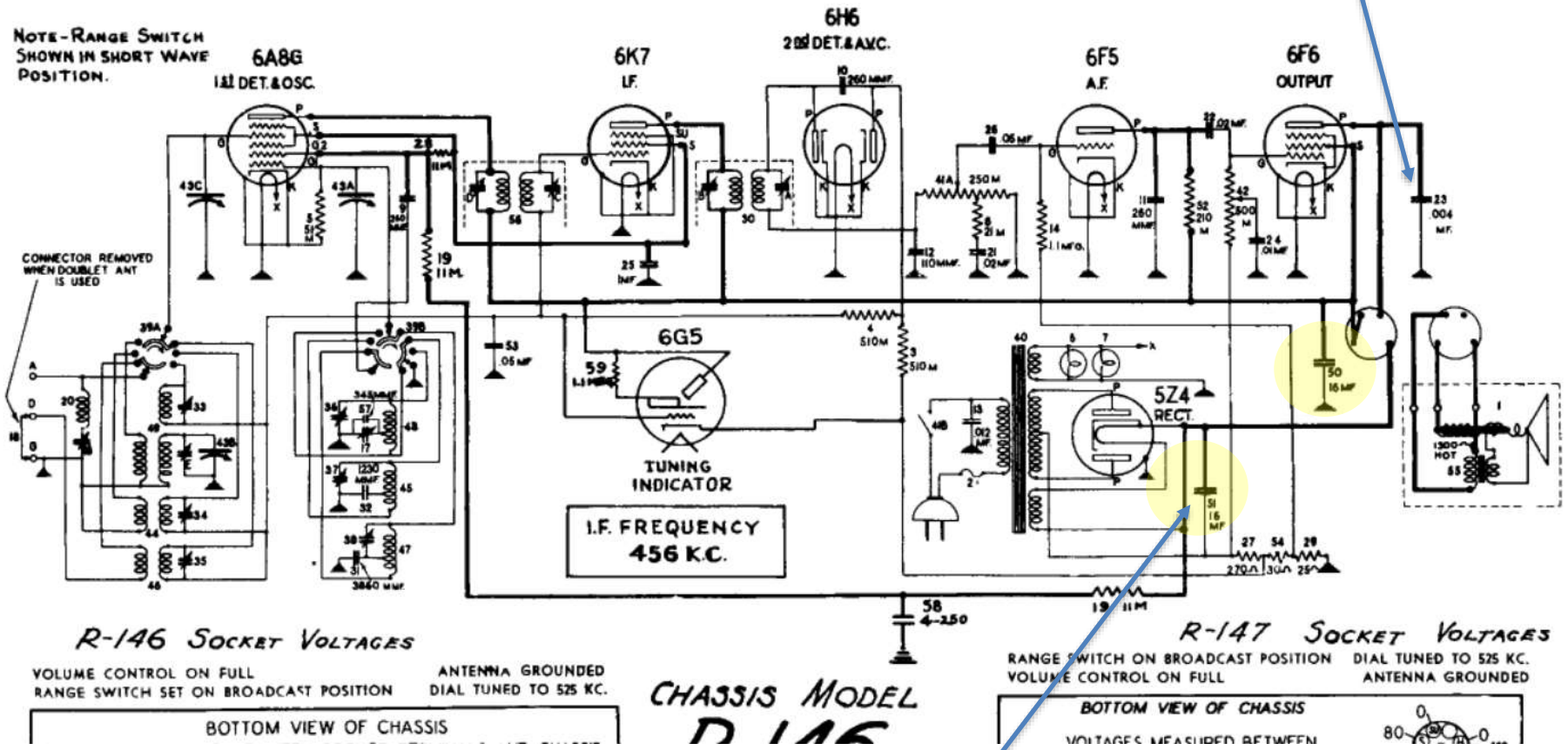


Filter (Electrolytic) Capacitors
Just replace them!
Watch polarity, voltage.

Don’t make this too big, stresses the rectifier.


