*Terence S. Small*

# The Evaluation of Clarinet Tone Quality Through the Use of Oscilloscopic Transparencies

MANY educators with little practical background in particular families or groups of instruments are required to teach instrumental music. They have often had little or no experience playing the instruments, and therefore their concepts of instrumental tone qualities is apt to be inexpert. Efforts are being made at the college level to correct this situation through improved curricula and higher standards. For example, instrumental skills classes give students a foundation in, and actual playing experience on instruments other than those of their respective major applied areas. Technique, instrumental care and repair, methods and materials, and the like are generally well covered in courses of this sort. On the other hand, apprehension of a more valid concept of tone qualities of the various instruments and the ability to produce these sounds within a limited time period is questionable. This study attempted to provide an improved method of teaching the evaluation of clarinet tone quality. It was hoped that the techniques outlined in the article would be applicable for teachers and students of all age levels and experience.

Since the author holds that the eye is more easily trained than the ear, it was his purpose to provide an instrument and procedure for the improved perception of clarinet tone quality in the teacher training program. The oscilloscope provided an opportunity for musicians to visualize their tone wave forms. By analyzing the oscilloscopic transparencies, they would have a new method by which clarinet tone quality might be (a) perceived, (b) compared, (c) diagnosed, (d) corrected, and (e) better understood by students and their teachers. This study also attempted to improve the training of teachers and prospective teachers of instrumental music by providing a new teaching aid, both for themselves and for their pupils. It was hoped that the techniques and their intelligent use would improve a situation that appears to be all too prevalent: that of the music teacher having little or no playing experience with a particular instrument that he must teach.

An oscilloscope is a device which translates audio frequencies into visual patterns by means of cathode ray discharge or bombardments on a coated screen. These visual patterns are called wave forms and are graphic representations of the complex linear motion of the sound wave. A given musical tone played into a microphone connected to an oscilloscope will produce a wave form which is unique to that tone. It is a visual summation of that tone with all its particular characteristics. Pitch, loudness, overtone structure, and relative strengths of the overtones present are all properties included in this summation. Photographs may be made of the tracings on an oscilloscope screen and thus provide the basis for the visualization of tone quality and for all other purposes of this research.

In devising a tool to diagnose clarinet tone quality, certain questions were asked that served as guidelines for the study. These questions included the following:

1. Would the techniques developed in this study be of value as a teaching aid?
2. What is the relationship between perception of wave form deficiencies and hearing the differences between like pitches with different tone qualities?
3. What are the most common deficiencies pertaining to tone production?
4. What are the most common deficiencies pertaining to equipment?
5. Are the procedures developed in this study more effective in the teaching of clarinet tone quality than those already in use?
6. What are the implications of the results of the study?
7. What recommendations may be made with reasonable assurance?
8. How may the several types of data be best reported?

In attempting to answer these and other questions pertaining to the research, a certain experimental design was established. The following is a brief description.

## Selecting the Subjects

Participating subjects were selected on the basis of the clarinet tone quality they produced. As many diverse tone qualities as possible were represented. All subjects were private students at the Cleveland Music School Settlement, Cleveland, Ohio. Age range of the group was from nine to fifteen years: the average age was 12.1 years. The average length of time spent playing the clarinet was 2.9 years, and the average length of time for private lessons was 2.85 years. Two subjects played additional instruments. A more complete analysis is given in Table 1.

## Apparatus

The following apparatus were used:

1. Reslo ribbon microphone, 30/50 ohms.
2. Eico Oscilloscope, model 425.
3. Dumont Oscillograph Record Camera, model 302.
4. Vue-Strobe, American Musical Instrument Company.
5. Audio preamplifier, General Electric specifications.

