Pultec EQP-1A Facts & Fiction

C. H. Preston

In the world of vintage pro audio gear the name Pultec has truly survived the test of time. The EQP-1A is surely one of the reasons for the success of the now iconic Pultec name. In 1969 The EQP-1A3 was listed in the Pultec catalog retailing for $496.00 US. Today the same unit will cost $7000-$10,000 with the later solid state model costing only moderately less. One has to wonder what it is that makes these units so valuable even though interfacing analog signals with a digital chain is becoming less common.

Inductor based equalizers were all but completely abandoned by manufacturers by the late 1970's with the exception of a few notable brands. The reason has much more to do with economics than it does with *state of the art improvements*. You can build a very versatile gyrator based equalizer for several dollars in parts while an inductor based EQ with the same versatility can cost several hundred dollars or more in parts depending on design. For design engineers whom may not have any connection to the recording industry other than designing a part for a manufacturer that supplies said industry, the choice is clear.

So why do people still pay such incredible money for a one channel vintage EQ? Because a Pultec equalizer adds sonic gratification to almost any sound you put through it. To the best of my knowledge there is no virtual plug-in that does the same thing, the same way as the real deal. The greatest virtue that inductor based equalizers have is the minimal phase shift quality afforded by LCR type circuits*.

Typically, with standard gyrator based equalizers, the more the controls are used, the more phase shift is introduced in the original signal. This is not the case with LCR equalizers which means they can be applied more aggressively with less negative phasing artifacts. I believe the last statement is the key to the EQP-1A's longevity. To be technically correct the EQP-1A only uses an inductor for the high end so there are time constants associated with the low end section which utilizes capacitor pairs to obtain the correct frequency points. Subsequently, there is a little phase smearing in the low end, probably another reason for the EQP-1A's long term success.

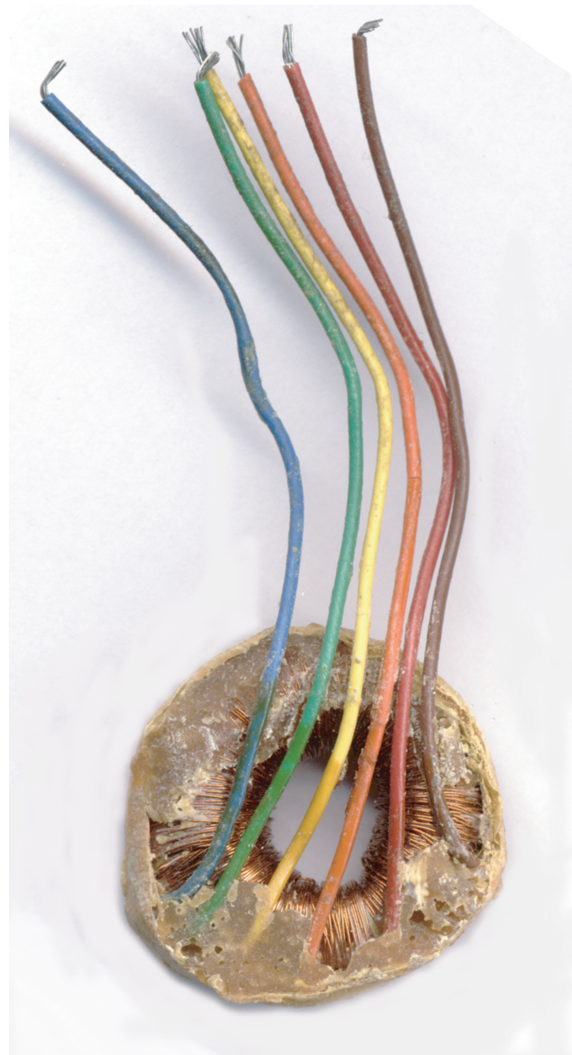


Fig 1. Original Pultec EQP-1A toroid coil. It is about 1" in diameter.

The earlier inductor based equalizers were basically a mathematical nightmare for the design engineer working mainly from a slide rule. The designs were often specific to certain applications that many times required very accurate signal modification. Filters were often several stages and very complex response curves could be obtained. Since filters similar to the types used in audio signal chains are used in many other fields of engineering, text books on the subject can be very intimidating. The number of equations can be daunting and finding the one(s) specific to one particular application can take time and patience.

Pultec EQP-1A Facts & Fiction

In the late 1920's radio was king and "talking" movies were just on the horizon. The Western Electric company was wiring the US for reliable telephone communications. In an effort to modify sound going through telephone lines WE developed the 1A equalizer. It has been asserted on other web resources that this unit was designed in the 1930's but that is not the case. A brief description of the 1A can be found on page 385 in Sterling's "The Radio Manual" 1st ed., along with a simplified schematic. That ed. of The Radio Manual has a 1928 copyright. As a side note the term "equalizer" for an audio filter was already in use by that date. A scan of the Western Electric 1A description can be found on page 7.

The first thing to understand about the EQP-1A is that, although the passive EQ circuit was licensed under patents belonging to Western Electric, the exact circuit was not designed by WE. This is true of most non WE products that bear licensing tags referencing WE patents. Western Electric not only patented their circuits but also the principles involved. So if, for instance, you were an amplifier manufacturer in the 50's and your design utilized negative feedback, you had to pay a licensing fee because such a technique was pioneered by WE.

So when you see WE patent tags on old vintage gear that does not mean that Western Electric engineers designed the circuit, it just means that techniques first patented by WE were incorporated in the design. This is the case with the EQP-1A which actually uses a slightly more basic circuit than the original Western Electric 1A. Western Electric was most concerned with simply retaining the control over their licensed information so the licensing terms were usually quite affordable which is why so many small companies were able to manufacture profitably even after the licensing fees.

Fig 2. The upper two photos are of an actual Western Electric 1A. The lower two are another similar WE equalizer model 17C (I think). These photos are from e-bay and regrettably I do not know who took the shots.

Pultec EQP-1A Facts & Fiction

The first Pultec EQP filters bore a little more resemblance to the original WE-1A circuit than the later tapped coil versions. They utilized two non tapped toroidal inductors which were switched together with the correct capacitors to obtain the correct responses. Later is was determined that a tapped single inductor was a more efficient way to do it and most EQP-1A's and A3's had the tapped coils. The schematic for the original early two inductor version of the Pultec EQP-1A can be found on page 8. The modern filter version can be found in the ProAudio manual collection at VintageWindings.com.

There is so much lore on the web regarding the filters used in the EQP series it's hard to know where to start debugging all of it. First, the most popular filter schematic on the web has been modified to accommodate capacitor values that are readily available today. The actual filter details from an original EQP-1A filter that I had on my bench can be found on page 9. I included all of the cap types. Most of the Pultec filters that I have worked on used Aerovox V161, Aerovox Duranite, and Sangamo MICA caps. While many of Pultecs' caps were purchased out of the standard Aerovox catalog, a good portion were purchased surplus and when you open Pultec filters you can find some very weird non-standard cap values. You will also find many substitutions that are only *relatively* close to the specified values. Not all Pultec EQP filters are the same, even from the same era and if you do the math for all of the values most Pultecs are 5-20% away from their advertised specifications.