56 RF
56 L.F.
56 Osc.
80 RECT.
Intermediate Frequency Transformers Tuned to 177.5 K. C.
FRONT OF SET
LINE
VOLTAGE TABLE
VOLUME CONTROL
1500 Ω
R-207-6 SPEAKER

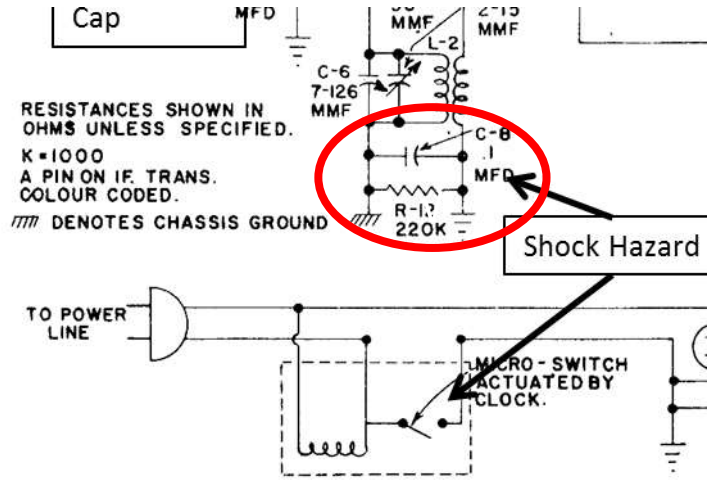
Tone capacitor has 300V across it!
This capacitor can fail, cause other damage.



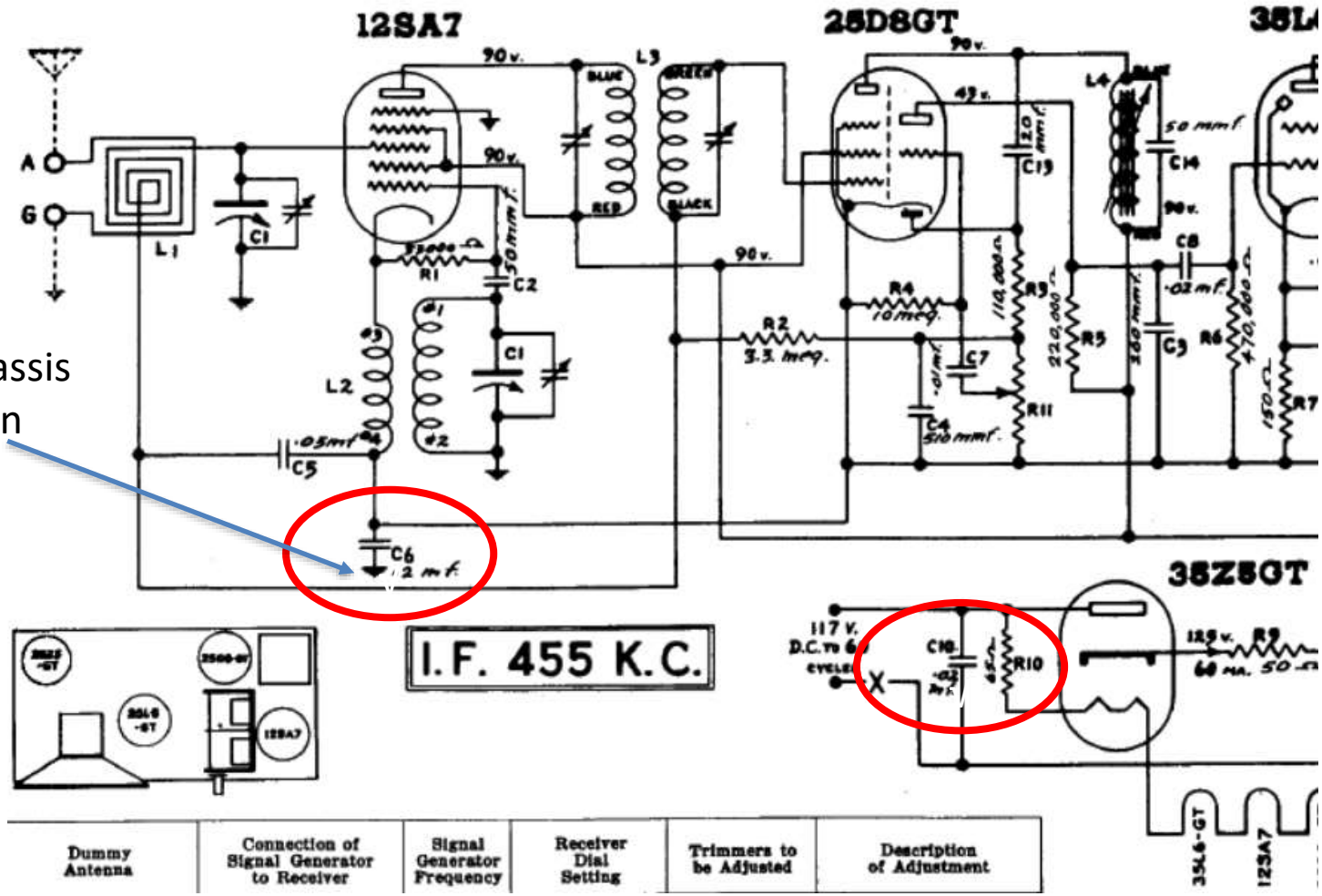
Note: This capacitor is not grounded!

