Precision Mica Capacitors in the Grebe Synchrophase

By Leigh Bassett, W3NLB

While examining several mica capacitors from the Grebe Synchrophase receiver (Fig. 1), I was surprised to find that they were manufactured to very tight tolerances. Although the design-nominal values of the parts are unknown, the construction techniques indicate that the tolerance was about ±5 percent.

Construction of the capacitors is very simple: a sandwich of copper plates with interleaved mica insulators, held between two phenolic blocks. Two flat-head screws on 1-inch centers pass up through the copper plates and serve as the electrical contacts on top. The mica insulators extend over both screws.

With one exception, each capacitor consists of several plates connected to each screw, and multiple insulators, like the unit shown in Fig. 1. But the lowest-value capacitor of the small size has only one plate connected to each screw and a single insulator.

Each rectangular copper plate is press-fit over the screw on one end. In the small capacitors (250 pF and smaller), the 0.505-inch by 0.943-inch plates extend about 3/4 of the distance to the other screw (Fig. 2). The large units (1000 pF and larger) have 1-inch by 1.375-inch plates with a clearance hole for the second screw, as shown in Fig. 3.

Mica is not the best choice for the insulator in a capacitor. The naturally-occurring mineral exhibits wide variations in its electrical properties. In particular, the dielectric constant varies from 2 to 9, although it is fairly constant for a given batch of material. Also, the thickness is not easily controlled, since the mineral is built up from many very thin layers which separate or flake off according to their own desires, not to those of the technician building the capacitors.

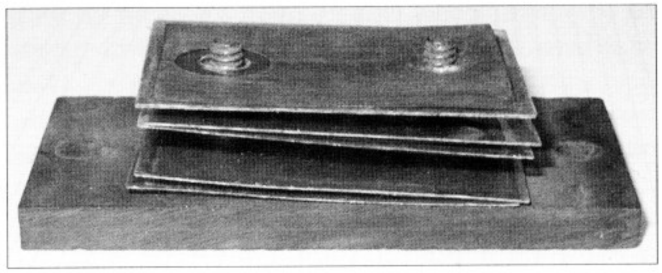

Figure 1. Side view of a typical Grebe capacitor.

To review basic capacitor physics: The capacitance of two parallel plates varies directly with the surface area and inversely with the thickness of the insulator according to the formula (for English units):

$$C = 0.22248 * k * A / t$$

where capacitance C is in microfarads, area A is in square inches, and thickness t is in inches. The dielectric constant k is dimensionless.

The final value of the multi-plate capacitors was set by adjusting the thickness of one or more mica layers, with up to three pieces of mica used in a single layer. A thicker insulator results in lower capacitance. Individual mica insulators in the large-format capacitors measured from 0.0041 to 0.0096 inch in thickness. Individual insulators in the small-format capacitors tended to be a bit thicker, in the range of 0.0075 to 0.0127 inch.

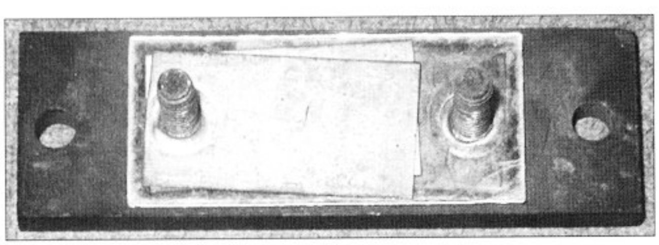

Figure 2. Top view of a small Grebe capacitor.

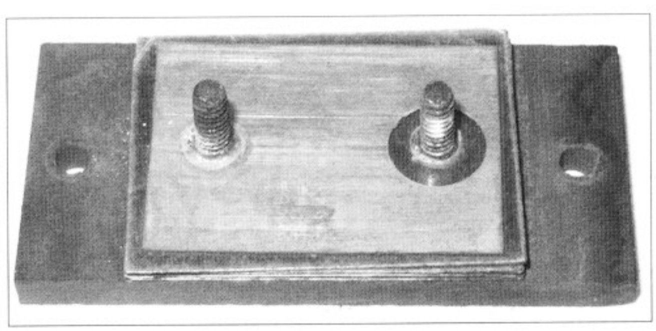

Figure 3. Top view of a large unit.