The capacitor choices were not made because the capacitors were sprinkled with fairy dust from a thousand magic sound making virgins. The inductors were mostly paired with MICA caps. At the time MICA caps were industry standard for applications where stability is paramount. They didn't have magic sound, they were just very stable over time and temperature. The MICA caps Pultec used were mostly Sangamo's and the catalog information is on page 12. Today, from a distortion (sound), and stability point of view, polystyrene and polypropylene caps are technically the best to use in filter applications. Cyril Bateman wrote several excellent multi-part articles on capacitor sound that I highly recommend reading. Bateman spent his career in the capacitor manufacturing business and he knows how to separate facts from fiction. I should also point out that capacitor manufacture has actually improved as have the materials that are used to make them. If you think that spending $300 and a year finding original type caps will give you more aural satisfaction than a nice set of polystyrenes/polypropylenes you may want to think again. Original capacitor specifications for Aerovox V161 and Aerovox Duranite capacitors can be found on pages 10 & 11. Aerovox V161's are made of Mylar film and were probably chosen for their durability and stability over time. Again, polypropylenes and polystyrenes are technically better choices. One thing that I can say for V161's and Sangamos is that they are robust capacitors. After opening multiple Pultec filter cases it has become apparent to me that the potting wax that Pultec used had too high of melting point. I have opened up cases that have had capacitors that were melted beyond recognition. An example of this can be seen in the photo in **figure 3** on the next page. This filter is from a Pultec EQH-2 and some of the caps were severely damaged during potting. I have found that this is the reason that many Pultec filters fail. Most often the toroid coils are usually still continuous. Many of the caps in the photo are still in spec. which speaks to the quality of US made products from the era. The Sangamo MICA caps survived the potting process slightly better. I'm not sure why but the Aerovox and Sangamo catalogs are the same format and are copyrighted by the same U.C.P. Inc. I'm not sure if the two companies had any other affiliation.

Pultec EQP-1A Facts & Fiction

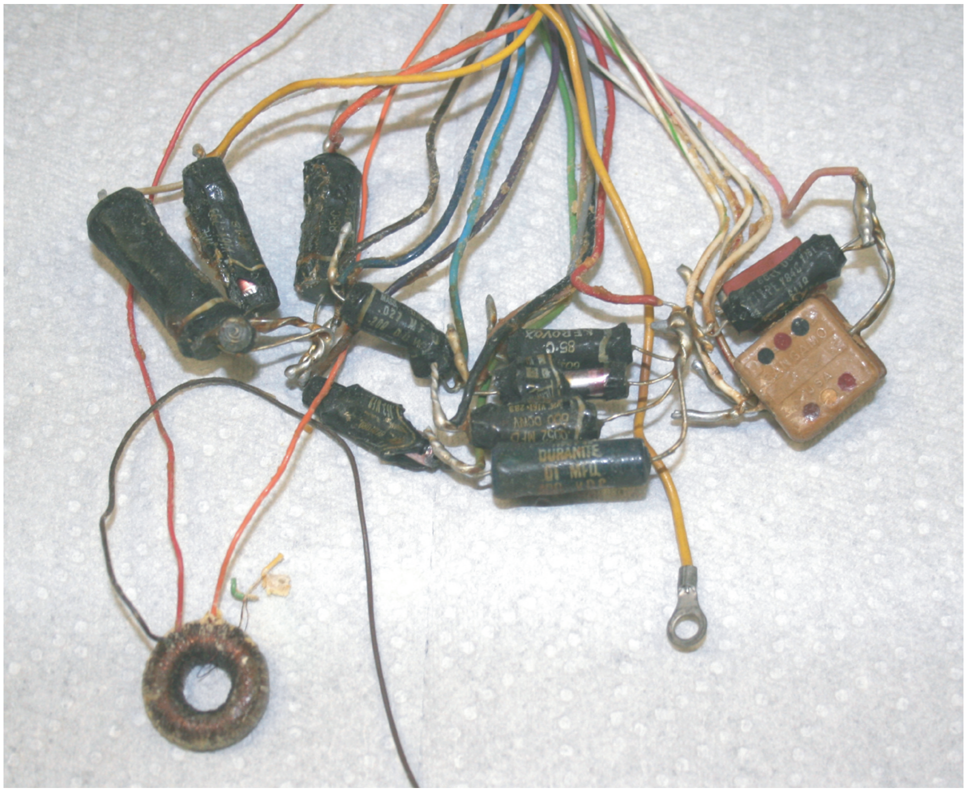


Fig 4. Here is what was removed from an original Pultec EQH-2 filter case. The capacitors were severely damaged by excessive heat used during the potting process. In order to remove the components from the case without damaging them further, the outside of the case is heated via a heat gun which softens the wax next to the sides. The complete wax enclosed unit slides out of the case and the rest of the wax is removed very carefully by hand pealing. This is the same sort of trap inside the EQP-1A case. The parts were just tossed in the case and the inductor was wrapped in Mu metal foil.

The original filter vs. the modern design.

The most important thing to keep in mind is that it is the mathematical association between the components that creates the resonant circuit. As long as the association between the values is the same, the values don't have to be. Put another way in an LCR series resonant circuit that needs to resonate at 6K you can use an inductance of 85mH and a capacitance of .0082uF which gives a frequency of 6028.42 Hz. (the R determines the slope or bandwidth). The same frequency point can be achieved with an inductance of 38.7mH and a capacitance of .018uF which will resonate at 6030.15 Hz. That is how resonant circuits work. It's just math, not magic.

As long as quality parts are used the values are changeable without affecting the sound. There is no perceivable sound difference between the original component values and the modern equivalent circuit as long as the component quality is comparable. Here is a great LCR calculator that I recommend to people wanting custom coils. http://www.calctool.org/CALC/eng/electronics/RLC_circuit

The toroid coil:

The toroid for the Pultec EQP-1A utilizes a small MPP core. There is much fervor on the web regarding it's size and the fact that it ***can*** be driven into saturation. The notion that saturating the inductor has anything to do with the sonic gratification associated with the EQP is complete nonsense. Under very extreme circumstances the inductor can saturate and when it does the resulting sound can not possibly be confused with good sound in any way. When an inductor saturates it rings. It can ring at the coil's inherent resonant frequency (and/or harmonics thereof) which is virtually always different from the resonance of the LCR circuit it is used in, or, it can ring at the resonance frequency of the LCR circuit, or, harmonics of the resonant circuit frequency, or, at all the above. Inductor saturation never sounds good. Western Electric grossly over sized their inductor coils specifically to avoid saturation. I incorporate that philosophy in my Vintage Windings EQP replacement toroids. I'm most interested in making the highest quality filter and use MPP cores that will not saturate under any condition that they will operate at in a line EQ. This means you can max the controls and the only components that will saturate are the transformers if the signal is too hot. That type of operation ***can*** sound good. Pultec used a small core because a larger one was more expensive, not because it sounded better.

