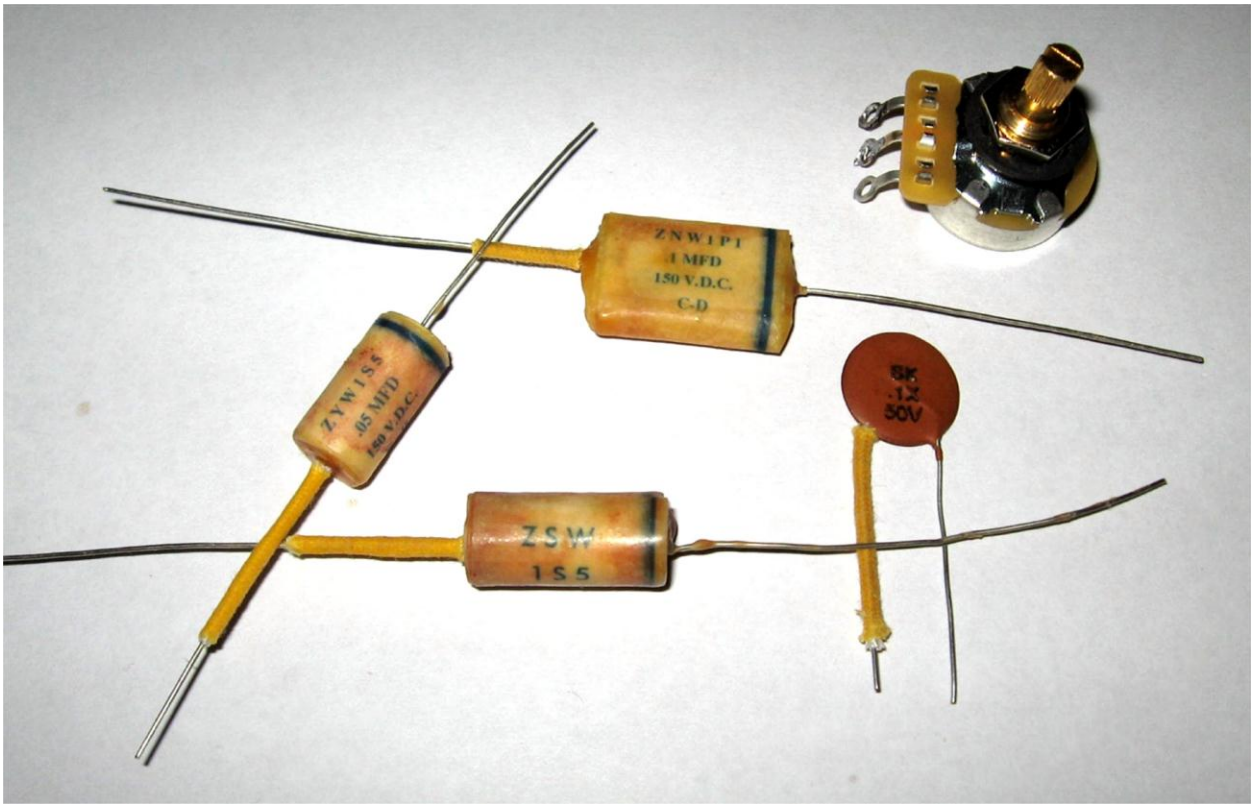
Reproduction 1950's Capacitors - For those that want even more of the vintage look inside their guitar, but with modern reliability and tones, and don't want to spend a king's ransom on it, I make reproductions of some of the paper-wax capacitors used in the 1950's and early 1960's such as the Cornell – Dubilier 0.1 MFD ZNW1P1 "phonebook" or sometimes called "chicklet" capacitor and the .05 MFD ZYW1S5 and ZSW1S5 "tubular" capacitors that Fender used up until about 1962. These were considered miniature sizes, and were good quality for their day, but haven't been made since the 50's and probably for good reason. I also make a reproduction of the "Red Dime" .1 uF capacitor that was used after that By Fender. Those who are advanced enough in stratology to already know about these, will be able to understand why someone might want this look. Every vintage strat from the 50's came with a ZNW1P1 installed. Yet, many players today might not choose the original capacitance values. So, though I do make some of them in the original values I also offer some very vintage looking versions that are available in smaller capacitances as well as the original values.