Mains/Line Capacitors

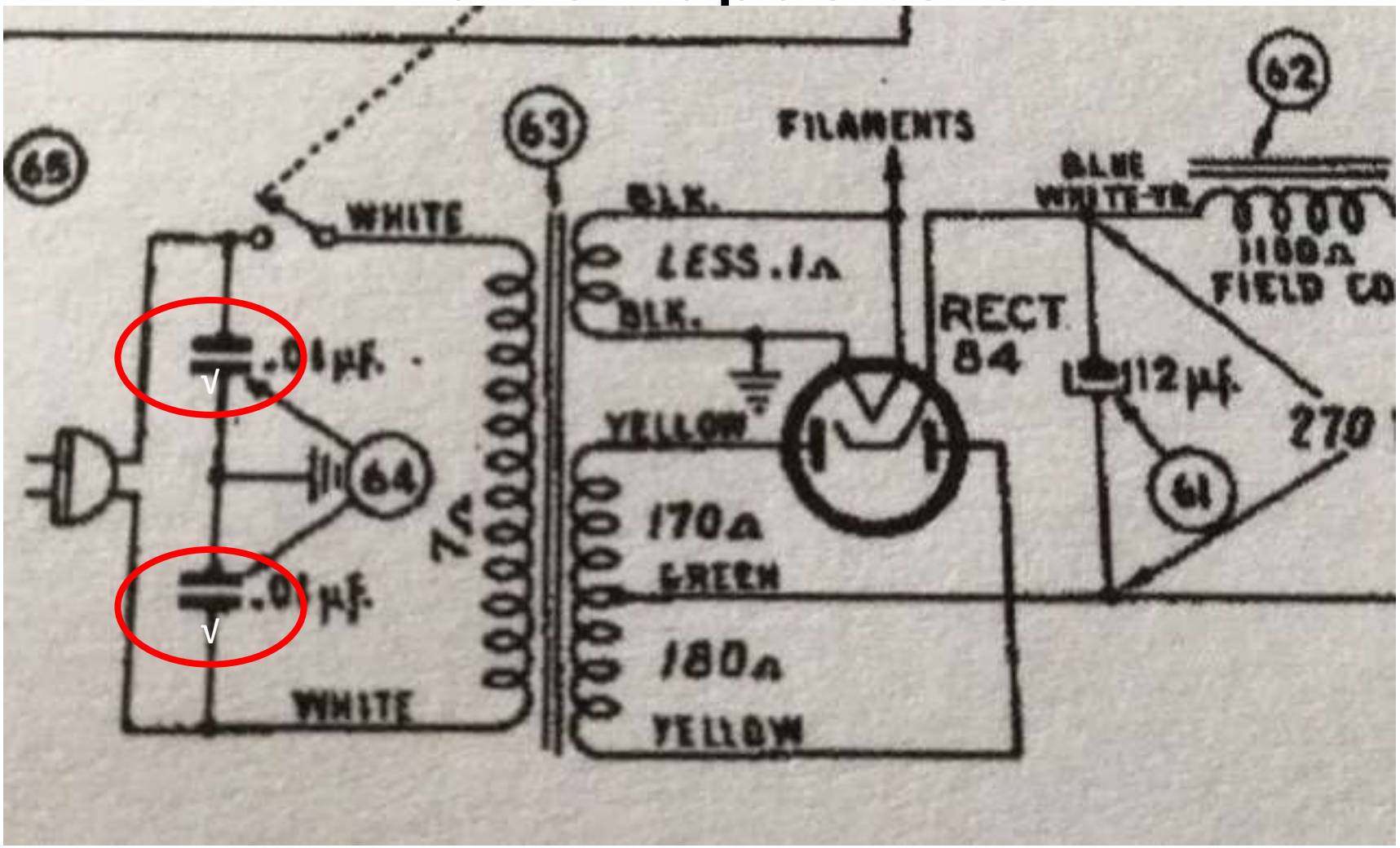
- Should be approved for use across the AC line.
- Opens a bigger question about safety in AC-DC sets.



