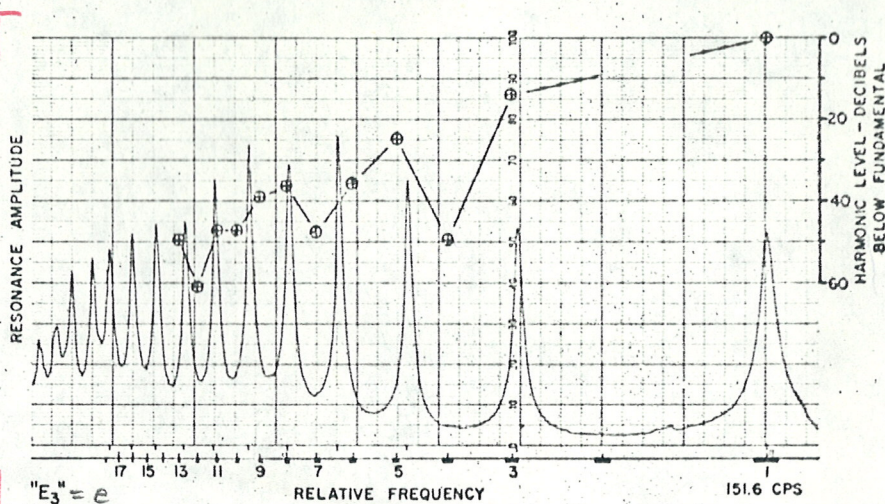


## RESONANCES OF CLARINET

Fig. 6. Composite chart of resonances and harmonic levels of sounded tone for the lowest note "E<sub>3</sub>" on a clarinet.

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hence, as the chart was being made, the gain of the system was increased by factors of 5 and 20 at the points shown, so that the higher harmonics would appear with a reasonable amplitude. It can be seen that, for this simple system, the odd harmonics decrease in amplitude in a very regular way and the even harmonics from four on up are present but are quite weak.

For ease of comparison, the harmonic amplitudes have been converted to harmonic levels below the fundamental and plotted directly on the resonance curves. Thus, the data in Fig. 5 have been replotted in Fig. 3, the levels being positioned directly above the corresponding harmonic marks and referred to the scale on the right; thus, the two curves were arbitrarily matched at the fundamental resonance frequency. For clarity, adjacent points are joined by a line; if a given harmonic has a level too low to plot, the line has a gap in it. It should be noted further that the vertical scale for the resonance curve (on the left) is linear, while that for the harmonic levels is logarithmic. We see from the composite chart of Fig. 3 that the brass tube has an internal standing wave whose odd harmonics decrease in amplitude relatively slowly and in a quite regular

fashion. In fact, the standing-wave structure is somewhat like that of a square wave, which has harmonics diminishing in amplitude as  $1/n$ , so would have harmonic levels given by the line of crosses shown in Fig. 3. When observed on an oscilloscope, the internal pressure variation in the mouthpiece resembles a square wave reasonably well.

### III. MEASUREMENTS ON CLARINETS

With the brass tube as a standard for comparison, we may now plot resonances for an actual clarinet. Figure 6 shows the composite chart for the lowest note "E<sub>3</sub>" on a Selmer Bundy plastic clarinet No. 328723. We see that this note (the lowest in the "chalumeau" register) has some 15 resonances of significant amplitude, fewer than those for the brass tube, and that the discrepancies between resonance frequencies and harmonic frequencies are greater. The resonance frequencies lie below the harmonic frequencies of the lowest resonance by amounts that increase with harmonic number. As a result, the eighth harmonic coincides more nearly with the fifth resonance than does either of the odd harmonics

Fig. 7. Composite chart for the note "F<sub>3</sub>" = f

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