Designing L-C Audio Filters

A nomogram eliminates all math in designing filters

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WITH the two nomograms on page 33 you can design your own audio filters without tedious mathematical calculations. The nomograms are for the *constant-k* filter, a simple but effective type of L-C circuit. The cutoff slopes you will get with them will be almost as sharp as the ideals shown in Fig. 1, depending on the d.c. resistance of the coils you use. For sharpest cutoff use low-resistance coils.

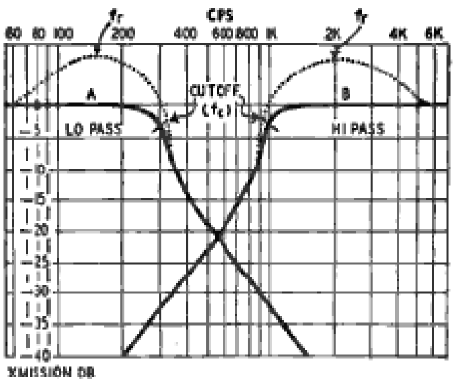


Fig. 1—Dotted lines show how response peaks if terminating resistance is high or absent.

To use the nomograms, first decide what kind of a filter you need. For a phonograph scratch filter, for instance, you might want a low-pass filter which would cut off at 6,000 cycles, leaving all lower frequencies practically untouched. Having decided on a fairly sharp cutoff, choose one of the *full-section* filters shown in Fig. 2. For a cutoff only half as steep as Fig. 1 indicates, you would choose a *half-section*, as in Fig. 3.

Either of the low-pass filters shown in Fig. 2-a, the T or pi, could be used, so you can decide on the basis of economy. A filter with only one choke being cheaper than one with two chokes, the pi filter would be selected.

First determine where the filter is to be placed. It could be in a low-impedance line if one is used, but suppose in this case you decide to place it in the amplifier between two tubes. The only important thing to know here is the resistance load the filter will face.

A filter will work with any load resistance as long as the resistance across the filter's input is equal to or greater than the output load. But it will work best when inserted in a line of uniform impedance—one terminated in the same resistance at both ends.

The resistance-coupled amplifier chart shows that a 6SJ7 (the tube you are using at the input to the filter) will work with a 100,000-ohm plate load resistor and a 100,000-ohm following grid resistor. Because the plate resistance of the pentode is high, its shunting effect on the plate load resistor is negligible and the line between the 6SJ7 plate and the following grid is, in effect, a 100,000-ohm line. If a triode, such as the 6C5, were used with the same resistors, the low plate resistance shunting the plate resistor would bring the net resistance at the input of the filter down far below 100,000 ohms. The circuit is shown in Fig. 4.

To find the values for the coil and capacitors, find a straightedge (transparent plastic rulers with a black line down the center work best) and turn to Nomogram 1. The cutoff frequency you have decided on is 6,000 cycles, and the terminating resistance R (or the nominal impedance of the line) is 100,000 ohms. Place the straightedge, as shown by the dashed line, so that it touches 6,000 cycles in the f_c column and 100,000 ohms in the R column. Then read the value of L from the center scale. Since this is to be a low-pass filter, the calibrations at the right of the center column are used. The value found is 5 henries. Referring back to the original filter diagram in **Fig. 2-a**, note that the choke to be used is marked "L". Therefore, you assign 5 henries to L in Fig. 4.

To find the capacitances, use the same method with Nomogram 2. C, read again from the right center column, is approximately .00055 μf, or 550 $\mu\mu f$.

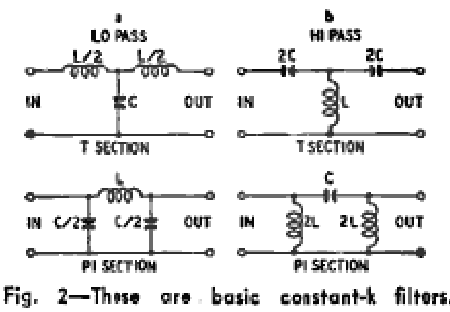


Fig. 2—These are basic constant-k filters.

However, the capacitors in the filter you are using (Fig. 2-a) are marked "C/2". Therefore you divide 550 by 2 and assign the value of 275 $\mu\mu f$ to C1 and C2 in Fig. 4.

And there's your filter!

Constructing coils

The only real problem in making up filters is the inductors. Coils made for filter purposes can be obtained from transformer manufacturers; some even have an inductance which can be varied over a limited range. But these run to anywhere between $5 and $20 or more. A simpler and much less expensive solution is to dig into the junk-box for old audio transformers and chokes.

To find a coil of a certain value, consult a resonance chart and choose a capacitor which will resonate with the desired coil at some audio frequency. For example, the 5-henry choke of Fig. 4 would resonate with a .005-μf capacitor at 1,000 cycles. Try placing various

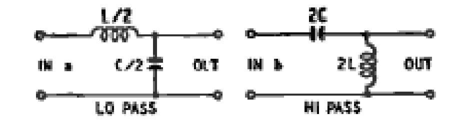


Fig. 3—Half-sections give less sharp cutoff.

coils in series with the capacitor across the output of an audio oscillator, with a vacuum-tube voltmeter also across the oscillator. Choose a coil which will cause the meter to dip at some frequency *lower* than the selected one (lower than 1,000 cycles, in this case). Then start removing core laminations or coil turns (or both) until the meter dip occurs at the desired frequency. To duplicate the conditions under which the coil will operate in the filter, it is a good idea to choose the same capacitors and resonant frequency for this trimming adjustment as will be used in the filter. The resonant frequency is one-half cutoff for a low-pass and twice cutoff for a high-pass filter. For that of Fig. 4, for instance, the 5-henry coil might be selected by placing it in series with 550 $\mu\mu f$ and trimming for a meter dip at 3,000 cycles.