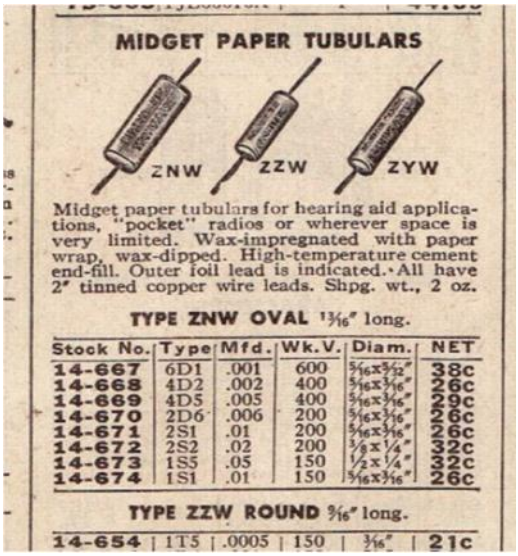


SCS Repro Capacitors

A couple of words of caution, be sure there is enough room in your guitar for these. They are approximately the original sizes, but that is much bigger than anything used today. The "phonebook" size is about 1" long x 7/32" wide x 5/8" thick. The tubular models are either 3/8" diameter by 1" long or 3/8" diameter x 13/16" long. I can make them somewhat smaller on custom orders so if you think there is a fit issue, contact me and I might be able to accommodate it, though they won't be quite as accurate looking. Also, mine don't use the original oiled paper in wax construction, they are made with a network of standard axial multilayer ceramics. They are fully functional, but not by any means a completely true copy. The only intent is for them to look vintage and do their jobs very well, probably even better than the originals.

<u>Construction vs. Tone, and some Myths</u>- The originals of the ZNW, ZYW, and ZSW caps were paper -wax construction. Some people think they were paper in oil construction, but it isn't so. They were just waxed paper and foil, no oil.

The original specs are very hard to find. But after much searching, I did find some. Here is a clip of a page from a 1950 Allied Radio catalog, which definitely states (by part number) that these were wax impregnated paper construction and wax dipped. Not that it makes a great deal of difference, mind you. At least not to me. Just pointing out a fact. In fact, for guitar tone controls, I don't think paper in oil sounds any better than any other good capacitor. I realize there is a lot of hype out there about tone capacitors. I do think that it is possible that some people might be able to hear some slight tonal differences among caps. But I think those differences are going to be beyond the hearing ability of most people. Here are some facts to consider.



MIDGET PAPER TUBULARS

ZNW ZZW ZYW

Midget paper tubulars for hearing aid applications, "pocket" radios or wherever space is very limited. Wax-impregnated with paper wrap, wax-dipped. High-temperature cement end-fill. Outer foil lead is indicated. All have 2" tinned copper wire leads. Shpg. wt., 2 oz.

TYPE ZNW OVAL 1 3/16" long.

Stock No.	Type	Mfd.	Wk. V.	Diam.	NET
14-667	6D1	.001	600	5/16x5/32"	38c
14-668	4D2	.002	400	5/16x3/16"	26c
14-669	4D5	.005	400	5/16x3/16"	29c
14-670	2D6	.006	200	5/16x3/16"	26c
14-671	2S1	.01	200	5/16x3/16"	26c
14-672	2S2	.02	200	3/8x1/4"	32c
14-673	1S5	.05	150	1/2x1/4"	32c
14-674	1S1	.01	150	5/16x3/16"	26c

TYPE ZZW ROUND 5/16" long.

14-654	1T5	.0005	150	3/16"	21c

For one thing, the tone capacitor in a guitar is taking higher frequencies out of the signal and sending them to ground, not through the amp to get magnified many times. That means you don't hear any of the signal that goes through the cap. You get to hear the other part of the signal that the capacitor blocks out. A guitar signal is an AC current, with a whole lot of different frequencies going on at the same time. For the lowest frequencies, the capacitor is effectively an open circuit. But for any given frequency present in the signal, the capacitor has a different amount of resistance (actually it is called impedance, but let's not get too technical with this) and the higher the frequency the less "resistance" there is. So the capacitor is going to let more of the higher frequencies through to ground and out of the signal, and less of the lower ones, which remain and go to the amp. The main thing that controls this is the capacitance value, (the microfarads abbreviated uF). That is so dominant that any of the other factors such as the ability of the dielectric to keep up with rapid changes, i.e. soakage, or microphonics etc. are going to be such small effects that almost no one can really hear them in this application. "Soakage" is basically a condition where the dielectric retains a charge for a short time after the voltage changes. It is kind of like a lag time. Microphonics are due to compression of the dielectric by mechanical vibrations, making the capacitor work a tiny bit like a condenser microphone does. By the way in the 50's capacitors were still called condensers. Of course, in amps, where in some cases the signal goes through the capacitor, as say for example in coupling caps, those effects might have some tonal consequences, and get amplified later down the line, but since the tone cap in a guitar is sending part of the signal to ground and not through the amplifier, the situation is different. Also one needs to remember that the tolerances on components back then were pretty loose, and they weren't even usually noted in catalogs. That means these varied quite a bit. Small changes in capacitance value would be much easier to hear than any of the other effects that get bantied about online.