What is it that makes the EQP sound so good? Aside from the lack of phasing issues, it is a matter of the whole being greater than the sum of parts. Even though transformers tend to get a bad rap in certain audio circles, it can be argued that most of the absolute best sounding audio gear have them. Many iconic pieces of gear, like the Fairchild 660/670, are loaded with transformers. Good transformers provide superb isolation between stages but they also take the edge off of the signal going through them. That is why some hard core audiophiles pay up to six figures for early Western Electric amplifiers, most of which had transformers between each stage. When an audio transformer is properly designed for a circuit it can provide a very slight +soft focus+ effect on the sound which many humans find very appealing. The bad press that transformers get has much more to do with manufacturers not wanting to shell out the money or have the added weight in their products. If you bash the transformer then it's a good thing that it is not used in your design. Transformers are still the only way to achieve absolute isolation to the best of my knowledge. The tube version of the EQP-1A used three transformers and the solid state version used two. The tube EQP-1A and it's variants used a Triad HS-56, Triad, HS-29, and a Peerless S-217-D. The two Triad transformers are very good quality and the S-217-D could be the best output transformer for 12AU7 triodes that was ever produced. During the late 1950's and early 60's it became fashionable to use an extra winding on the output transformer which was used for feedback. This trick was not new, the BBC had been using the technique since the 40's and manufacturers like Langevin, Universal Audio, RCA, and several others also made small signal audio amplifiers utilizing a tertiary winding for feedback. Incidentally, the Langevin TF-322-B is also a great output transformer but can't be used in the Pultec circuit because it is a 10K - 150/600 unit. The S-217-D is a 12,500 - 75/150/300/600 transformer.

The line amp in a tube version of the EQP adds "happiness" to a signal without the EQ. It could easily be argued that having three transformers in a circuit does color the sound somewhat, however, just as certain colors are more pleasing to the human eye, certain sound coloration can also be pleasing to the ear. The Fairchild 660 is an example of this and the Pultec EQP series is another classic example. In the case of the Pultecs the euphoric sound most mistakenly associated with a saturated inductor is actually, for the most part, caused by the interaction of all of the transformers in the circuit and a well designed, simple, line amp. The reality of a well designed LCR circuit is that if quality parts are used, the filter design is good, the transformers are of high quality and the gain amp is good, the unit will sound excellent. There are absolutely no magic component values, no magic parts, no magic fairy dust to sprinkle.

A word about bandwidth

The bandwidth of the type of LCR topography used in the EQPs is determined by the R of the resonant circuit. That is determined by the dc resistance of the inductor plus any extra resistors in series with it and it's associated cap. (this is for a series resonant circuit). In an LCR circuit without a bandwidth pot, like a Sphere 900, it is important to try to match the original inductor resistance as closely as possible. That will retain the original bell curve and bandwidth. In the case of the EQP series there is a bandwidth pot in series with whichever frequency is selected. So, as long as the inductor has a resistance the same as the original or ***less*** it will work fine in the circuit. Having a coil with less resistance actually makes the unit a little more versatile. The lower the resistance, the higher the coil Q and the tighter the curve (narrower bandwidth). This can make the EQ work more like a notch filter when the bandwidth pot is at it's minimum and when the resistance from the pot is added the unit will still provide all of the original curve widths. Technically, the higher Q coil makes the most efficient LCR circuit (Transmission Networks and Wave Filters, Shea).

I purposely did not mention ferrite or soft metal inductor cores in this article. That subject is quite complicated and will be given the appropriate attention in a separate paper. Suffice to say here that MPP cores were originally developed by Western Electric specifically for audio (and related) filter coils. It is still the best, and subsequently most expensive core material for that application. The cost of MPP cores goes up exponentially as it's permeability goes up. A 1.4" core with a permeability of 125 costs around $7.00 US but the same size core with a perm. of 600 is about $40.00!! (and harder to source). Ferrite toroid cores are much less expensive. I only use ferrites in circuits that originally used them and have reasons for my poor regard for them. The problem with MPP cores is that higher value inductors need high perm cores in order to keep the dc R low and they often have to be wound with special winding techniques to keep the capacitive leakage low. The capacity of an inductor is part of the overall capacity of the LCR circuit so it should be made as low as possible.

Conclusion:

The EQP series EQs are as useful today as they were 65 years ago and the same can't be said for very many products produced that many years past. Is the sound worth shelling out huge dollars for a vintage model? Well it sure doesn't hurt having them on your studio's equipment list. If it's really the sound you're after you will be just as satisfied with a recreation as long as good parts and a high level of build quality is implemented. That also goes for the SS version. A good LCR EQ or two can make a good recording really shine. EQ's can't make a bad recording better, they can only help the sound.

Note:

* There are good explanations of this in many text books. A couple good examples can be found in Douglas Self's "Small Signal Audio Design" which should be in any ProAudio enthusiast's book collection and Steve Dove's incredible series of articles that appeared in Studio Sound mag on studio console design. The later is available at VintageWindings.com on the ProAudio manuals page.

59. 1-A Equalizer—This equalizer is used to correct the frequency characteristic of one of the telephone lines by forming a shunt which affords a variable impedance for different frequencies. The shunt is composed of a variable resistance connected in series with a parallel circuit of inductance and capacity. The inductance forms a low impedance for the low frequencies so that the shunt is practically equal to the fixed resistance for low frequencies. As the frequency goes up, the shunt goes up in impedance, due to the increased inductive reactance, until the inductance and capacity resonate when the shunt impedance is a maximum. Two coils are provided with a key to connect either one or the other of them in the circuit. These circuits are good for equalizing frequencies up to 3000 and 5000 cycles respectively and the key is marked for these frequencies. Equalizing frequencies up to 3000 cycles introduces a loss at 1000 cycles of about 6 TU and equalizing to 5000 cycles causes a loss of about 10 TU. The series resistance is adjusted by a key which throws 1000 ohms in and out and 3 dial rheostats controlling 1110 ohms in steps of 1 ohm. This gives a continuous range of 2110 ohms in steps of 1 ohm.

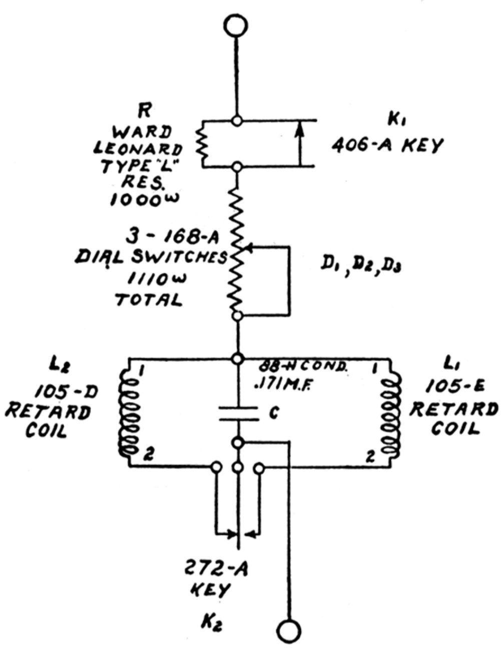


Fig. 218. Simplified Circuit of 1-A Equalizer.

