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The effects of air and lip-pressure variations on the motion of a clarinet reed within an artificial embouchure

Miller, Douglas Evan, Ed.D.

The University of North Carolina at Greensboro, 1988

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THE EFFECTS OF AIR AND LIP-PRESSURE VARIATIONS ON THE MOTION OF A CLARINET REED WITHIN AN ARTIFICIAL EMBOUCHURE

by

Douglas Evan Miller

A Dissertation Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
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of the Requirements for the Degree
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1988

Approved by

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APPROVAL PAGE

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To observe the influence of air and lip-pressure variations on reed motion, a blowing chamber containing an artificial-embouchure device was constructed into which a clarinet was inserted and sealed at the barrel joint. A DC light source was directed through the bell end of the clarinet into a photo transistor mounted near the mouthpiece. Light fluctuations produced by the reed´s movement were converted to voltages and directed to an analog-to-digital converter unit interfaced with an Apple IIe computer.

In air-pressure experiments, lip pressure was held constant while air pressure was varied. In lip-pressure experiments, air pressure was held constant while lip pressure was varied. Intensities were measured on a sound-level meter and air-pressure was monitored via a U-tube water manometer connected to the chamber; thus, the reed´s vibrational patterns were observed at specific air pressures, lip pressures, and itensities.

Conclusions: 1) For low-intensity tones in all registers, reed motion was sinusoidal. 2) For high-intensity tones in all registers, the reed closed for a portion of its cycle and smaller vibrations were superimposed upon the reed´s waveform when it reached maximum displacement. 3) The reed´s mode of vibration in

the steady state matched closely the mode of the air column. 4) The reed's natural frequency of vibration was distinguishable within the steady state waveform. 5) Small inaudible vibrations of the reed at its natural frequency were evident before the reed began to follow the requirements of the air column. 6) At constant lip pressure, an increase in air pressure increased reed amplitude and closure time but did not affect the reed's frequency of vibration. 7) At constant air pressure, lip-pressure reduction increased reed amplitude and intensity. 8) At specific air and lip pressures conducive to a wide range of intensities, closure was not more than 48 percent of a cycle. 9) An increase in reed amplitude did not always produce an increase in intensity level.

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CHAPTER I

INTRODUCTION

The oscillations of a reed are paramount for the production of sound on a clarinet. Not only is it the most unstable and inconsistent part of the instrument, but also the basic element providing the physical vibration necessary for the production of tone. For these reasons, the reed is frequently the center of attention when tone quality is less than satisfactory. Because most clarinetists lack a scientific understanding of the characteristics surrounding a reed´s vibrational patterns, there is justification for seeking empirical data which will serve as a basis for establishing foundations leading toward better control of the reed.

Purpose of the Study

The purpose of this study was to observe the influence of air and lip-pressure variations upon the oscillatory patterns of a clarinet reed as it vibrated at different frequencies. Results from the study may yield objective data about reed motion which can be of substantial significance in pedagogical applications regarding control of lip and air pressures necessary for optimum tonal production. Furthermore, the observed changes in the oscillatory patterns of the reed may have an effect on the shape and size of the puffs of air entering the body of the clarinet; consequently, results may indicate that vibrational patterns of the reed may produce harmonic variations in the tone. This potential might explain tonal differences observed when two clarinetists perform on the same instrument.

Delimitations of the Study

This study is not meant to be conclusive, but rather, exploratory. In the interest of conducting a comprehensive examination of the effects of air and lip-pressure variations on reed motion, the investigation necessarily encompassed specific physical characteristics of reed motion such as intensity, amplitude, and closure. A primary motive in conducting this study was to supplement previous findings regarding reed motion by considering the effects of air and lip-pressure variations, variables which have been unheeded in previous studies of this nature. Conclusions from the study are divergent in the interest of presenting a multilateral theory of reed motion under the two conditions stated above. The efficacy and statistical sophistication of the findings are therefore somewhat limited in the interest of this divergency.

