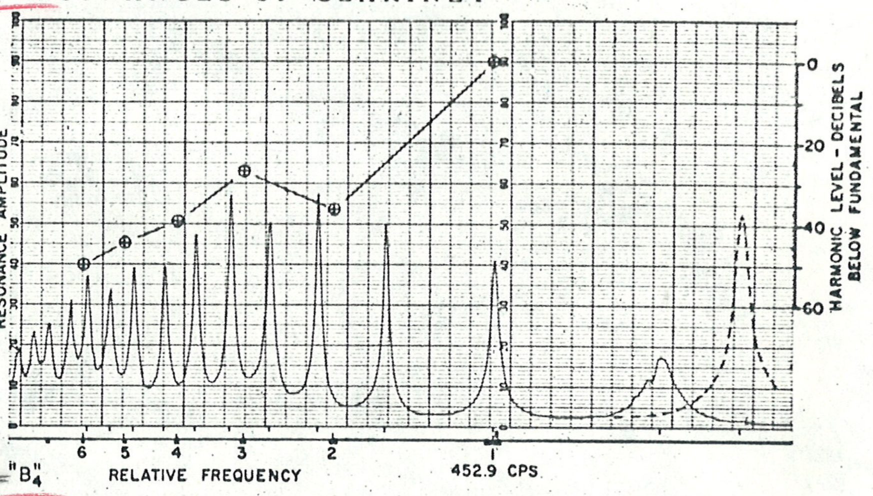

Fig. 11. Composite chart for the lowest note "B_4" in the "clarinet" register. Dashed curve from Fig. 6.

Dia 21/35

so that the frequency is approximately three times that of the fundamental mode. This is accomplished by opening a small hole (closest to the mouthpiece) by means of the "speaker key" operated by the left thumb. It is commonly thought that this hole facilitates the production of a pressure node at the proper place in the instrument so as to produce the next higher mode, which is assumed[9] to be (inaccurately) the third harmonic. What actually happens is shown in Fig. 11, which shows the composite chart for this note. It uses the entire instrument with the speaker key open, and has a resonance curve nearly identical to that for "E_3" except for the lowest peak. This peak is lower in amplitude and considerably displaced, its original shape and location (from Fig. 6) being shown by the dashed line in Fig. 11; the displacement amounts to 600 cents. The next higher resonance is higheri n frequency an amount that is difficult to see from the charts but that a separate experiment gave as 27 cents. Higher resonances are displaced less than 10 cents. The Q's of all the resonances above the lowest are essentially unaffected.

With the lowest resonance spoiled, the clarinet operates on the next good resonance, which in a well-built instrument is very nearly at three times the fundamental frequency. The second harmonic of this new resonance is very nearly six times the frequency of the lowest resonance, and so on; since these high harmonics did not match the resonances for the lower register, they cannot match them in the higher register either. This is obvious in Fig. 11, and also in Figs. 12 and 13, which show charts for the notes "D_5" and "G_5." It can be seen that none of the harmonic frequencies match those of the resonances at all well. In this region, therefore, the even harmonics are about as important as the

Figures 12 and 13 show that the low resonance is not affected quite as much for the higher notes as it is for the lower notes in the upper register. For "D_5," the lowest resonance is shifted up from the point marked X in Fig. 12; this amounts to 550 cents. The corresponding shift for "G_5" is 380 cents. Traces of these spoiled resonances may be heard when inexpert clarinettists "tongue" notes in the higher register.

It should be mentioned that the resonance and harmonic structure data are illustrative of a particular clarinet blown on the artificial embouchure, and would not be applicable in detail to other clarinets. General features should be similar, however. In particular, the harmonic structure of a given tone depends considerably on reed adjustments; for example, in Fig. 13, the fourth harmonic is missing; in other runs for the same note, however, it has appeared as prominently as its neighbors.

IV. COMPARISON OF CLARINETS

Up to this point in the investigation, it was hoped that the resonance curves as measured above could be correlated with the quality of a clarinet as judged by the player, so that these curves might afford some means of objective evaluation. To investigate this possibility, resonance and mouthpiece pressure harmonic structure curves were run for a number of notes on each of five different clarinets: the author's clarinet, a wood Bundy; two Selmer Bundy clarinets, one wood and one plastic, stated by the manufacturer to be made to identical dimensions; and two Leblanc plastic clarinets. The results were disappointing; the resonance curves for all five clarinets were remarkably similar, as were the harmonic structure curves. Figure 14 shows the composite charts for two of these five clarinets for the