Actual chassis connection



Mains Capacitors



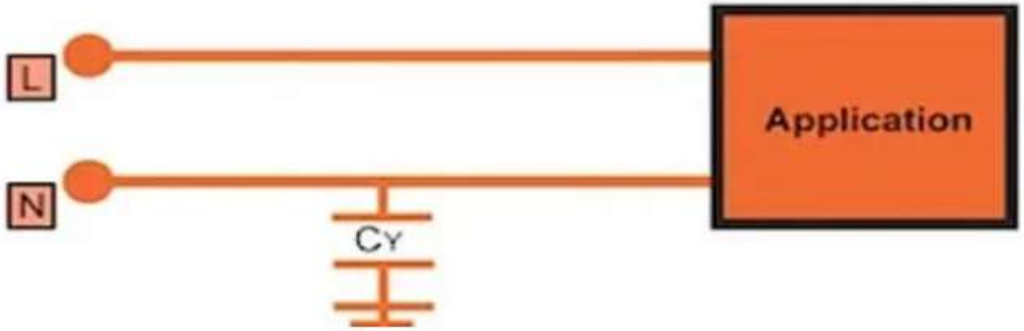
X and Y capacitors

- Capacitors that fail to a short-circuit present a special challenge when connected directly to the mains. Fire and shock hazard.
- X- and Y- capacitors, designed specifically to be connected to the incoming line, address this issue.
- X caps have proven reliability. Y caps are designed to fail open.
- Y caps are more expensive. I just buy Y caps. 0.01 or 0.05uF.

X and Y capacitors

Class **X** Capacitor (Line - to -Line)

Class **Y** Capacitor (Line - to -Ground)



Sub-class	Peak pulse voltage V_p in operation	Application	Peak values of surge voltage V_p (before endurance test)
X1	$2.5\ kV < V_p \leq 4.0\ kV$	High pulse application	$C_R \leq 1.0\ \mu F$: $V_p = 4.0\ kV$
			$C_R > 1.0\ \mu F$: (enter C_R in μF) $V_p = \frac{4}{\sqrt{C_R}}\ kV$
X2	$V_p \leq 2.5\ kV$	General purpose	$C_R \leq 1.0\ \mu F$: $V_p = 2.5\ kV$
			$C_R > 1.0\ \mu F$: (enter C_R in μF) $V_p = \frac{2.5}{\sqrt{C_R}}\ kV$
X3	$V_p \leq 1.2\ kV$	General purpose	No test