Significance of the Study

Single-reed instruments have been common since antiquity. Although manifesting a variety of physical forms, acoustical principles underlying primitive and modern single-reed instruments are very similar. They are comprised of an excitation mechanism, or tone-producing element, coupled to the body of the instrument, which, in turn, shapes an internal air column according to its contour. In a clarinet, the air column is in the shape of a cylinder. The excitation system, consisting of the embouchure, reed, mouthpiece, and ligature, transduces air-pressure provided by the performer into regular air puffs, thus exciting the air column, which, in turn, reacts to vibrational patterns of the reed. The excitation system must therefore match the acoustical requirements of the cylinder (bore) to which it is attached. Stubbins (1965) stated that "intonation, tone quality, ease of performance, flexibility, articulation, and dynamic control, are all affected by this reactance between the air column of the instrument and the tone-generating system" (p. 60).

Historically, a great variety of methods have been employed to excite the resonance frequencies of the air column. The "shepherd's pipe," one of the most primitive single-reed instruments, had a reed which was simply a sliver of cane split from the body of the instrument; thus, a single tube of cane formed the mouthpiece, ligature, and reed. In the seventeenth century, when this sliver was separated and bound to the instrument by a string, it was given the name "chalumeau." Other single-reed instruments, like the "pibgorn," or "Welsh hornpipe" (sixteenth century), had a reed which was completely enclosed within a chamber and did not make direct contact with the performer´s lips. The modern clarinet is a descendant of the chalumeau since it has a separate reed attached to the exterior of the instrument.

Since the creation of the clarinet by Johann Denner in the seventeenth century, trial and error on the part of craftsmen and musicians has yielded improvements upon its various parts. The physical weight of the key system, for example, has increased dramatically, requiring it to be mounted to a body of greater density and strength. Other improvements include a more efficient placement of tone holes, providing instruments with better intonation, and alterations on the size of the bore for greater tonal projection and ease of playing. In contrast, the design of the mouthpiece and reed has varied considerably less than the lower sections of the instrument described above. The reed remains today, as it was in Denner´s time; a major variable of tone production over which the clarinetist has immediate and direct control. The mouthpiece, barrel, and lower clarinet sections are not economically feasible items to replace while the reed is generally considered to be easily obtained, altered, and adjusted. For this reason, once a player has settled on a specific configuration for the instrument, attention is focused on the reed when tone quality is less than satisfactory. Not only is the reed the most inconsistent variable of clarinet tone production but also the part which embodies the most motion. The physical behaviors of vibrating reeds are therefore important for an understanding of the acoustics of the instrument and control of the sound which is produced.

Assuming the excitation mechanism forms a carefully balanced system consisting of the mouthpiece, embouchure, ligature, and reed, it follows that this system may be mathematically described as a complex equation comprised of these four variables. If response of the system is less than satisfactory, the equation may be rebalanced through regulation of the variables. Since these variables can be manipulated by the performer to balance their relationship within the system, it becomes evident that specific parameters governing the effects each variable has upon the equation might be formulated. Alterations in any of the four variables (excluding the human factor), may result in profound alterations of the entire system. Since the mouthpiece and ligature are manufactured as part of the instrument, they are generally purchased as a package; thus the reed and embouchure often become logical points of adjustment. In practice, some techniques of reed adjustment appear to be more effective than others; thus, one assumption forming a basis for the present study lies with an inconsistency in method sustained by a general lack of knowledge about single-reed behavior.

Theories of Reed Motion

Theories regarding the function of the single reed within the excitation mechanism can be traced back to the 1930s and divided into two distinct categories. One group of theories was based upon the premise that the reed never completely closed the chink or aperture between the reed and the mouthpiece. Ghosh (1938) developed a mathematical theory of reed motion based upon this premise. A similar view of non-closure was presented by Redfield (1934) in his study of air-column behavior in orchestral wind instruments. These theories, however, were not supported by experiments conducted by McGinnis and Gallagher (1941); consequently, a second theoretical category emerged. Using photographs of reed motion produced under a strobe light, McGinnis and Gallagher concluded that the reed completely closed on the mouthpiece during part of a vibrational cycle. Since then, theories have been presented which align more closely with these findings (presented in Chapter II).