TABLE 1
SUMMARY OF SUBJECT DATA SHEETS

| *Subject* | *Age, Sex* | *School Grade* | *Instruments, years played* | *Years of private study* | *Musical organizations* | *Position held* |
|---|---|---|---|---|---|---|
| 1 | 13F | 7 | Clarinet 2½ | 2½ | Band choir | 4th chair |
| 2 | 15M | 10 | Clarinet 5½ | 5½ | Band | 4th chair |
| | | | Percussion 1½ | 1½ | | |
| 3 | 12M | 7 | Clarinet 1 | 1 | | |
| 4 | 13M | 8 | Clarinet 5 | 5 | Band, | 1st chair |
| | | | Bassoon 1 | 1 | Orchestra | 1st chair |
| 5 | 10M | 5 | Clarinet 1½ | 1 | Orchestra | 2nd chair |
| 6 | 13M | 8 | Clarinet 1 | 1 | Band (jr.) | 1st chair |
| | | | | | Band (adv.) | 2nd chair |
| 7 | 13F | 8 | Clarinet 4½ | 4½ | Choir | |
| | | | | | Chorus | |
| 8 | 11M | 6 | Clarinet 4 | 4 | Orchestra | 1st chair |
| 9 | 12M | 7 | Clarinet 3 | 3 | | |
| 10 | 9M | 4 | Clarinet 1 | 1 | | |

6. General Radio Sound Level Meter, Type 759-B.
7. Selmer clarinet mouthpieces: HS, HS*, HS**, B, B*.
8. Selmer Centered-Tone B♭ clarinet, model 16 (control).
9. Vandoren clarinet reed, #2½ (control).
10. Realist 35mm camera.

The Eico oscilloscope was vital to evaluating tone quality (Figure 1). Quality depends largely upon the components of the wave form: i.e., "on

OSCILLOSCOPE WITH TRANSPARENCY ATTACHED

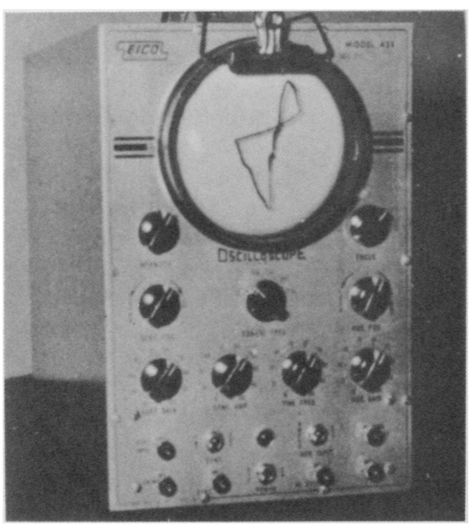


**Figure 1**

the number, intensity, and the distribution of the harmonic components into which a sound can be analyzed."[1] This is further substantiated by Bartholomew, who states that "tone quality depends largely on the 'degree of complexity' of the vibration. In other words, differences in tone quality result from the number of partials present, and their relative intensities to each other."[2] Miller states:

Since pitch depends upon frequency, and loudness upon amplitude (and frequency), we conclude that quality must depend upon the only other property of a periodic vibration, the peculiar kind or form of the motion; or if we represent the vibration by a curve or wave line, quality is dependent upon the peculiarities represented by the shape of the curve.[3]

Therefore this study dealt with the physical aspect of sound that seems to have the most influence on tone quality and that can be readily projected on the oscilloscope screen: i.e., wave form. The oscilloscope has great sensitivity to sound frequencies and will reproduce the wave form of a given pitch accurately. An audio frequency preamplifier, constructed according to General Electric Company specifications, was used in conjunction with the oscilloscope in order to obtain wave form reproductions of greater overall size. The preamplifier then remained in use throughout the entire experiment.

The wave forms reproduced by the oscilloscope were photographed and printed on a transparent base for purposes of later comparison. The control photographs were taken using a Dumont Oscillograph Record Camera, using Polaroid film type 47. This film has an ASA rating of 3,000. All pictures were taken at 1/50 of a second with an f 1.9mm lens opening. Inasmuch as the pictures obtained were positive prints, and were smaller than the 1:1 image required (actual size), photographic enlargement on a negative base was necessary to produce the desired transparencies.

To check the pitch of the various tones used in the study, the Vue-Strobe was employed. It is an electronic device which will give an accurate visual measurement of sound frequencies from approximately 32 to 4,067 cycles per second.

Intensity variations were observed to produce greatly altered wave forms. The Sound Level Meter was of major importance in controlling this variable. The device is actually little more than a VU meter connected to a microphone. The simple meter gives readings in decibels, step-down circuits allowing great flexibility in the use of the instrument. Meter readings were carefully recorded in the production of the control

---

[1] A. B. Wood, *A Textbook of Sound* (New York: The MacMillan Co., 1930), p. 386.

[2] Wilmer T. Bartholomew, *Acoustics of Music* (New York: Prentice-Hall, Inc., 1947), p. 12.