I'd guess that probably if old paper - wax ones were dried up, or have been affected by humidity, which might be more likely, they could sound bad. Actually, I sometimes wonder if the dried up ones aren't the good sounding ones, and the ones that haven't are bad sounding.

Paper-in-Oil Construction wasn't used by Fender for any guitar tone capacitors I don't think ever. Gibson hardly ever used any oil filled ones either. They were too expensive for one thing, and not necessary. The oil impregnated paper construction was for high voltages, as in TV circuits- it was not even needed in many audio amplifiers. I am not sure how the paper in oil capacitors got such a mystique among audiophiles. They were kind of notorious for high soakage. But again that is something to worry about in amplifiers. Anyway, I don't have the expertise or materials for that kind of construction especially for any small difference it might make. I do have some new old stock examples of PIO caps for sale. The proprietary capacitor oils that were used in the 1950's very likely contained highly toxic pcb chemicals, and haven't been available for many years. The military versions were sealed up in metal tubes with glass seals so they don't dry out.

Black Beauties and Bumblebees, which are the same Sprague product, were not paper in oil either. Sprague called them Black Beauty Telecaps. The original ones were simply paper capacitors with a molded plastic case. The "bee" stripes were a code for marking the capacitance. So a bumblebee is a black beauty with stripes. If they were rated for 600 volts or more they were oil filled. Otherwise they were just paper. And Gibson used 400 volt rated ones quite a bit. Also many makers made similar molded tubulars. If the mold mark has a 2 in a circle it is a Sprague. If it has another number it is someone else's brand of the similar common molded paper capacitor at the time. They were intended to be used in TV's. At some point around the early 1960's, Sprague and the other vendors quit using the stripes and started printing the capacitance on them. Also around 1959-1960 the construction of them was changed to what Sprague called difilm in which the dielectric was paper with a mylar film, (not just mylar by itself). The electrodes were still made of foil. At that time they also changed the voltage rating to which they started being oil filled to 1600 volt ratings and up instead of 600. So some of the earlier "bumblebees" may have been oil filled, you can tell if they have a filler tube on one end. But most were not, they were just either paper or mylar capacitors.

I have seen audio spectrum analysis tests of various capacitor types installed in a guitar tone control and the differences are extremely minor between the capacitor types. If you're interested in more detail, check out SK Guitars capacitor test. In this test, mylar caps were very close if not indistinguishable from paper in oil. Multilayer ceramic was not included in that test, but according to the manufacturer's datasheets those have very similar frequency response characteristics to mylar. The ceramic capacitors that were tested were the disk type instead, which are supposed to not have quite as good frequency response as the multilayer versions. Yet Fender used them for years. They were probably in all of the strats used by Jimi and the best I can tell, likely Stevie Ray too, so ceramics can't be too bad. They can sound really good with single coils. If you are really looking for paper in oil construction in a repro cap you will need to get the Luxe versions, which use Russian PIO caps inside, or else just look for NOS Military spec Vitamin Q's, or other brands military paper-oil versions such as Gudeman, Aerovox, John Fast, Dearborn, etc that are made in metal tubes hermetically sealed with glass. They have mostly been out of production since the 1980's. So, all of that considered, mine are just made up

to correct values with networks of good quality contemporary Vishay or AVX axial multilayer ceramic capacitors set in shrink tubing and potted with a waxed paper outer wrapping. In one case I use a Mallory 150 polyester (Mylar) cap so it will fit well into the required package sizes. They are made to look a little aged but not too heavily and not intended to try to fool anyone into thinking they are originals. I don't claim that they sound any better than other good capacitors.

Choosing Capacitor Values - All of the differences between capacitor construction types of the same values are so subtle that you just about need to have Eric Johnson ears and a really excellent amp to actually be able to tell the difference with any certainty. If you have only a dog's hearing, that might not be enough. But most everyone should be able to hear some differences in the capacitance value chosen. You might have already guessed I don't buy into much of the hype. Really, there is no such thing as an ideal tone capacitor, it all depends on your tastes, your guitar's characteristics, and your needs as a player. Also, even if you leave the tone control on its brightest setting all the time the value of the capacitor makes a difference in the tone (unless you have installed no-load tone pots)