The McGinnis and Gallagher (1941) study constitutes a major contribution to the literature on reed motion and very few subsequent studies in this area have been published. Their research greatly expanded knowledge about the vibrational cycle and behavior of the reed. Although the McGinnis and Gallagher study was an important contribution to research on reed motion, numerous variables possibly affecting their findings were left uncontrolled. Specific intensities, lip pressures, and air pressures, for example, were not taken into consideration in their research. Further studies in this area were not conducted until approximately two decades later when John Backus (1960) published observations of ocilloscopic traces of light variations passing between the reed and mouthpiece as tones were produced. As in the McGinnis and Gallagher study, specific parameters of his experiments were not published. These studies, although important in their own right, left many questions unanswered regarding reed behavior under more specifically controlled conditions and did not address the critical interrelationship between air pressure, lip pressure, and reed motion. Research, as exemplified in the present study, may reveal the importance of careful adjustment of air and lip pressure and yield parameters regarding their interaction in the production of musical sound.

Reed Motion and Tone Quality

Vibrational patterns produced by the reed may have an important bearing upon clarinet tone quality. Since applied lip and air pressure are not consistent between players, control of these two factors may demonstrate that reed vibrations are important in the quality of tone produced. Previous research (Parker, 1947; Lanier, 1960; Backus, 1961, 1963, 1964) has shown that the material from which the body of the clarinet is made has little effect upon its tone quality. The tonal spectrum which is produced might therefore depend largely upon variables within the excitation mechanism. In addition, studies of the excitation mechanism by Parker (1947) and Mooney (1968) have suggested that the size and shape of the oral cavity does not affect tone quality; thus, evidence supports the isolation of other variables within the excitation mechanism affecting tone quality such as air pressure, lip pressure exerted by the embouchure, amount of mouthpiece inserted within the embouchure, ligature pressure, reed mass, reed density, and the internal and external dimensions of the mouthpiece. By controlling all of these variables except air and lip pressure, the effects of air and lip-pressure variations upon the vibrational pattern of the reed may be observed. If the wave form produced by the reed changes in each register for different air and lip pressures, it might be concluded that air is entering the air column in varying amounts and configurations. Therefore, the size and shape of the air puffs entering the clarinet may depend upon vibrational characteristics of the tone being produced. This would indicate that the reed's vibrational pattern could be considered as a possible factor contributing to the harmonic structure of the tone.

Statement of the Problem

With the growth of public school instrumental music during this century, a practical interest in the technical aspects of tone production in wind instruments has been fostered among teachers and researchers. Studies of reed motion have been conducted in an attempt to better understand the often curious behavior of woodwind instruments. In recent years, researchers have presented many intriguing questions regarding reed motion, and with the current availability of computer analysis of the tonal spectrum, the possibility of scientific, innovative, and exacting research in this area has become feasible.

Basic characteristics of reed behavior have not, to date, been studied in a thorough and organized way. Research has been, at best, general, and sometimes, misleading. Interesting theories regarding reed motion have surfaced regularly, but few have been supported by quantitative data. To understand reed motion to a degree necessary for making accurate generalizations about its behavior requires systematic research conducted under carefully controlled conditions. Such research might form a substantial foundation for more diverse theories of reed motion.