Sub-class	Type of bridged insulation	Rated AC voltage	Peak values of surge voltage V_p (before endurance test)
Y1	Double or reinforced insulation	$V_R \leq 250\ V$	8.0 kV
Y2	Basic or supple-mentary insulation	$150\ V \leq V_R \leq 250\ V$	5.0 kV
Y3	Basic or supple-mentary insulation	$150\ V \leq V_R \leq 250\ V$	No test
Y4	Basic or supple-mentary insulation	$V_R < 150\ V$	2.5 kV

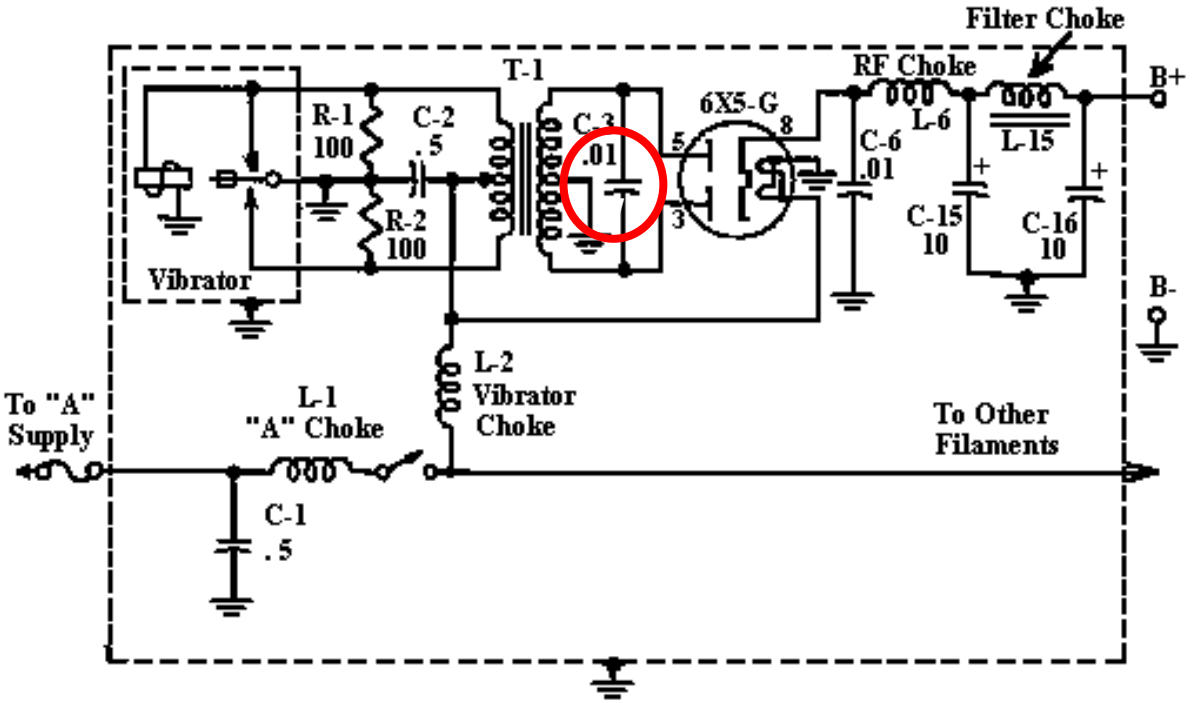
A Y2 cap can replace an X2 capacitor. NOT Vice-Versa

Line Capacitors: Bigger Discussion

- If you make a radio safe, you may not need a line capacitor anymore.
- This raises a bigger question about how to make a radio safe. Whole topic.
- AND, a warning that all tube radios work on lethal voltages that can kill you. (I'm probably on my 9^{th} life) Do your research and stay alive.

Vibrator Buffer Capacitors

- Car radios: *Always* replace the buffer capacitor with the vibrator. If this capacitor fails, it will kill the vibrator. This capacitor absorbs huge voltage spikes, it is a punishing job.



Audiophile Capacitors

- Capacitors in the audio path of an amplifier can affect the “sound” of an amplifier.
- There is a cult-like culture in some audiophile circles about the relative merits of capacitors, but there are some “sound” ground rules:
  - Avoid ceramic capacitors in audio. They can have voltage dependent capacitance and microphonics.
  - Paper capacitor leakage can upset amplifier biasing, p-p balance. If your audio amplifier still has paper caps, replace them all.