Before connecting the equalizer to a line, the line should be tested to see that it is continuous and not shorted and that neither side is grounded. A 1-A equalizer is adjusted approximately by setting the resistance according to the attenuation of the line to be equalized as shown by the curve, figure 219. If the attenuation of the line is not known, or if this approximate adjustment is not satisfactory, it will be necessary to take gain-frequency characteristics of the line, using several values of equalizer resistance. As this operation requires the use of additional apparatus, it is suggested that the customer engage the service of the telephone company supplying the lines.

Fig 2. The Western Electric EQ-1A as described in the 1928 1st Ed. of The Radio Manual.

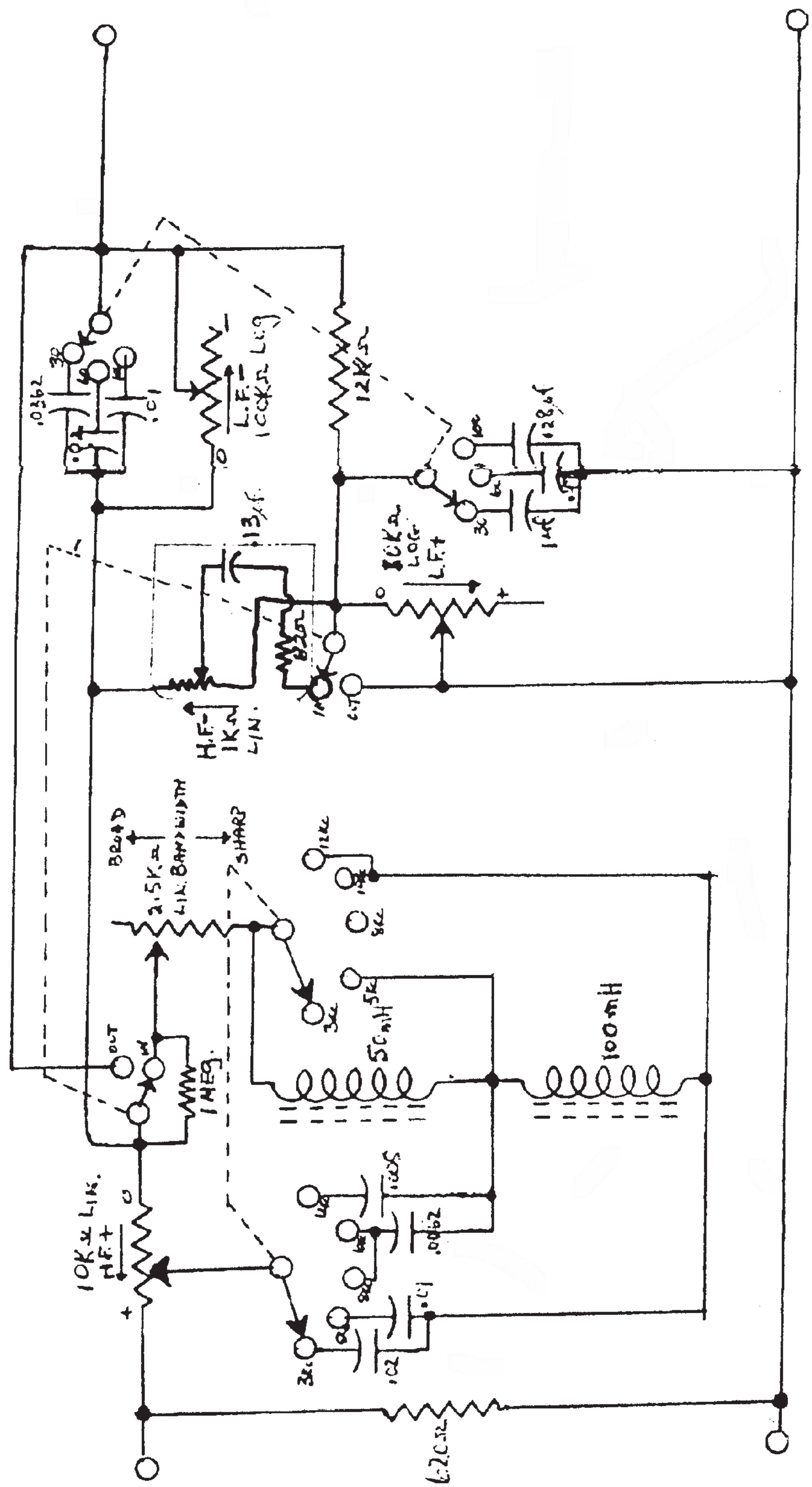


Fig 2. The Original EQP-1A two inductor version. Author unknown.

