An Acoustical Analysis of Tones Produced by Clarinets Constructed of Various Materials

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THERE HAS BEEN much discussion as to whether or not the material out of which an instrument is made exerts any influence on its timbre. However, research, experimentation, and publications on this subject are relatively limited. The present analysis was conducted to determine if there are differences in timbre great enough to be seen in the wave form traced on the oscilloscope or registered by the harmonic analyzer.

The analysis was limited to the first eight partials of two tones produced by three ebonite, three metal, and three wood B-flat clarinets. The tones chosen for analysis consisted of the "open G" (*f'*) and "low C" (*b*-flat).

Physically the clarinet is a single reed instrument that employs a bamboo reed of the beating type fastened to the mouthpiece by a ligature; it is constructed of a combined conical and cylindrical tube that is pierced by side holes; and keys, rings, and the finger tips open and close the holes.

Acoustically the clarinet is a combined conical and cylindrical tube, and its tone is generated by a vibrating reed which sets into vibration an enclosed column of air. Moreover, its reed alternately opens and closes the mouthpiece opening while vibrating against the mouthpiece lay.[1] These physical and acoustical properties assist in dictating the partials that the instrument will produce.

Clarinetists are aware of differences in tones produced from an instrument employing different mouthpieces and reeds. Many are aware that the variance in the thickness and evenness of the reed cause alterations in its mode of vibration. This in conjunction with changes in the lay and inside taper of the mouthpiece alters the strength of existing partials and may increase or decrease the total number of partials produced, thus causing the timbre of the tone to change.

The analysis of tones produced by a wind instrument blown by an individual is difficult if not impossible with the harmonic analyzer used by the writer because of the following factors: (1) The short duration of the tone produced, (2) the slight fluctuations in volume of the tone, (3) the possible alteration of pitch caused by the involuntary changing of position and pressure of the lips, and (4) the player's efforts to produce a "good" tone.

The initial procedure in collecting data was to eliminate these variables. This was done by constructing a mechanical embouchure capable of sustaining tones of any given duration. After this was accomplished, the first eight partials of G and C were analyzed to determine their relative strength. Then tone spectra were drawn for each note, depicting graphically the partials and their relative strengths. The wave forms created by these partials on the oscilloscope were

[1] C. S. McGinnis and C. Gallagher, "The Reed's Mode of Vibration," *The Clarinet*, I (Fall 1951), 8.

photographed to provide additional visual information. These photographs were taken with a Zeiss Ikon 35mm. camera on plus "X" film with a shutter speed of 1/50 of a second and a diaphragm opening of f3.5.

In performing these experiments the control of variables was crucial. Intensity, the variable of paramount concern, was controlled by the use of the oscilloscope and the sound-level meter. The oscilloscope contributed to the control of this variable by providing visible wave forms that would increase or decrease in amplitude should any fluctuation in intensity occur in the tone being analyzed. The sound level meter connected with the harmonic analyzer also indicated changes in intensity. The visual representation of acoustical energy received by these instruments served as a basis for the adjustment of air pressure in the mechanical embouchure and the amount of pressure on the reed.

All experiments were conducted in the same room with the equipment placed in a fixed position. The oscilloscope and the sound-level meter microphones were kept at a fixed distance from each clarinet; the clarinet was mounted at a given spot and was blown by the mechanical embouchure; the experimenter sat at a constant distance from the equipment while conducting the experiments; all experiments were performed and checked several times before the final data were recorded; and all wave forms were photographed by the same camera, using a constant shutter speed and diaphragm opening.

In an attempt to eliminate the variables that occur when an instrument is blown by an individual, the writer sought to secure a mechanical device capable of blowing all instruments under the same conditions. With the assistance of Mr. O. E. Campbell, Supervisor of the Physics Shop, New Physics Building, Ohio State University, a mechanical embouchure was constructed from a brass cylindrical tube 1/16 of an inch thick with an outside diameter of 2½ inches and a length of 4½ inches. A plate was constructed so that it could be easily fastened to the front of the tube by screws. In the center of this plate a hole was cut to allow the round corked end of a clarinet mouthpiece to extend far enough to permit the fitting of the barrel joint of the clarinet. The mouthpiece employed in the embouchure was "turned" (cut on the lathe) to allow for the thickness of the brass plate. A clamp was then adjusted around the mouthpiece immediately beyond the ligature to hold the mouthpiece firmly and to serve as a base for the screws used to anchor it to the brass plate. A plate was soldered to the opposite end of the tube to form an airtight chamber.