To date, few studies of reed motion have been conducted under circumstances which invited accurate control of the variables previously mentioned as being possible contributors to tone production on the clarinet. As a result, many methods used to physically control the action of a reed are obvious products of trial, error, and inefficient ways of measuring. Physics of woodwind sound production are generally dependent upon physical characteristics of reeds and their motion under specific conditions. Benade (1960) wrote:

> The makers of wood winds not only discovered the ideal shapes generations ago; they have also empirically exploited the effect of departures from the ideal. They judiciously alter the cross section of the bore by a few thousandths of an inch to compensate for various upsetting effects caused by the complex behaviors of reeds and holes. . . . Although the necessary modifications of a bore can in general be predicted quantitatively by proper mathematical analysis, to my knowledge such methods have almost never been employed by the manufacturers of wood winds. They make the final adjustments in the taper of each bore by a process of trial and error (p. 150).

Detailed computer analyses of the vibrational cycle of the reed are needed to explain its motion in a more exact and scientific manner. A thorough understanding of reed behavior may enhance existing knowledge regarding the acoustics of the clarinet and its pedagogy.

A primary objective of this study was to control variables of the excitation mechanism which might affect reed motion. In this way, it was hoped that the study would clearly interrelate specific aspects of air and lip-pressure variations on reed motion and yield practical theories which might serve as a foundation for further research. A second objective was to use the findings to clarify existing theories of reed motion which might better serve the demands of current pedagogical practice. For example, in consideration of research conclusions and subsequent observations presented above, two questions emerge as significant points of concern: if the reed does not completely close upon the mouthpiece, regardless of the amount of applied air pressure, it might be concluded that maintaining a perfectly flat surface on the back of the reed is not necessary; conversely, if the reed does close completely for some tones, then a flat reed surface would appear to be imperative.

Foundations for the Study

The following assumptions are presented in regard to this study: (1) via the aid of instrumentation, the reed will exhibit observable motion when a sound is produced, (2) controlled variations in air pressure will be externally and artificially applied to the clarinet at the mouthpiece end in a manner judged to be similar to human performance, (3) "intensity" will represent sound pressure level, (4) controlled variations in air pressure will produce variations in the intensity level of the sound produced by the clarinet, (5) the natural vibrational frequency of the reed will be damped by an artificial lip mechanism, (6) threshold sound pressure will be the air pressure needed to produce an audible sound, and (7) "pitch" [the psychological counterpart of frequency which is the number of physical vibrations (oscillations) of a mass per second] will represent tones produced by the clarinet.

Primary research questions which formed the foundation for this study are listed below.

1. At specific frequencies, air pressures, and lip pressures, does the reed completely close on the mouthpiece during any part of its cycle of vibration?

2. What is the interrelationship between applied air pressure, lip pressure, reed amplitude and intensity at specific frequencies?

3. What is the relationship between the frequency of the reed's vibration and the fundamental frequency of the tone produced?

Secondary research questions of focus within this study are as follows:

1. Do air-pressure requirements for low-intensity tones vary with applied lip pressures?

2. What parameters of lip and air pressure are necessary when changing intensity levels on the clarinet?

3. How do air-pressure requirements vary with the frequency being produced at a specific intensity level?

4. What behavior does the reed exhibit at air pressures which are below the threshold of sound production?

CHAPTER II

REVIEW OF THE LITERATURE

The earliest attempts to explain reed motion on the clarinet were in the form of mathematical procedures based upon the assumption that during the vibrational cycle, the reed only partially closed the aperture between the mouthpiece and the reed. These theoretical explanations of the action of the vibrating reed were an attempt to clarify the presence of even-numbered harmonics in the clarinet tone which had first been observed by Blaikley (1884) and Miller (1926). Prior to these discoveries, the clarinet was generally considered to behave as a closed tube (stopped tube) with its audible tone containing only odd-numbered harmonics.