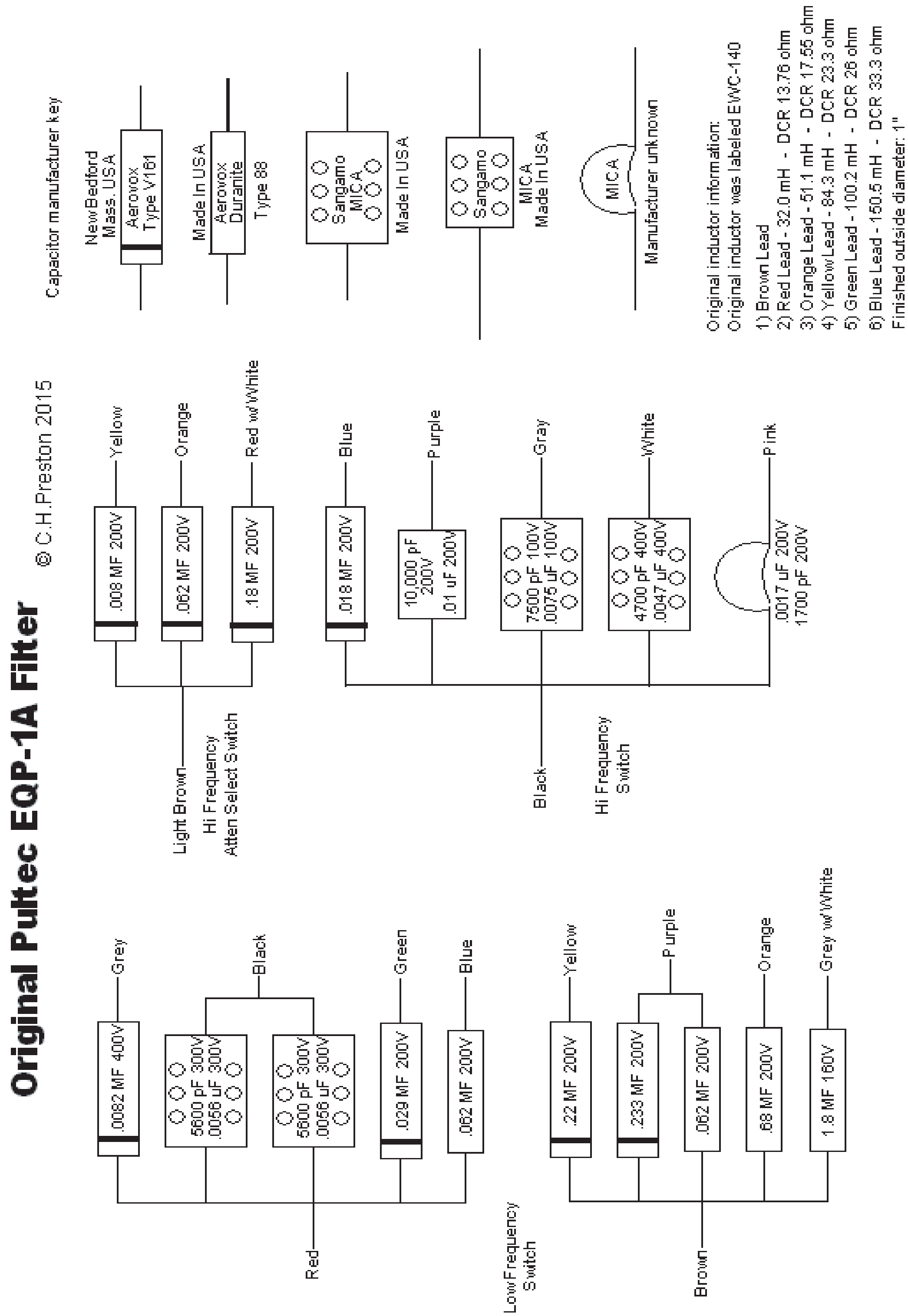


Fig 2. The later Original EQP-1A filter units utilizing one toroid coil .
This version is the most common EQP filter.

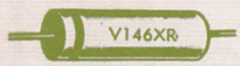
SECTION 1500

AEROVOX

CAPACITORS

PAPER CAPACITORS (cont.)

TYPE V146XR AEROFILM® "WRAP AND FILL" MYLAR CAPACITORS



Miniature, mylar, tubular capacitor sections, extended foil construction, wrapped with a synthetic film and end-sealed with a plastic resin.

These units offer high insulation resistance, high operating temperature, low power factor and outstanding resistance to moisture.

Ideal for use in miniaturized circuits where size and weight are important factors.

Operating Temperature Range: Capable of operation in a temperature range of —65°C to +85°C at full voltage rating and to 125°C with voltage derating as follows:

DC Rated Voltage at 85°C	Maximum DC Working Voltage at 125°C
150	100
200	125
400	200
600	300

Leads: solder-coated "copper-weld" wire, 2" minimum length. Over .375 diameter #20AWG (.032) .375 and smaller #22AWG (.025).

Tolerance: Standard ±10%. Available in closer tolerances on special order.

For Full technical information request bulletin NPJ-121

STOCK LISTING

Capacity In Mfd.	150 VDC D L	Cat. No.	Net Price*	200 VDC D L	Cat. No.	Net Price*	400 VDC D L	Cat. No.	Net Price*	600 VDC D L	Cat. No.	Net Price*
.001	See Note 1			.156 x 1/2	V146XR-16	.21	156 x 5/8	V146XR-37	.21	.156 x 3/4	V146XR-58	.24
.0015	See Note 1			.156 x 1/2	V146XR-17	.21	.156 x 5/8	V146XR38	.21	.171 x 3/4	V146XR-59	.24
.0022	See Note 1			.156 x 1/2	V146XR-18	.21	.156 x 5/8	V146XR-39	.21	.187 x 3/4	V146XR-60	.24
.0033	See Note 1			.156 x 1/2	V146XR-19	.21	.156 x 5/8	V146XR-40	.24	.203 x 3/4	V146XR-61	.24
.0047	See Note 1			.156 x 1/2	V146XR-20	.21	.187 x 5/8	V146XR-41	.24	.234 x 3/4	V146XR-62	.27
.0068	See Note 1			.156 x 1/2	V146XR-21	.21	.218 x 5/8	V146XR-42	.24	.265 x 3/4	V146XR-63	.27
.01	.156 x ½	V146XR- 1	.21	.171 x 1/2	V146XR-22	.21	.250 x 5/8	V146XR-43	.27	.312 x 3/4	V146XR-64	.30
.015	.187 x ½	V146XR- 2	.21	.203 x 1/2	V146XR-23	.21	.296 x 5/8	V146XR-44	.27	.312 x 7/8	V146XR-65	.30
.022	.203 x 5/8	V146XR- 3	.24	.250 x 5/8	V146XR-24	.24	.312 x 3/4	V146XR-45	.27	.375 x 7/8	V146XR-66	.30
.033	.218 x 5/8	V146XR- 4	.24	.250 x 3/4	V146XR-25	.24	.312 x 7/8	V146XR-46	.27	.406 x 1	V146XR-67	.30
.047	.234 x 3/4	V146XR- 5	.27	.296 x 3/4	V146XR-26	.27	.343 x 7/8	V146XR-47	.30	.453 x 1	V146XR-68	.33
.068	.265 x 3/4	V146XR- 6	.27	.343 x 3/4	V146XR-27	.27	.375 x 1	V146XR-48	.33	.531 x 1	V146XR-69	.36
.1	.281 x 7/8	V146XR- 7	.36	.375 x 7/8	V146XR-28	.36	.421 x 1	V146XR-49	.33	.562 x 1-3/8	V146XR-70	.42
.15	.328 x 7/8	V146XR- 8	.36	.453 x 7/8	V146XR-29	.36	.468 x 1-1/4	V146XR-50	.36	.671 x 1-3/8	V146XR-71	.45
.22	.385 x 1	V146XR- 9	.39	.438 x 1-1/8	V146XR-30	.39	.546 x 1-3/8	V146XR-51	.42	.718 x 1-5/8	V146XR-72	.51
.33	.375 x 1-1/8	V146XR-10	.45	.484 x 1-1/8	V146XR-31	45	.593 x 1-5/8	V146XR 52	.66	.765 x 2	V146XR-73	.90
.47	.468 x 1-1/4	V146XR-11	.51	.546 x 1-1/4	V146XR-32	.51	.671 x 1-5/8	V146XR-53	.78	.859 x 2	V146XR-74	1.14
.68	.562 x 1-1/4	V146XR-12	.57	.609 x 1-5/8	V146XR-33	.57	.796 x 1-3/4	V146XR-54	.96	1.016 x 2	V146XR-75	1.53
1.0	.593 x 1-1/2	V146XR-13	.87	.671 x 1-3/4	V146XR-34	.87	.812 x 2	V146XR-55	1.20	1.125 x 2-1/2	V146XR-76	2.55
1.5	.718 x 1-3/4	V146XR-14	1.23	.828 x 1-3/4	V146XR-35	1.23	.921 x 2-1/4	V146XR-56	1.56	1.234 x 3	V146XR-77	3.48
2.0	.812 x 1-3/4	V146XR-15	1.50	.875 x 1-7/8	V146XR-36	1.50	1.093 x 2-1/4	V146XR-57	2.04	1.421 x 3	V146XR-78	4.38

Note 1: These capacity values are only made at 200 VDC or higher.
The 200 VDC unit may be used for lower voltage requirements since sizes are as small as or smaller than competitive 100 VDC units.
*Request O.E.M. prices in the following quantities: 25-49, 50-99, 100-499

® Registered Trademark

TYPE V161

AEROFILM® (MYLAR*) CAPACITORS

V161 Aerofilm Tubular Capacitors are high quality units in Polycap® cases. These units have exceptionally high insulation resistance and low dielectric absorption and power factor. They are extremely stable having a relatively small capacitance change with temperature variations over a range of 0 to 85°C.
Their excellent resistance to humidity and moisture are due to the use of Aerofilm (Aerovox's trade name for Mylar* polyester film), finest quality casing material, and an epoxy end fill which will not flow, soften or melt at any operating temperature. Standard tolerance is ±20% but also available in ±5% and ±10%.