If it is possible, removing turns is the best plan, because the resistance of the coil will make the filter results depart somewhat from the ideal abrupt cutoff. Reducing the resistance by removing wire will raise the coil's Q and help lessen the effect.

If odd-value capacitors are specified, they can be made up by paralleling standard sizes. It should not be necessary to parallel more than two capacitors, since the greater precision obtained with more than two is not worth while.

After the filter is connected, it may be necessary to trim it slightly. This can be done by making further adjustments to the coil. If exact results are wanted, running a series of curves with an audio oscillator and output meter will show just what the filter does.

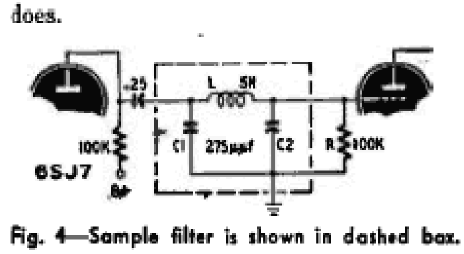
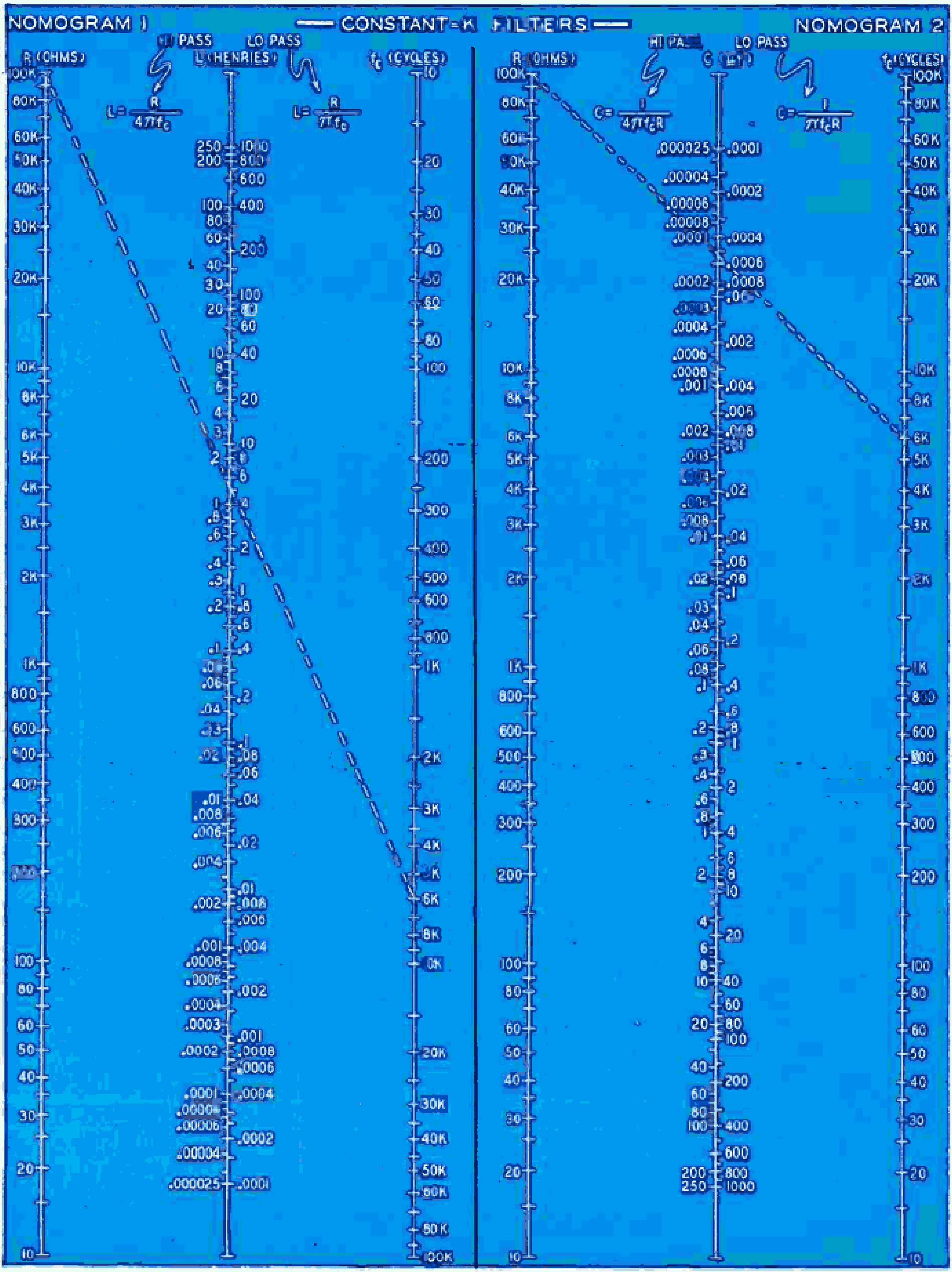


Fig. 4—Sample filter is shown in dashed box.



These nomograms make it possible for you to design audio filters without making calculations. Nomograms were derived from formulas shown.