The desired pressure on the clarinet reed was attained by anchoring a rubber pad to a movable metal rod. The amount of pressure exerted by the pad and the position of the pad on the reed were regulated by a screw type adjustment anchored to the outer wall of the chamber.

Compressed air was passed through a low-pressure pneumatic regulator to supply a controllable air pressure into the chamber. This regulator permitted the regulation of air pressure from 0 to 5 pounds accurately to within .7 of an ounce variance. Additional control was attained by passing the air from the regulator through a large airtight container before passing it into the embouchure.

Tone spectra revealed that the third and fifth partials of metal clarinets tested were not as pronounced as the

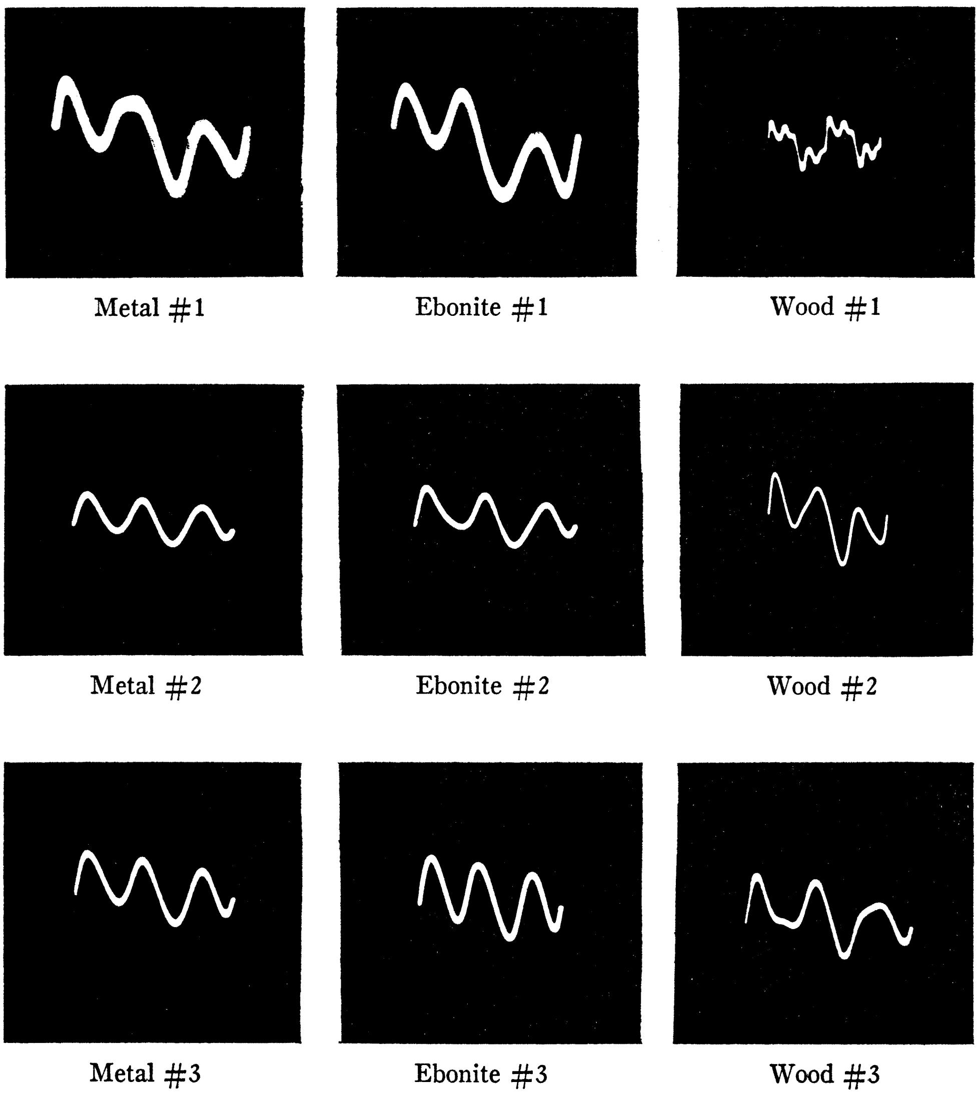

Fig. 1. Oscillograms for open G.