Cap. Mfd.	Size	Net Price*
	200 VDCW	
.0047	9/32 x 15/16	$.15
.0068	9/32 x 15/16	.15
.01	9/32 x 15/16	.15
.015	9/32 x 15/16	.15
.022	5/16 x 1	.15
.033	5/16 x 1	.15
.047	5/16 x 1-1/16	.15
.05	5/16 x 1-1/16	.15
.068	11/32 x 1-1/16	.18
.1	3/8 x 1¼	.21
.15	13/32 x 1¼	.24
.22	½ x 1¼	.24
.25	½ x 1¼	.27
.33	½ x 1½	.33
.47	9/16 x 1½	.39
.68	19/32 x 1¼	.51
1.0	13/16 x 1-7/8	.57
	400 VDCW	
.0015	9/32 x 15/16	.15
.0022	9/32 x 15/16	.15
.0033	9/32 x 15/16	.15

Cap. Mfd.	Size	Net Price*
.0047	9/32 x 15/16	$.15
.0068	9/32 x 15/16	.15
.01	5/16 x 1	.15
.015	5/16 x 1	.15
.02	5/16 x 1-1/16	.15
.022	11/32 x 1-1/16	.15
.03	3/8 x 1-1/16	.18
.033	3/8 x 1-1/16	.18
.047	3/8 x 1¼	.18
.05	3/8 x 1¼	.18
.068	7/16 x 1¼	.21
.1	½ x 1¼	.21
.15	9/16 x 1½	.36
.22	9/16 x 1½	.39
.25	9/16 x 1¾	.39
.33	5/8 x 1¾	.51
.47	11/16 x 2	.66
.5	11/16 x 2	.69
.68	25/32 x 2	.87
1.0	7/8 x 2-1/8	1.05
	600 VDCW	
.001	9/32 x 15/16	.15
.0015	9/32 x 15/16	.15
.002	9/32 x 15/16	.15
.0022	9/32 x 15/16	.15

Cap. Mfd.	Size	Net Price*
.003	9/32 x 15/16	$.15
.0033	9/32 x 15/16	.15
.004	5/16 x 1	.15
.0047	5/16 x 1	.15
.005	5/16 x 1	.15
.0068	5/16 x 1	.18
.01	11/32 x 1-1/16	.18
.015	3/8 x 1-3/16	.18
.02	3/8 x 1-3/16	.18
.022	13/32 x 1-3/16	.18
.03	7/16 x 1-3/16	.21
.033	7/16 x 1-3/16	.21
.04	½ x 1¼	.24
.047	½ x 1¼	.24
.05	½ x 1¼	.24
.068	½ x 1½	.27
.075	½ x 1½	.27
.1	9/16 x 1½	.30
.15	5/8 x 1-5/8	.39
.2	23/32 x 1-5/8	.48
.22	¾ x 1-5/8	.51
.25	¾ x 1¾	.54
.33	13/16 x 1-7/8	.78
.47	7/8 x 2-1/8	.84
.5	7/8 x 2-1/8	.87

Cap. Mfd.	Size	Net Price*
	1000 VDCW	
.001	9/32 x 15/16	.30
.0012	9/32 x 15/16	.30
.0015	9/32 x 15/16	.30
.0018	9/32 x 15/16	.30
.002	9/32 x 15/16	.30
.0022	9/32 x 15/16	.30
.0033	5/16 x 1	.30
.0039	5/16 x 1	.30
.0047	5/16 x 1	.30
.0068	11/32 x 1-1/16	.30
.01	3/8 x 1-1/16	.30
.018	7/16 x 1-1/4	.36
.022	7/16 x 1-1/4	.36
.025	1/2 x 1-1/4	.36
.027	1/2 x 1-1/4	.36
.033	1/2 x 1-1/4	.36
.039	1/2 x 1-1/2	.36
.047	1/2 x 1-1/2	.42
.056	9/16 x 1-5/8	.45
.068	9/16 x 1-5/8	.48
.075	5/8 x 1-5/8	.51
.1	11/16 x 1-7/8	.54
.15	13/16 x 1-7/8	.66