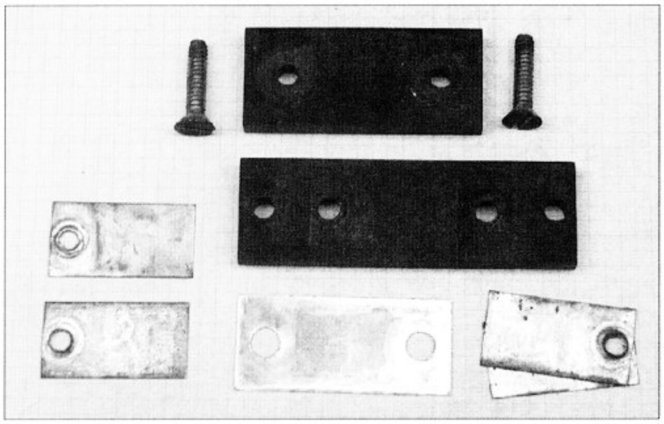

Figure 4. Disassembled Grebe capacitor.

But for the smallest capacitor, the increments provided by insulator selection were too coarse. Finer control was needed to achieve the desired accuracy, so the designers devised a method of adjusting the area of the plates by a small amount. Each plate consists of two copper rectangles with one rotated through a small angle relative to the other. Two standard angles were used: five degrees and ten degrees. By chance or by design, one degree of rotation corresponds to about a one percent increase in surface area. So the two observed rotations correspond to five percent and ten percent increases in both area and capacitance. The disassembled capacitor is shown in Fig. 4.

The intent of this technique is confirmed by studying two examples which have only single copper plates rather than the pairs as described above. These two examples also had the thinnest mica sheets (both measured 0.0098 inch), which would result in the highest capacitance. The values of these parts were taken as the nominal value, since no adjustment was performed. Based on an average measured capacitance of 40.2 pF, the calculated k-value would be 5.5, which is in the middle of the accepted range for mica.

So what was the acceptable error? From three other specimens I observed that:

1) 0.0083 inch was too thin, so a 0.0035-inch insulator was added. The resulting 0.0118-inch insulator was too thick, and a five degree correction was made.

2) One insulator measured 0.0110 inch, with a five degree correction.

3) And one measured 0.0127 inch, for which a ten degree correction was selected. These observations appear to confirm the five percent error limit.

It's interesting to speculate about the processes and techniques required to make these parts. It was obviously very labor intensive. The individual copper and mica components were accurately positioned, indicating that some type of fixture was used for the assembly. Most of the capacitors still measure quite close to their calculated values. The few that were low were easily repaired by turning the screws, thus restoring the electrical contact between the screws and the individual copper plates. It appears that all parts tested would work as well today as the day they left the

---

(Continued from page 10)
read about the process in a book. He prefers to align IFs by ear, just tweaking them for maximum volume. I prefer to connect an analog VOM and tune for maximum deflection of the needle, which I think is more accurate.

The DVD includes slow pans of his fine antique radio collection. Even if you don't pay attention to the technical information, you will enjoy seeing the radios. Menassa has a knack for convincing viewers that restoring radios is fun and not that difficult. More than any book, these two volumes and their "You can learn to do this, too!" upbeat attitude will hopefully encourage new collectors to take the restoration plunge. I think that is their greatest contribution. (Those who purchase the videos and DVDs need to know, though, that not every sentence he utters can be accepted at face value. We three reviewers have not documented every place where a statement could be misleading.) To be a successful radio restorer, you need to read books, too, and have a mentor who can help you when you encounter difficulty. But videos/DVDs like these can certainly be helpful to the novice.

For more information on these videos/DVDs and a streaming video sample of their content, check Bret Menassa's website: www.bretsoldradios.com. The VHS videotape versions are $34.99 each and the DVD versions are $39.99 each. Include $3 shipping and handling to order either one. Or, order *both* volumes for $59.99 VHS or $69.99 DVD, postpaid in the U.S. (Bret's email is bretsoldradios@att.net.)

Bret's Old Radios
PO Box 51671
Denton, TX 76206■