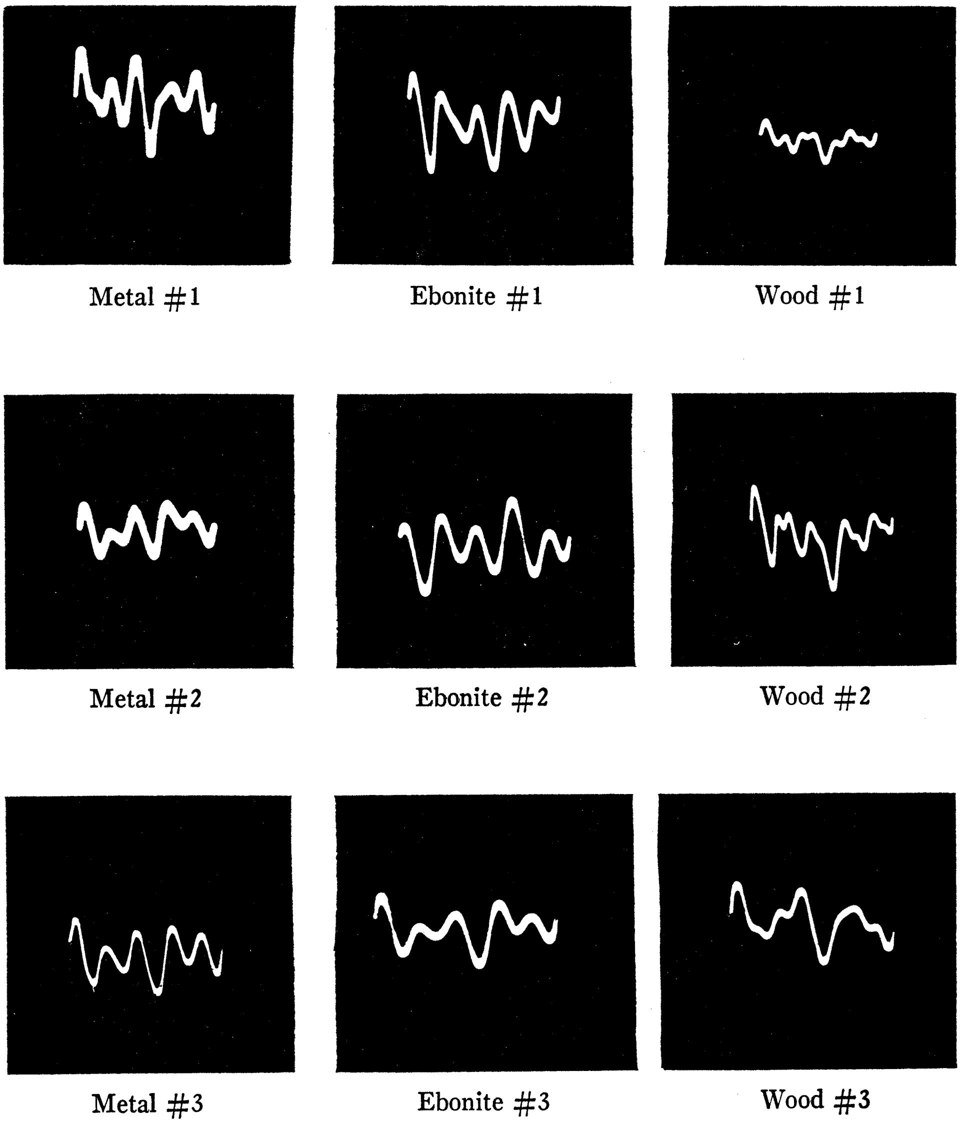

Fig. 2. Oscillograms for low C.