*Dupont trademark

*Request O.E.M. Prices in the following quantities: 25-49, 50-99, 100-249

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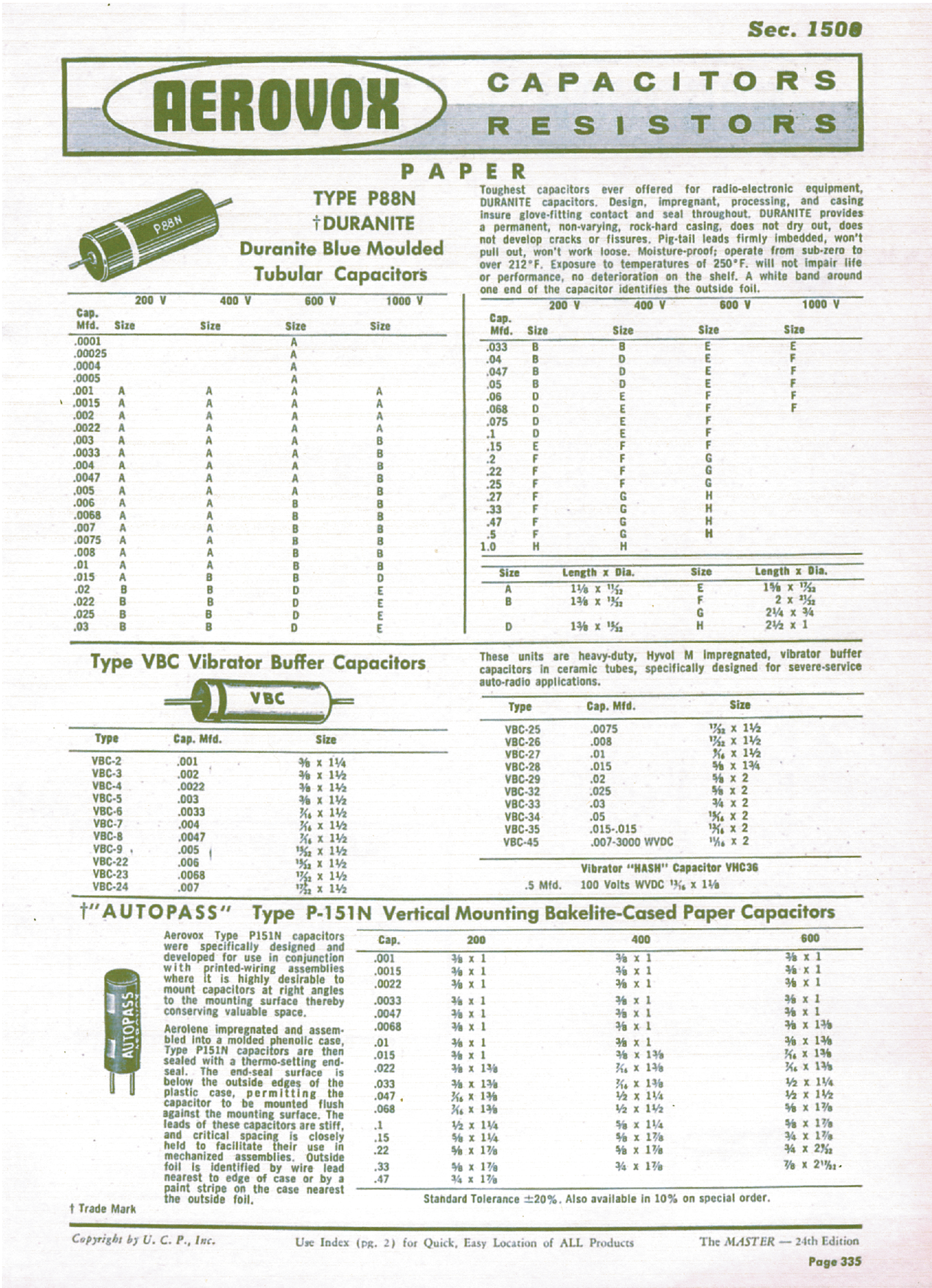
Fig 2. The Aerovox V161 capacitor info. from their 1966 catalog .



Sec. 1500

AEROVOX CAPACITORS RESISTORS

PAPER

TYPE P88N
†DURANITE
Duranite Blue Moulded Tubular Capacitors

Toughest capacitors ever offered for radio-electronic equipment, DURANITE capacitors. Design, impregnant, processing, and casing insure glove-fitting contact and seal throughout. DURANITE provides a permanent, non-varying, rock-hard casing, does not dry out, does not develop cracks or fissures. Pig-tail leads firmly imbedded, won't pull out, won't work loose. Moisture-proof; operate from sub-zero to over 212°F. Exposure to temperatures of 250°F. will not impair life or performance, no deterioration on the shelf. A white band around one end of the capacitor identifies the outside foil.

	200 V	400 V	600 V	1000 V
Cap. Mfd.	Size	Size	Size	Size
.0001			A	
.00025			A	
.0004			A	
.0005			A	
.001	A	A	A	A
.0015	A	A	A	A
.002	A	A	A	A
.0022	A	A	A	A
.003	A	A	A	B
.0033	A	A	A	B
.004	A	A	A	B
.0047	A	A	A	B
.005	A	A	A	B
.006	A	A	B	B
.0068	A	A	B	B
.007	A	A	B	B
.0075	A	A	B	B
.008	A	A	B	B
.01	A	A	B	B
.015	A	B	B	D
.02	B	B	D	E
.022	B	B	D	E
.025	B	B	D	E
.03	B	B	D	E
.033	B	B	E	E
.04	B	D	E	F
.047	B	D	E	F
.05	B	D	E	F
.06	D	E	F	F
.068	D	E	F	F
.075	D	E	F	
.1	D	E	F	
.15	E	F	F	
.2	F	F	G	
.22	F	F	G	
.25	F	F	G	
.27	F	G	H	
.33	F	G	H	
.47	F	G	H	
.5	F	G	H	
1.0	H	H		

Size	Length x Dia.	Size	Length x Dia.
A	1 1/8 x 11/32	E	1 5/8 x 17/32
B	1 3/8 x 13/32	F	2 x 21/32
		G	2 1/4 x 3/4
D	1 3/8 x 15/32	H	2 1/2 x 1

Type VBC Vibrator Buffer Capacitors

These units are heavy-duty, Hyvol M impregnated, vibrator buffer capacitors in ceramic tubes, specifically designed for severe-service auto-radio applications.

Type	Cap. Mfd.	Size
VBC-2	.001	3/8 x 1 1/4
VBC-3	.002	3/8 x 1 1/2
VBC-4	.0022	3/8 x 1 1/2
VBC-5	.003	3/8 x 1 1/2
VBC-6	.0033	7/16 x 1 1/2
VBC-7	.004	7/16 x 1 1/2
VBC-8	.0047	7/16 x 1 1/2
VBC-9	.005	15/32 x 1 1/2
VBC-22	.006	15/32 x 1 1/2
VBC-23	.0068	17/32 x 1 1/2
VBC-24	.007	17/32 x 1 1/2
VBC-25	.0075	17/32 x 1 1/2
VBC-26	.008	17/32 x 1 1/2
VBC-27	.01	9/16 x 1 1/2
VBC-28	.015	5/8 x 1 3/4
VBC-29	.02	5/8 x 2
VBC-32	.025	5/8 x 2
VBC-33	.03	3/4 x 2
VBC-34	.05	15/16 x 2
VBC-35	.015-.015	13/16 x 2
VBC-45	.007-3000 WVDC	11/16 x 2

Vibrator "HASH" Capacitor VHC36

.5 Mfd. 100 Volts WVDC 13/16 x 1 1/8

†"AUTOPASS" Type P-151N Vertical Mounting Bakelite-Cased Paper Capacitors

Aerovox Type P151N capacitors were specifically designed and developed for use in conjunction with printed-wiring assemblies where it is highly desirable to mount capacitors at right angles to the mounting surface thereby conserving valuable space.

Aerolene impregnated and assembled into a molded phenolic case, Type P151N capacitors are then sealed with a thermo-setting end-seal. The end-seal surface is below the outside edges of the plastic case, permitting the capacitor to be mounted flush against the mounting surface. The leads of these capacitors are stiff, and critical spacing is closely held to facilitate their use in mechanized assemblies. Outside foil is identified by wire lead nearest to edge of case or by a paint stripe on the case nearest the outside foil.