[3] Dayton C. Miller, *The Science of Musical Sound* (New York: The MacMillan Co., 1922), p. 59.

transparencies, and great care was taken to have each subject match these readings throughout the study.

The control instrument for this experiment was the author's Selmer B♭ clarinet, model 16. The instrument is a standard model, with the exception of an articulated G♯ key. It was ascertained through the use of the Vue-Strobe and consultation with other trained clarinetists that the control instrument possessed superior intonation and tone quality. All control transparencies were made from control photographs of sounds produced by this instrument.

Five standard Selmer mouthpieces were used in the study. Each was chosen on the basis of best compensation for physiological aspects of the individual student. Figure 2 shows the relative placement of the control mouthpieces as compared to other Selmer mouthpieces. The letters at the top of the figure indicate the openings between the tip of the mouthpiece and the reed. As we go from A to E, the facings curve more and more, making the opening wider. The length of the lay from the mouthpiece tip to the point where the reed meets the facing is indicated by the letters below the illustration.

A Vandoren clarinet reed was used in making the control transparencies and was substituted on occasion for the student reeds to determine how much effect the strength and type of reed had on tone quality. The Vandoren reed used was #2½ strength.

RELATIVE POSITIONING OF CLARINET MOUTHPIECES

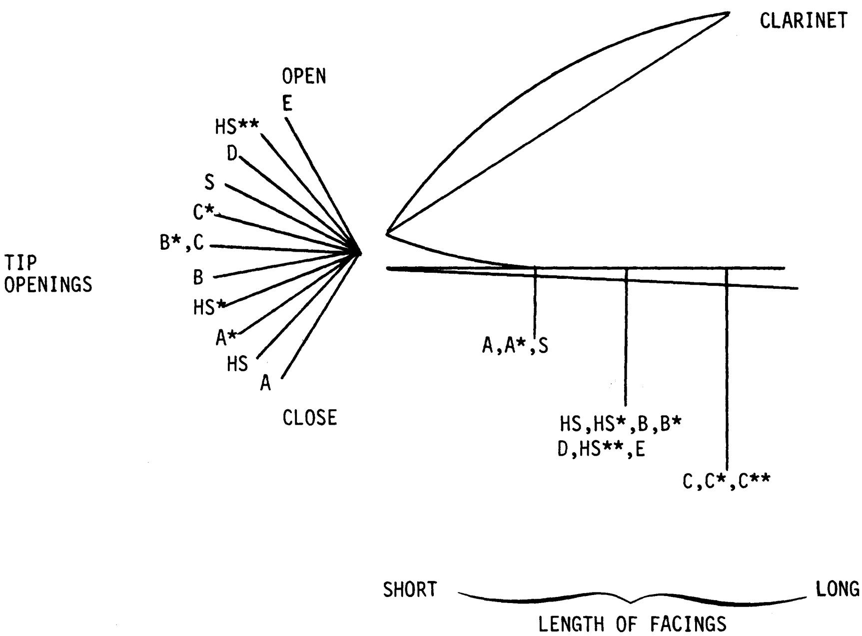



Figure 2

The study took place over a period of eight consecutive weeks beginning February 25 and ending April 15, 1963. Each subject participated for ten minutes per week and care was taken to ensure that no student worked for more or less than the specified length of time on each session.

## PROCEDURE

The study was limited to the clarinet. Certain tones were selected as being representative of the various registers of the instrument: low "E" ($D_3$–146.83 cps), open "G" ($F_4$–349.93 cps), middle "B" ($A_4$–440.00 cps), and high "C" ($B\flat_5$–932.33 cps). Each pitch played on the control instrument was carefully checked with the Vue-Strobe and the Sound Level Meter before being photographed by the laboratory assistant. The tones were produced in a seated position with the bell of the instrument pointed directly at the microphone at a distance of eleven inches. Great care was taken to ensure the largest and most stable wave forms of each tone. This was done so that the individual student could easily compare the control wave form with his own during the study. Photographs were then made as described above, and the control transparencies were derived from the Polaroid prints.

The oscilloscope was introduced to all subjects several times before the experiment was begun. Each student was asked to fill out an information blank concerning himself and his instrument. He was asked his age, the number of years he had played the clarinet, participation in musical organizations, and other instruments he played. Information was gathered about his clarinet—its make, its condition, and the equipment it bore. Specific information about reed make and strength was also requested.