Das (1931) deduced mathematically that the periodicity of the reed's vibration on a mouthpiece relied upon the length of the tube to which it was attached, thus vibrating at the fundamental frequency of the tone being played. He concluded that the motion of the reed could be described as vibration around an equilibrium position and that the reed moved periodically toward and away from the mouthpiece, completely closing the reed-mouthpiece aperture during the part of the cycle when the air pressure within the mouthpiece was low. Das (1931) stated:

> The solution . . . can be interpreted as a vibration about a centre of rest which has a sudden shift . . . alternately away from and towards the mouth-piece . . . thus during a condensation the reed opens the chink fully so as to admit air into the tube and shuts up during a rarefaction. . . . The reed vibrates practically in the same phase with the change in pressure in the mouth-piece *[sic],* opening itself so as to admit air into the tube when the pressure is large and shutting up at low pressure" (p. 231).

Das (1931) deduced that when air pressure within the mouthpiece was low, the reed was drawn inward against its surface (lay). Since, in this case, more of the reed´s back was in contact with the surface of the mouthpiece, the vibrating length of the reed was shortened. When air pressure within the instrument equalized with air pressure in the mouth, the reed returned to the position of rest, leaving less of the reed´s back against the lay of the mouthpiece and more of the reed´s length free to vibrate.

In opposition to Das, Redfield (1934) concluded that the reed never completely stopped the applied air supply entering the body of the instrument from the performer´s mouth. Using a stethoscope, Redfield observed that sounds transmitted to the medium from the instrument were also transmitted to air confined within the buccal, pharyngeal, laryngeal and pulmonary cavities of the player´s body. He concluded that if the reed were closing completely on the mouthpiece, these frequencies would not have been observable within the neck of the player.

A mathematical theory was presented under the same assumption by Ghosh (1938) in which he deduced, at unspecified frequencies, that the blowing pressure within the mouth remained constant while the pressure within the clarinet and across the reed showed periodic variations. These periodic variations, according to Ghosh, were the result of only a partial closing of the reed on the mouthpiece. He writes: "the chink between the mouthpiece and the reed never shuts completely, that is, the conductivity of the chink is not zero, as in the older theory" (p. 262).

An experimental attempt to "freeze" the image of the vibrating reed was conducted in Germany by Ashoff (1936) using an artificial embouchure and a stroboscope. In order for the reed to be properly photographed, however, he found it necessary to cover the reed with an aluminum coating. This may have caused the reed to exhibit artificial behavior during its vibrational cycle. Ashoff concluded that the reed did not completely close on the mouthpiece during its cycle of vibration.

An experimental study similar to Aschoff´s was completed by McGinnis and Gallagher (1941) whereby an artificial embouchure was used, in conjunction with a stroboscope, to produce stop-action photographs of the reed as it vibrated. Unlike the Aschoff study, McGinnis and Gallagher were able to successfully photograph the reed without covering it with aluminum. For tones of high intensity, McGinnis and Gallagher (1941) used photography to support the premise that the reed remained closed for about 1/2 of its cycle, spent 1/4 of the cycle in transit, and opened for the remaining 1/4 of the cycle, regardless of the frequency of the tone being played. For any pitch, the fundamental frequency of the reed's vibration was found to be stable within one percent of the fundamental frequency of the tone produced. The researchers found that under normal conditions, the reed vibrated as a unit with the extreme tip remaining parallel to the facing of the mouthpiece. Regarding the motion of the reed for tones of high intensity, they stated:

> The motion of the reed during a complete cycle is of interest. Consider that the chink is just on the point of closing. With the aperture closed, the reed appears motionless to the eye for about half the time of a complete cycle. It then leaves the mouthpiece with relatively high velocity and reaches its position of maximum displacement in a series of short spurts. The time spent apparently motionless at maximum displacement is roughly a quarter of the fundamental period. The tip of the reed now returns to the mouthpiece in another series of short spurts, and the fundamental cycle is complete. Thus the actual motion of the reed occupies only about a quarter of the entire period. This description agrees in a general way with the results predicted by Das (1931) in his mathematical development, which, however, were without experimental confirmation (p. 531).

To determine if the reed closed on the mouthpiece, Obrien (1953) allowed an adjustable needle to protrude through the aperture between the reed and mouthpiece. He found that when the clarinet was blown in a "normal" way, a tone was produced only when the needle was drawn below the plane of the mouthpiece surface. He concluded from these results that the reed must close completely in order for a sound to be produced.