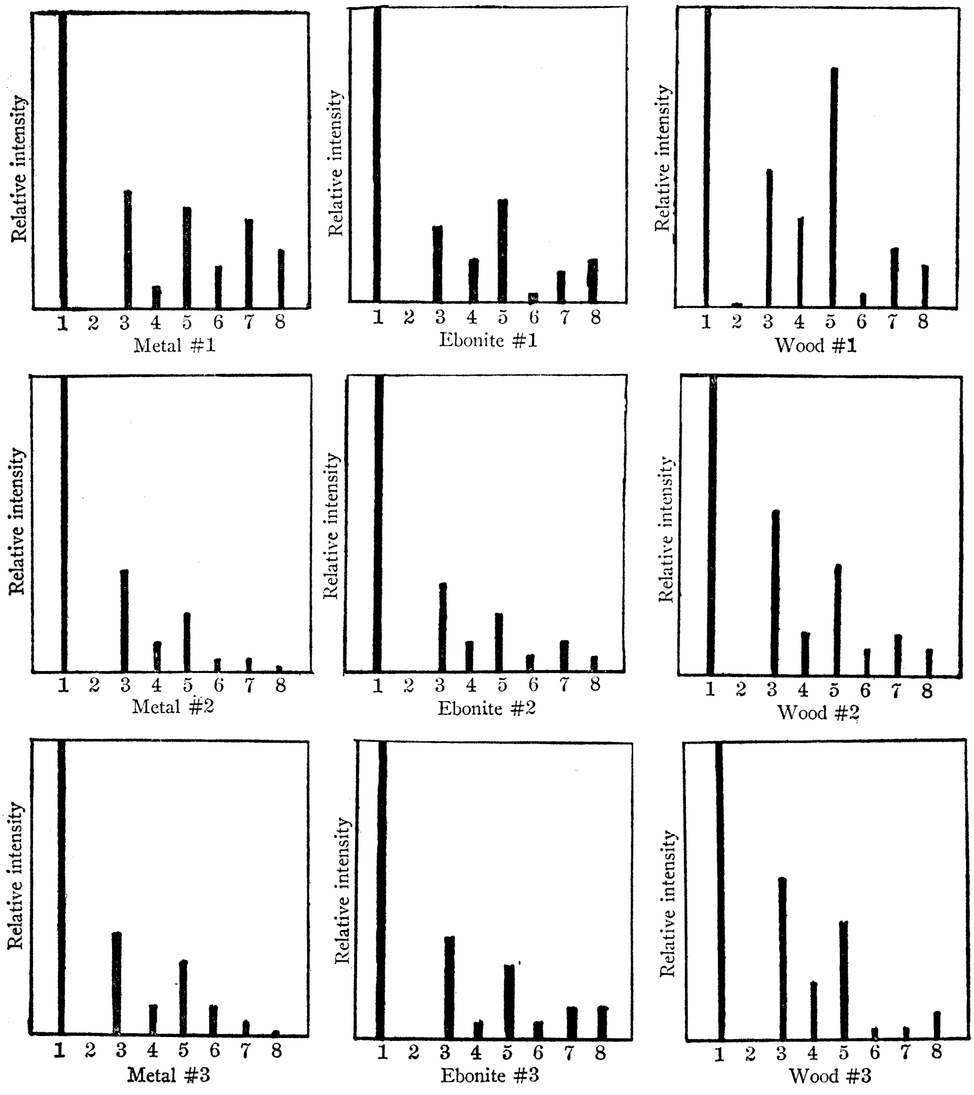

Fig. 3. Tone spectra, open G, showing fundamental and first seven partials.