As noted earlier, capacitors block DC and lower frequencies and pass higher ones through. The larger the capacitance value, the more of the high frequencies get through the capacitor. One analogy to think of this is like having a pile of water balloons in a basket. The water in any one balloon can't move into the next one, but a wave started in one will travel through all of them. In the guitar's tone control the capacitor takes those high frequencies out of the signal and to ground. In this circuit, the tone pot is used as a variable resistor to control how much the capacitor gets to steal out of the signal. The rest of the signal goes on to the amp without going through the capacitor, so it still has all its frequencies remaining. The tone pots are usually wired (not always though) so that when the tone control is on 0, the resistance is near zero and the capacitor is fully in the circuit, making the tone as dark as the capacitor value permits. When the control is on 10 the resistance is whatever the tone pot goes up to, which lets more of the signal get sent through to the amp through the main part of the circuit. This makes the tone brighter. But even with the tone control on 10, the pot's resistance isn't infinite, so though less of the capacitor is used, it is still stealing some highs from the signal path, and thus still affects the tone somewhat. Using a larger pot value makes this effect smaller, but the range of the tone control is then limited so that all the action happens at the high numbers. For example with a one megohm pot, the pickups can run pretty much wide open on 10. The amount of highs that are removed even with the tone control on 0 is primarily determined by the capacitance value, with smaller capacitor values removing less of the highs.

Some guitars with a 5-way switch are wired so that when the switch is set to the bridge position, the capacitor is out of the circuit completely, letting all of the high frequencies pass through to the amp. There are also some modifications possible to tone pots to achieve the same result. That's what a no-load pot does. It lets the resistance increase up to the pot's value, then the next little bit of turning is like a switch to open the pot totally and cut the cap out entirely. But for most guitars, the capacitor value has the most effect on tone and it is always in the circuit to some degree. So to brighten them up, just choose a smaller value for the capacitor(s). In my opinion one of the biggest reasons that cheap capacitors have a reputation for sounding bad is because they have a wide tolerance range, which often is as much as +80% -20%. That means a .022 nominal value is probably more and could really be as much as .039. Mine are individually

tested to a tolerance of +/- 10% to the stated values. Most of them are within 5%. Multilayer ceramics do have one of the better frequency responses. Mine do have approximately the stated voltage ratings. The phonebook ones are about 200v. and the tubular ones are about 100v. nominal. The voltage rating doesn't have much effect in this application, anything over about 10-16 volts will do. Any voltage over that won't make any difference at all. Some people have put forward a theory on forums that higher voltage caps sound better. That's just not so at all. I think the higher voltage parts were just used originally by guitar makers, just because they were already stocked for use in amplifiers.

The .1uF value, though vintage accurate, is may be too much for some people's taste. .1uF is a lot of capacitor, and pretty dark. I think it would definitely be too dark for a humbucker, but it sounds good on some strats. Don't forget that a .1uF value was definitely what was in the Strats used by the likes of all early players such as Hank Marvin and Buddy Holly, even up to the Hendrix era. Yet, if great usability of the tone control is one of your goals, experts suggest using .022uF or even a lot less. The .022uF value is the size used in many current production Fenders. It seems to be very popular in places like Nashville to use .01uF which is $1/10^{th}$ of the ZNW1P1. This gives somewhat less range to the tone control but is nice and bright. So I offer a .01uF reproduction version that looks almost exactly the same but has 1/10 the capacitance. I have labeled it ZNW1S1. Of course this part number was never used but it still looks very vintage. Along the same lines, I offer the ZNW1S2 which is .022uF and the ZNW1S5 which is .047uF, in the "phonebook" sized packages.

Why are these made with a network of small sized capacitors instead of just one? Mainly it is just about the look, to get the right shape for the package, which is just easier with several small capacitors instead of one. But a network also provides an opportunity to increase reliability. Capacitors can either fail open or become shorted. If a normal tone capacitor fails by shorting, depending on the kind of short, it may just change value, but more likely the guitar goes dead unless the tone pot can go all the way to off. This is because all of the signal then goes to ground through the path intended for the capacitor. If a tone capacitor fails open, the guitar will continue to work, but without the tone control. (like it is on 10) The modern capacitors almost never fail in this application anyway, but for example my ZNW1P1 contains four .1uF 50v. capacitors in a series-parallel network and will continue to function (though at a somewhat different smaller value) if any one of them does fail either open or shorted. The ZYW1S5 and other "tubular" models are similarly made but sometimes, in order to maintain the proper vintage shape I have to use other configurations including either one, two, or three smaller caps. All of this is a solution to a problem that hardly ever happens anyway, they're mainly for the look, but why not take advantage of the opportunity if it is convenient.

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