Following this, an identical briefing was given each subject. He was told that the control transparency shown him for each of the four tones utilized in the study was to be as closely matched as possible on the oscilloscope screen. A demonstration was given showing the student the proper procedure to be followed. The subject was also told that the control transparency was a picture of what a "good" tone should look like and that he was taking part in an experiment designed to improve his tone quality on the clarinet.

Each student was given sufficient time in which to warm up before each session. All electrical apparatus were turned on at least fifteen minutes before actual use in the study. Subjects began the study with their own instruments, mouthpieces, and reeds. Each of the four tones used in the experiment was played by the students, checked with the Vue-Strobe and Sound Level Meter, and photographed prior to the first session. Careful measurement was made of the distance from instrument bell to microphone and care was taken to have each bell pointed directly at the microphone at all times.

Each ten-minute session was organized in identical fashion. The student warmed up and tuned with the Vue-Strobe. The control transparency for a given tone was clipped to the oscilloscope screen and the various dial settings were made for that tone. Each tone required slight changes in frequency settings, and in vertical and horizontal gain controls. The subject then played the same pitch into the microphone at the same intensity level as the control wave form as indicated by the Sound Level Meter. The student and teacher were then able to compare the two wave forms (student and control) and various corrective measures were attempted. At each session data were recorded for: (a) relaxation —"open throat"; (b) breath support—"diaphragm" principle; (c) embouchure change; (d) instrument angle to mouth; (e) posture (seated). On each of the eight weekly sessions with the subjects, a different equipment combination was used, that is to say a different combination of instrument, mouthpiece, and reed. These combinations followed a set pattern and encompassed all of the possibilities of variance with the three factors: instrument, mouthpiece, and reed. The following is a list of equipment changes by week:

1. Original equipment (instrument, mouthpiece, and reed).
2. Control reed (original instrument and mouthpiece).
3. Control mouthpiece (original instrument and reed).
4. Control mouthpiece and reed (original instrument).
5. Control instrument (original mouthpiece and reed).
6. Control instrument and mouthpiece (original reed).
7. Control instrument and reed (original mouthpiece).
8. Control instrument, mouthpiece, and reed.

With each equipment change, the various corrective measures were attempted and notes taken on individual data sheets (Table 2). At the

TABLE 2
SUMMARY OF EQUIPMENT CHANGE RESULTS BY WEEK

| *Subject* | *Week 1* *Orig** | *Week 2* *Rd* | *Week 3* *Mp* | *Week 4* *Mp & Rd* | *Week 5* *In* | *Week 6* *In & Mp* | *Week 7* *In & Rd* | *Week 8* *All C* |
|---|---|---|---|---|---|---|---|---|
| 1 | | G | F | G | F | F | B | G |
| 2 | | F | G | G | F | G | F | B |
| 3 | | F | G | B | F | G | F | G |
| 4 | | G | G | G | F | G | B | G |
| 5 | | F | G | G | F | G | F | B |
| 6 | | G | G | G | F | B | F | G |
| 7 | | G | N** | N | F | N | B | N |
| 8 | | G | F | G | F | F | B | G |
| 9 | | F | G | G | F | B | G | G |
| 10 | | F | F | G | G | B | G | G |

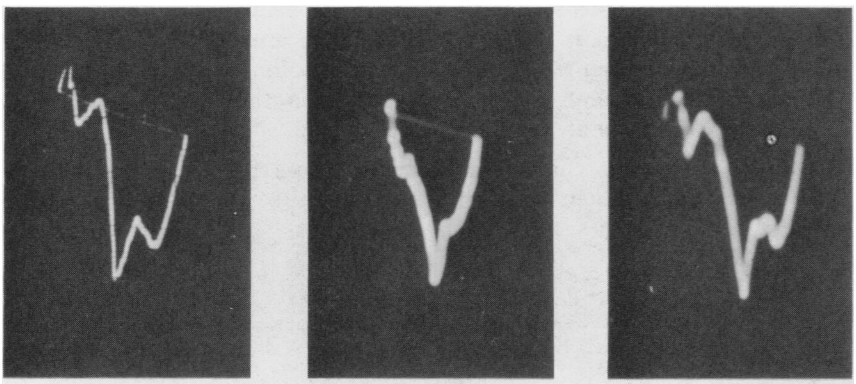
* Abbreviations in this table stand for: *Orig* = original equipment, *Rd* = control reed, *Mp* = control mouthpiece, *In* = control instrument, *All C* = all control equipment; *N* = none, F = fair, G = good, B = best.