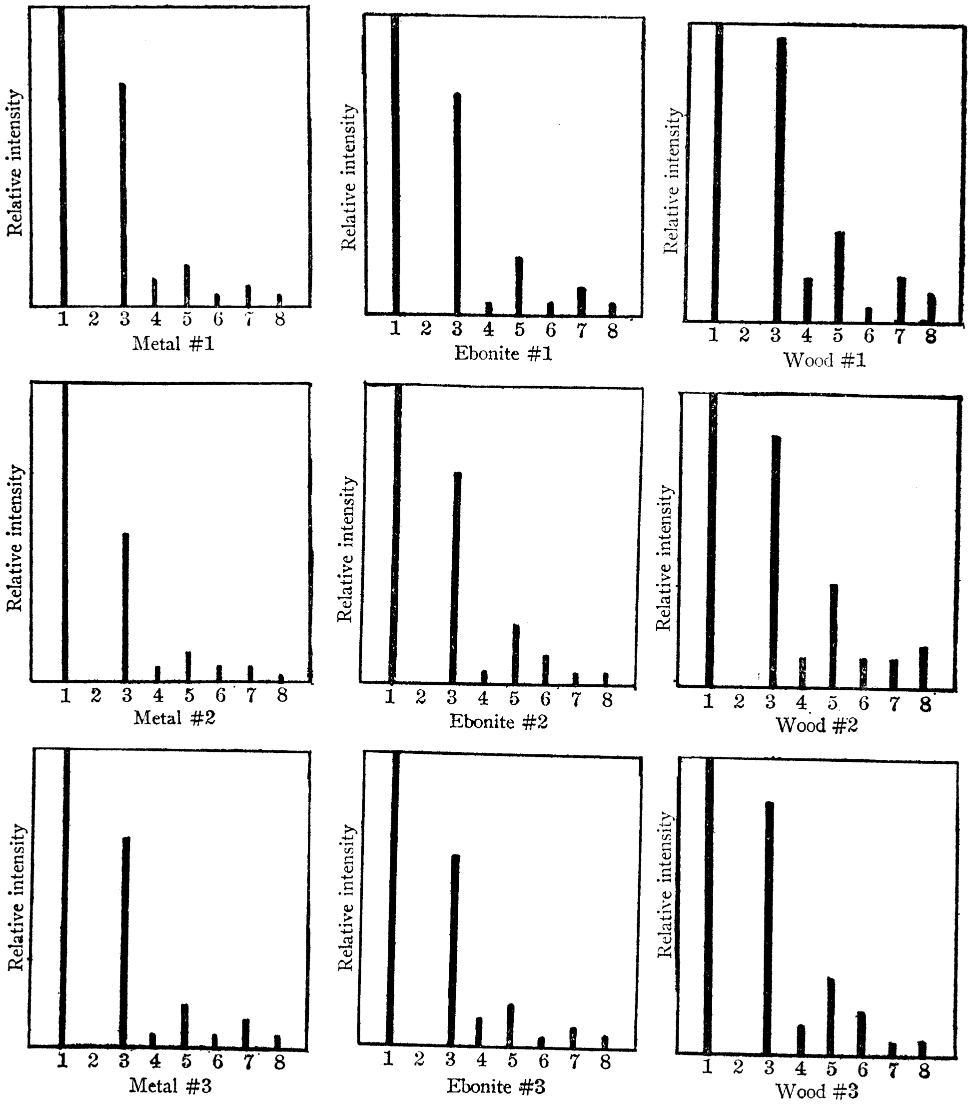

Fig. 4. Tone spectra, low C, showing fundamental and first seven partials.

corresponding partials of the wood instruments tested. Further support of this observation is evident in the oscillograms of tones produced from metal clarinets tested (Figures 1 & 2) in that they are simpler in structure than those of the wood instruments (Figures 1 & 2). This is an indication of the presence of fewer partials; the more complex the wave form the greater the number of partials present.

The compound that comprises the ebonite clarinet possesses less support for partials than wood. The wooden instrument proved to be a better resonator in that it supports a greater number of partials. This support of partials gives rise to a richer tone that possesses greater carrying power and ease of production. If the reader will inspect the tone spectra (Figures 3 & 4), he will note that the wooden clarinets produced stronger third and fifth partials than the ebonite and metal instrument. Study of the oscillographs (Figures 1 & 2), will reveal that a greater number of partials were produced by the wooden instruments tested.

The evidence indicates that the material enclosing a vibrating column of air is of importance to tonal richness. The type and thickness of the material will tend to reinforce or subdue certain partials of the tone.

The writer feels it important to inform the reader that the differences in timbre of tones produced from metal, ebonite, and wooden clarinets were not too recognizable by the unassisted ear.

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SOCIETY FOR RESEARCH IN MUSIC EDUCATION

Balloting by mail for the first time in the history of the Music Educators National Conference, the membership in January approved amendments to the Constitution which created the Society for Research in Music Education. The membership in the Society automatically consists of all special active and life members of the MENC. Meetings of the Society for Research in Music Education will be held in conjunction with the National biennial conventions and at the six Division meetings.

The Music Education Research Council, appointed by the Board of Directors of the Music Educators National Conference, serves as the governing body of the Society for Research in Music Education. The Council initiates and conducts studies and investigations that are approved by the National Board of Directors of the MENC. It is planned that members of the Society for Research in Music Education shall have opportunity to participate in the studies, investigations, experiments and discussions embraced in an enlarged program of research conducted under the auspices of the Music Education Research Council.

New members of the Research Council approved on the 1960 ballot are T. C. Collins, Roderick Gordon, Wolfgang Kuhn, Robert Marvel, Roger Phelps, and Homer Ulrich. Other members of the council are: Robert W. House, Thurber H. Madison, Robert E. Nye, Ralph C. Rea, Ralph E. Rush, Jack R. Stephenson, of the term 1956-1962, and Oleta A. Benn, Samuel S. Fain, Alfred W. Humphreys, George H. Kyme, Jack Pernecky and William N. Reeves of the 1958-1964 term. George Kyme is the new chairman and Jack Pernecky the new secretary of the Council.