Cap.	200	400	600
.001	3/8 x 1	3/8 x 1	3/8 x 1
.0015	3/8 x 1	3/8 x 1	3/8 x 1
.0022	3/8 x 1	3/8 x 1	3/8 x 1
.0033	3/8 x 1	3/8 x 1	3/8 x 1
.0047	3/8 x 1	3/8 x 1	3/8 x 1
.0068	3/8 x 1	3/8 x 1	3/8 x 1 3/8
.01	3/8 x 1	3/8 x 1	3/8 x 1 3/8
.015	3/8 x 1	3/8 x 1 3/8	7/16 x 1 3/8
.022	3/8 x 1 3/8	7/16 x 1 3/8	7/16 x 1 3/8
.033	3/8 x 1 3/8	7/16 x 1 3/8	1/2 x 1 1/4
.047	7/16 x 1 3/8	1/2 x 1 1/4	1/2 x 1 1/2
.068	7/16 x 1 3/8	1/2 x 1 1/2	5/8 x 1 7/8
.1	1/2 x 1 1/4	5/8 x 1 1/4	5/8 x 1 7/8
.15	5/8 x 1 1/4	5/8 x 1 7/8	3/4 x 1 7/8
.22	5/8 x 1 7/8	5/8 x 1 7/8	3/4 x 2 9/32
.33	5/8 x 1 7/8	3/4 x 1 7/8	7/8 x 2 11/32
.47	3/4 x 1 7/8		

Standard Tolerance ±20%. Also available in 10% on special order.

† Trade Mark

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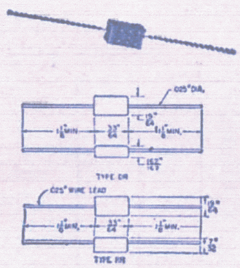
Fig 2. The Aerovox Duranite capacitor info. from their 1966 catalog .

Sec. 1500

SANGAMO CAPACITORS

MICA CAPACITORS



TYPE RR-DR
silvered mica

SANGAMO Mica Capacitors are designed for use in electronic circuits where frequency stability and minimum losses must be maintained. These capacitors are fabricated from the finest India Ruby mica which is rigidly tested to provide the long life, and high factor of safety specified for these units.

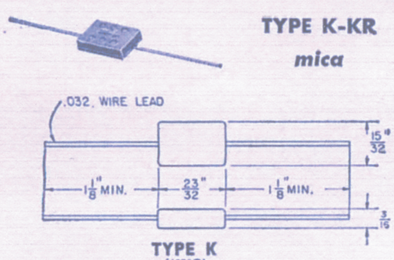
TYPE RR-DR
(125°C)
500 W.V.D.C. 1000 T.V.D.C.

Catalog Number	Capacity Mmfds.	List Price Tolerance		
		5% J	2% G	1% F
		$	$	$
DR-1410	10	.40		
DR-1412	12	.40		
DR-1415	15	.40		
DR-1418	18	.40		
DR-1420	20	.40		
DR-1422	22	.40		
DR-1424	24	.40		
DR-1427	27	.40	.46	
DR-1430	30	.40	.46	
DR-1433	33	.40	.46	

Catalog Number	Capacity Mmfds.	List Price Tolerance		
		5% J	2% G	1% F
DR-1436	36	.40	.46	
DR-1439	39	.40	.46	
DR-1443	43	.40	.46	
DR-1447	47	.40	.46	
DR-1450	50	.40	.46	.50
DR-1451	51	.40	.46	.50
DR-1456	56	.40	.46	.50
DR-1462	62	.40	.46	.50
DR-1468	68	.40	.46	.50
DR-1475	75	.40	.46	.50
DR-1482	82	.45	.52	.56
DR-1491	91	.45	.52	.56
DR-1310	100	.45	.52	.56
DR-1311	110	.45	.52	.56
DR-1312	120	.45	.52	.56
DR-1313	130	.45	.52	.56
DR-1315	150	.45	.52	.56
DR-1316	160	.50	.58	.63
DR-1318	180	.50	.58	.63
DR-1320	200	.50	.58	.63
DR-1322	220	.55	.63	.69
DR-1324	240	.55	.63	.69
DR-1325	250	.55	.63	.69
DR-1327	270	.60	.69	.75
DR-1330	300	.60	.75	.81
RR-1333	330	.65	.75	.81
RR-1336	360	.70	.81	.88
RR-1339	390	.70	.81	.88
*RR-06343	430	.75	.92	1.00
*RR-06347	470	.80	.92	1.00
*RR-06350	500	.80	.92	1.00
*RR-06351	510	.80	.92	1.00

NOTE: * Voltage rating 300 WVDC—(TVDC-600V)
NOTE: Standard Tolerance ±5%, but not less than ±1.0 mmf.
NOTE: Normally supplied in "C" characteristic, available in other characteristics on request.

TYPE K-KR
mica



TYPE K
(125°C)
500 W.V.D.C. 1000 T.V.D.C.

Catalog Number	Capacity Mmfds.	List Price Tolerance		
		M ±20%	K ±10%	J ±5%
K-1550	5	$0.30	$	$
K-1410	10	.30		
K-1412	12	.30	.33	
K-1415	15	.30	.33	
K-1418	18	.30	.33	
K-1420	20	.30	.33	.38
K-1422	22	.30	.33	.38
K-1424	24	.30	.33	.38
K-1427	27	.30	.33	.38
K-1430	30	.30	.33	.38
K-1433	33	.20	.22	.25
K-1436	36	.20	.22	.25
K-1439	39	.20	.22	.25
K-1443	43	.20	.22	.25
K-1447	47	.20	.22	.25
K-1450	50	.20	.22	.25
K-1451	51	.20	.22	.25
K-1456	56	.20	.22	.25
K-1462	62	.20	.22	.25
K-1468	68	.20	.22	.25

Catalog Number	Capacity Mmfds.	List Price Tolerance		
		M ±20%	K ±10%	J ±5%
K-1475	75	.20	.22	.25
K-1482	82	.20	.22	.25
K-1491	91	.20	.22	.25
K-1310	100	.20	.22	.25
K-1312	120	.20	.22	.25
K-1313	130	.25	.28	.31
K-1315	150	.25	.28	.31
K-1316	160	.25	.28	.31
K-1318	180	.25	.28	.31
K-1320	200	.25	.28	.31
K-1322	220	.25	.28	.31
K-1324	240	.30	.33	.38
K-1325	250	.30	.33	.38
K-1327	270	.30	.33	.38
K-1330	300	.30	.33	.38
K-1333	330	.30	.33	.38
K-1336	360	.30	.33	.38
K-1339	390	.30	.33	.38
K-1340	400	.30	.33	.38
K-1343	430	.30	.33	.38
K-1347	470	.30	.33	.38
K-1350	500	.30	.33	.38
K-1351	510	.30	.33	.38
K-1356	560	.35	.39	.44
K-1360	600	.35	.39	.44
K-1362	620	.35	.39	.44
K-1368	680	.35	.39	.44
K-1370	700	.35	.39	.44
K-1375	750	.35	.39	.44
K-1380	800	.35	.39	.44
K-1382	820	.40	.44	.50
K-1390	900	.45	.50	.56
K-1391	910	.45	.50	.56
K-1210	1000	.45	.50	.56

NOTE: Standard Tolerance ±20% but not less than ±1.0 mmf.
NOTE: Normally supplied in "C" characteristic, available in other characteristics on request.

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Fig 2. The Sangamo capacitor info. from their 1960 catalog .