** Subject 7 was unable to complete the experiment due to unforeseen difficulties with her mouthpiece. The reader is referred to Chapter III, page 80, of the original thesis.

end of the study, photographs were taken of each subject's tones using his original equipment, and of his tones utilizing equipment combinations that appeared to produce the best results—i.e., best approximations of the control wave forms. This last set of photographs was made because the writer was curious about the major deficiency area (s) of the subjects that related to equipment.

Each student was treated separately in a written analysis. Photographs (Figure 3) were made prior to the study (Time 1) and at its conclusion (Time 2). The individual control transparencies were reduced in size for the purpose of comparison between the Time 1 and Time 2 photographs of each subject's wave forms. A simple overlay method was used in the comparisons (transparency. over the corresponding picture). The same method was used with equipment changes which appeared to produce best results. Figure 3 shows a comparison of control wave forms of low "E" ($D_3$—146.83 cps) with Subject 8's Time 1 and Time 2 performances of the same pitch.

WAVE FORMS OF LOW *E* ($D_3$—146.83 CPS)



Subject 8 Time 1 | Control | Subject 8 Time 2

Figure 3

## RESULTS

1. Tone qualities of all subjects were improved in varying degrees. In the majority of cases, the improvement was considerable. The reader is referred to Table 2.
2. Four subjects mentioned that they could hear the differences between satisfactory and unsatisfactory tone qualities even without the use of the oscilloscope as a result of the study.
3. All participants were considerably motivated by the study and the various procedures utilized. Interest was high throughout the study and all subjects were quite anxious to improve their tone qualities.

4. Certain corrective measures were observed to greatly improve tone quality. In every case, increased breath support was a major factor. Certain other factors were less effective but of importance. The reader is referred to Table 3.

5. Certain equipment changes and combinations were observed to greatly improve tone quality. Results varied with the individual student, however the control reed and mouthpieces were the major factors in the majority of cases. Either or both, used in combination with the subject's original instrument, made considerable improvements (Table 2).

6. All students participating in the study have continued to play with greatly improved tone quality since the termination of the experiment. The younger students occasionally have required a reminder, but the majority have no trouble in producing the satisfactory tone qualities developed during the study. It would be difficult to ascertain whether this is a kind of muscular memory or whether the subjects have learned to aurally detect poor tone quality. The point is that all subjects have retained the satisfactory tone quality achieved during the study.

## Conclusions

1. The procedures developed in this study are of value as a teaching aid. By using conventional methods, the researcher had formerly needed an average of two to three years to teach a student of this age level to produce a satisfactory clarinet tone. The subjects participating in the current study achieved satisfactory tone qualities in eight weeks, with ten-minute sessions per week. Several times during the study the students themselves discovered means by which their deficient tone qualities could be improved.

Table 3

Summary of Corrective Measure Data

| *Subject* | **Corrective Measures* | | | |
|---|---|---|---|---|
| | *Throat* | *Breath Support Diaphragm* | *Embouchure Change Lip Pressure* | *Posture Seated* |
| 1 | Relaxed | Increased | Less Pressure | |
| 2 | | Increased | More Pressure | |
| 3 | Relaxed | Increased | Less Pressure | |
| 4 | | Increased | Less Pressure | |
| 5 | | Increased | More Pressure | |
| 6 | | Increased | Less Pressure | |
| 7 | | Increased | | More Erect |
| 8 | | Increased with Control | More Pressure | More Erect |
| 9 | | Increased | More Pressure | |
| 10 | | Increased | More Pressure | |

* Instrument angle to mouth was also observed; however, no changes were recorded during the testing sessions.

2. The results of this research indicate that a relationship does exist between perception of wave form differences and hearing discrepancies between like pitches with different tone qualities. Several students mentioned that they could hear these differences without the aid of the oscilloscope as a result of the study. While this observation was not unanimous among the participants, it would be most tempting to conclude that, given sufficient time, all subjects could become adept in distinguishing between poor and satisfactory tone quality through the procedures developed in the study.

3. The most common deficiencies pertaining to equipment were mouthpieces and reeds. In the great majority of cases, substitution of the control reed and/or one of the control mouthpieces allowed the student to produce greatly improved tone quality (Table 2).

