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Analysis of the sounds of traditional acoustic instruments can be used to derive efficient analogs for electronic synthesis. Spectral envelopes of several acoustic instruments played at different dynamic markings with the view of isolating important spectrum changes with intensity are discussed. Results of some elementary synthesis employing some of these dynamic spectrum changes are presented.

INTRODUCTION: It is well known that most acoustical musical instruments have a timbre, or tone quality, which varies with the intensity or loudness level at which the instrument is played. These tone quality variations are in general very complex, but there appear to be some generalizations for some classes of instruments [1].

Current electronic music synthesis techniques exploit the potential musical value of dynamic tone quality variation by means of voltage-controlled waveshape sources and filtering devices. The purpose of this discussion is to categorize, in a simplified manner, the variation of the spectral content of 11 orchestral instruments. The intent here is to point out qualitative features. It is felt that these features should prove valuable in electronic music synthesis in general, and not only for simulative synthesis.

All the instruments discussed here are nonpercussive. In general, the sound produced by such instruments can be (somewhat arbitrarily) divided into two categories, 1) amplitude only, but that the waveform (shape) is continuously in flux.

The particular element of flux addressed here is the change of spectral content as the intensity (or loudness) of the sound changes. No attempt is made here to discuss the physical reasons for these changes in spectrum, but rather to categorize these changes in a manner to make them useful in electronic music synthesis.

PROCEDURE

The spectral envelope curves shown in Figs. 1–11 are derived from harmonic amplitude measurements made for a number of notes (usually 20 or more) of the scale played at a prescribed dynamic marking (pp, mf, ff). This technique has been described elsewhere [1]. The instruments were tape recorded in an anechoic chamber, digitized, and analyzed on a digital computer. The statistical nature of

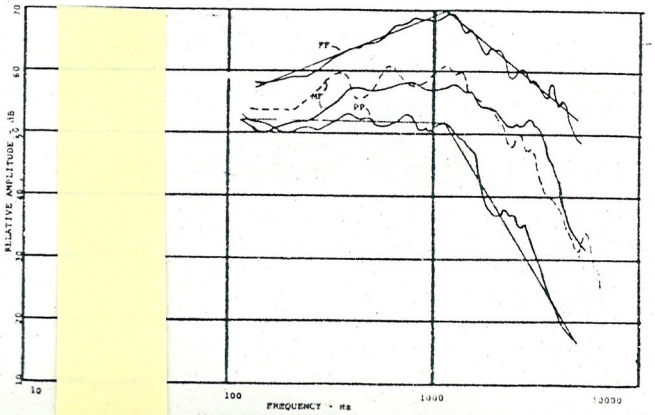

Fig. 1. Trumpet spectral envelope.

* Presented May 14, 1975, at the 51st Convention of the Audio Engineering Society, Los Angeles.