Audiophile Capacitors

- Avoid electrolytic unless *only* DC is present across it (like filter caps). (Not always practical (eg: speaker coupling cap), so just go for quality, high temp rating)
- For cross-overs, I would avoid both polar and non-polar electrolytics.
- Watch value/tolerance closely.
- IMO, you do not need to spend $50 for a 0.1uF 600V capacitor. Any new film-type capacitor should work perfectly well. ← there are others who differ in opinion!

Capacitors Sources

- Capacitors are not expensive and easily available from many sources.
- www.justradios.com (located in Toronto)
  - 0.047uF, 630V: $0.44US
  - 22uF, 450V: $1.89US
- Digikey
  - 0.047uF, 400V/ 600V are $0.50
  - 22uF, 450V are $1.50
- Useful caps can be found in used Compact Fluorescent Lamp and LED assemblies, switch mode power supplies, etc.

Local Supply…

- I just visited Gervais Electronics/Accessotronik 716 Industrial Ave. (Ottawa)
- They have some suitable HV electrolytic capacitors: 22uF, 250V OR 450V for example.
- They have *very few* capacitors that would replace paper capacitors in our radios.
- They have a bargain on X1- Y2- type 0.0047uF “1000V” safety capacitors: bag of 25 for $2.87

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ACCESS TRONIK
WWW.ACCESSOTRONIK.COM
ACCESSOTRONIK 800-335-6050
4.7NF 1KV CERAMIC 25PK
CER-4700PF-25
LOC:A028 LOT: 4322826-2
ACCESS TRONIK
WWW.ACCESSOTRONIK.COM
ACCESSOTRONIK 800-335-6050
22UF, 250V, POLAR, RADIAL, ELEC
NEVH22M250DD
LOC:A029-0 LOT: 4328742-2

ALMOST DONE: HIDING CAPACITORS AND TO HOW TO RECAP

Hiding Capacitors

- Best to hide your caps so that the radio “looks” authentic.
- Print a capacitor label to wrap around a capacitor.
- Hide a capacitor in a coffin.

Philco Capacitors

Hiding Capacitors

Before

Old Guts

New Guts

After

Recapping…

- Capacitors (not tubes) are the “Achilles Heal” of the radios we love.
- Electrolytic capacitors are STILL the weak point in many modern electronic things.
- I replace capacitors more frequently than tubes.
  - A capacitor degrades with *time* (in fact, some say that maintaining a voltage on an electrolytic keeps them healthy).
  - A tube degrades with *use*.
  - Since our radios are not used much, the caps are usually the main problem.

To Recap or Not To Recap

- Don’t touch the RF (usually mica) caps in the RF part of the radio unless absolutely necessary.
- Especially true in short wave radios and FM radios.

- If a cap gets warm, replace it. ← but, in the case of a filter capacitor, make sure the rectifier is OK first.

To Recap or Not To Recap

- Some suggest replacing all electrolytic capacitors. I tend to agree.
- Certainly, everyone agrees that **wet** electrolytics will be dry and dead by now.
- “Dry” electrolytics (especially in “cheap” consumer electronics) will usually have dried up.
- I have seen 50 year old healthy “dry” electrolytic capacitors in good (HP) test equipment I have left in place.

To Recap or Not To Recap

- Some say you should replace ALL paper capacitors. They *will* fail someday.
- Some say you should replace just proven bad paper capacitors. The radio will “look” more authentic.
- Some say you should replace paper caps that would cause damage if they fail.
- IMO, it depends whether the radio will be used regularly.

Caps that would cause damage if they fail

- The coupling capacitor to the audio output pentode. Absolutely check it. Generally replace it.
- A capacitor across the main B+ . Good idea to replace it.
- Any capacitor connected to the power line. Safety issue.

Will He Ever Stop Talking: Conclusions

- If you're fixing old radios or electronics, you'll encounter some dead capacitors.
- Fortunately, most of the time they are not too critical and easily available and easily replaceable.