4. The most common deficiency pertaining to tone production was lack of breath support. In every case, increased breath support brought about greatly improved tone quality on all pitches utilized. Table 3 shows all corrective measures and their relative importances in the study.

5. The procedures developed in this study are more effective in the teaching of clarinet tone quality than those already in use. In Conclusion 1, the time element was stressed. Satisfactory tone quality was achieved with all subjects (in eight weeks as opposed to two to three years) through the use of oscilloscopic transparencies and the procedures developed in this study. Mention was also made of the fact that several students taught themselves by observing the control transparencies and their own wave forms. The substitution of various items of control equipment gave results which could be seen as well as heard by the student and the teacher. It would also appear that the procedures enabled the student to aurally distinguish between tone qualities much more quickly than if he could not first perceive wave form differences.

6. Increased breath support, embouchure change, reed, and mouthpiece were the major factors in satisfactory tone production with the participants in this study. Best results were achieved with all subjects when these factors were manipulated. In most cases, increased breath support and the use of the control reed and mouthpiece gave much more satisfactory tone qualities. Embouchure changes varied with the individual, although the use of increased pressure on the mouthpiece and reed gave best results in the majority of cases.

Certain of the tones utilized in the study showed greater improvement than others. In general, the lower tones appeared to improve to a greater degree than high "C." One conclusion to be drawn from this may relate to the age and relative embouchure maturities of the participants. Several students found it quite difficult to produce high "C" and other altissimo register pitches both before the study was made and after it was concluded. It may be that their embouchures are not sufficiently developed at this early stage of their playing experience to allow them to produce the higher tones with satisfactory tone quality. Another conclusion may be that, on most of the student-owned instruments in the study, the "closed" tube responded to a greater degree than the "open" tube. Many clarinetists have had the experience of meeting with considerable difficulty when playing the "open" pitches on a given instrument. Open "G" and high "C" are usually particularly poor insofar as intonation and overall response are concerned. As a result of this study, however, no conclusive statements may be made with regard to this matter.

## Implications for Future Research

In view of the results of this study, the need for further research in the use of an oscilloscope to diagnose instrumental tone quality seems obvious. Some implications for further study are the following:

1. The extension of the procedures developed in this study to other wind instruments. The findings of the study indicate that the use of oscilloscopic transparencies is a major teaching tool in the matter of clarinet tone quality. It would appear to be most fruitful to utilize the same techniques for the improvement of other wind instrument tonal qualities. It might also be possible to adapt these procedures for stringed instruments and the human voice if vibrato is eliminated. Since vibrato implies changing pitch, it would be most difficult to perceive the resultant unstable wave forms.

2. The use of the procedures developed in the study as a means of self-teaching. Several students participating in the experiment learned for themselves the correct methods of improving their tone qualities simply by trial and error. The perception of wave form differences between student and control tones is most effective and immediate. Again, all the wind instruments and perhaps the strings and the voice might be included.

3. The adaptation of these procedures for homogeneous class use. The use of a closed circuit television camera attached to the oscilloscope screen is suggested. Television monitors would allow larger classes the same advantages as the individual student.

4. The extension of the procedures for intonation, breath support, and breath control study. These items are all easily perceived in relation to control transparencies with regard to size or in the shape of the wave forms produced.

5. Further investigation into the matter of the relationship between perception of wave form differences and hearing discrepancies between like pitches with different tone qualities.

On the basis of the results from this study, a thorough investigation would appear to be in order.

6. A study of instrumental characteristics with relation to the procedures developed in the present research. The lower tones utilized in this study showed greater improvement than the higher pitches. No con-

clusions could be drawn from this as a result of the findings. An investigation of this matter would appear to be fruitful.

The above mentioned studies would appear to be most helpful in dealing with the problem of instrumental tone quality in general. It is the writer's recommendation that studies dealing with this subject be documented not only with wave form photographs, but also with tape recordings. It is further recommended that the results of this research be utilized in the teaching of instrumental tone quality. It is the writer's firm conviction that the apprehension of a more valid concept and standards of tonal quality will be greatly facilitated through the use of oscilloscopic transparencies and the oscilloscopic device itself. The results of this study should help the music educator become a more effective teacher.[4]

University of Florida

[4] This article is based on the author's Masters thesis, "The Use of Oscilloscopic Transparencies as a Diagnostic Tool in the Evaluation of Clarinet Tone Quality" (Western Reserve University, 1964).