Using an artificial embouchure, John Backus (1960 to 1974) at the University of Southern California, Los Angeles, conducted a distinguished and inventive series of investigations on the vibrations of clarinet reeds. In one study, Backus (1960) directed light through the bell end of a clarinet and into the aperture between the reed and mouthpiece, where fluctuations in light intensity were monitored by a photomultiplier tube (a light-sensitive transducer) mounted at the tip of the mouthpiece. As the artificially-blown reed vibrated, light-intensity variations were observed on an oscilloscope. By superimposing photographs of oscilloscopic wave patterns created during various stages of the reed's vibration, comparisons were made between the reed's closure times. Backus concluded that the motion of the reed was quite simple and had nearly the same pattern for all tones throughout the range of the clarinet. For high-intensity tones in the chalumeau register, it was observed that the aperture between the reed and the mouthpiece closed for nearly one-half of the cycle, opened for almost one-half of the cycle, and spent the short remainder of time in transit. For low-intensity tones, he found that the aperture did not close completely and the motion became nearly sinusoidal.

Backus (1961) used an artificial embouchure to study the relationship of reed motion to air-column vibrations. A small condenser microphone was inserted within the mouthpiece and arranged so that the microphone assembly could be used in conjunction with the photocell assembly mentioned above. The signal outputs from both assemblies were directed to an oscillosope, making possible simultaneous observation of reed and air-column vibrations. Backus concluded that variations in reed motion followed closely the variations in the air column, thus adding more support to the theories of Das (1931).

In an experimental study of effects of reed/mouthpiece aperture on minimum blowing pressures in the clarinet, Backus (1962) used an artificial embouchure to measure reed/mouthiece aperture, blowing pressure, and operating frequency when the clarinet was "barely" sounding. He found that minimum blowing pressure was directly proportional to reed/mouthpiece aperture and reed stiffness.

Coppenbarger (1971) investigated a vibrating clarinet reed utilizing an artificial embouchure, high-speed cinematography, and a harmonic wave analyzer. He attempted to correlate tone production with reed movement, thus concluding that the reed vibrated at the same frequency as the frequency of the tone being produced. Coppenbarger observed that the lip pressure required to produce a tone with an artificial embouchure reduced the mouthpiece-reed gap 43 percent from its rest position, and that the reed closed completely about 40 percent of a cycle, but never more than 45 percent.

Studies of Reed Closure Times

The earliest observations regarding the reed´s closure time on the mouthpiece were made by McGinnis, Hawkins, and Sher (1943). In an experimental study of tone quality of high-intensity tones, they observed that it was the closure time of the reed which caused the clarinet to behave as a "stopped tube," thus producing odd-numbered harmonics. They observed that during one complete cycle of the reed´s vibration, the sound disturbance (condensation) had traveled four lengths of the clarinet. Regarding one cycle of vibration, they stated: "It is important to note that the reed is in its closed position for at least half of the entire period" (p. 229).

It was not until 1960 that Backus studied closure times for loud, medium, and soft tones using tones of different frequencies. Backus (1960) stated:

> First, it will be noted that for loud tones the reed aperture is completely closed for nearly half the cycle, and practically completely open for the other half. As the intensity decreases the closed time diminishes, and for soft tones the aperture does not

> close at all during the cycle. Second, the waveform is fairly complex for loud tones although the fundamental predominates; for soft tones the waveform is nearly sinusoidal. Third, the waveform becomes simpler as the frequency is increased. (p. 808)

It is possible that various closure times may influence the tone quality produced. It may be assumed that the longer the reed stays open, the amount of air that would be admitted into the body of the clarinet would be greater. This would produce a larger and differently shaped puff of air than one which would result from a longer closure time. Backus (1962) observed:

> The harmonic structure of the clarinet tone for several different notes of the scale was recorded at four different loudness levels. It was found that the higher harmonics disappeared as the tone became softer, the number of harmonics decreasing from as many as 15 or more for loud tones to 1 or 2 for soft tones. (p. 717)

Stubbins (1965) also stated that different closure times of the reed had a direct influence on tone quality, but did not support his contentions with quantitative data. Stubbins concluded that a vibrating reed, opening and closing on the mouthpiece, behaved as a valve, admitting "air puffs" of different shapes and sizes into the body of the clarinet. These air puffs, Stubbins contended, contained the potiential for different harmonic patterns in the tone. He stated:

> If a valve flies open and shut very abruptly, and admits the air for only about one-twentieth of a cycle of vibration, it has a potential of producing approximately equal amounts of all of the harmonics. If a valve flies open abruptly, and remains open for about one-fourth of a cycle, and then shuts abruptly,

> it has the potential of producing a harmonic pattern which is quite different from the former. A valve opening for only one-eighth of a cycle, again produces a different pattern (p. 59).

When Backus (1961) tested different reeds for closure using an artificial embouchure, he concluded from his observations that some reeds were closing the mouthpiece aperture only on one side. He therefore concluded: "the quality of the tone produced by the reed as judged by the ear does not seem to depend on whether or not the aperture closes completely" (p. 808).

Backus (1966) also studied the effect of warping of the reed tip on clarinet tone. He found that the aperture between the reed and mouthpiece does not close completely during the part of the cycle that the reed is in contact with the mouthpiece due to the presence of a certain amount of warping. That part of the reed which is not in contact with the mouthpiece can still oscillate with a small amplitude at a high frequency.

In a study of the effects of wall material on the steady-state tone quality of woodwind instruments, Backus (1964) found that vibrations of the clarinet body felt by the performer when playing are "caused by the reed beating against the mouthpiece, and not to radial vibrations due to expansion of the tube because of the pressure of the internal standing wave" (p.1884).

Coppenbarger (1970) used high-speed motion pictures of the reed to analyze its movement for tones of high intensity. By counting the number of frames in the high-speed film, Coppenbarger was able to draw interesting conclusions regarding the reed's closure time on the mouthpiece. Although he analyzed tones of unspecified intensities, he observed a rather consistent pattern of reed behavior. He stated:

> The reed usually remains closed with the mouthpiece 40 percent to 45 percent of the complete cycle. There are times when the reed just touches the mouthpiece and opens. When the tip of the reed leaves the mouthpiece, it starts to open in the shape of a sine wave but rapidly gains speed, which tends to square up its shape (p. 113).

The studies reviewed above represent a comprehensive overview of research on reed motion to date. They were focused primarily upon theories regarding reed closure and presented, in this writer's opinion, a somewhat simplistic view of reed motion at unspecified lip pressures and intensities. The predominating lack of attention in these studies to the effects of lip and air-pressure variations on reed motion have yielded tentative and somewhat incomplete evaluations of specific aspects of the findings.

For example, an irregularity may be observed in the findings, and subsequent evaluation, of McGinnis, Hawkins, and Sher (1943), in which they seem to contend that the clarinet acts as a "closed pipe," producing odd-numbered harmonics, as a consequence of the reed's closure on the mouthpiece. If applied lip and air-pressure variations had been considered in their experiment, or the specific degree at which the reed may be considered to be "closed" on the mouthpiece, the researchers may have been reluctant to present such a simple and comprehensive statement. A study such as the present one, in which air and lip-pressure variations are considered in relationship to reed motion, is warranted to explain anomalies found in modern theories of reed motion.

CHAPTER III

PROCEDURES AND EQUIPMENT

Procedural Overview

The purpose of this study was to observe the vibrations of a clarinet reed in all registers as various air and lip pressures were applied. In an attempt to observe the motion of a clarinet reed during the production of a sound, an air-tight chamber was constructed to serve as an artificial embouchure (see Figure 1). Multidirectional manipulation of lower-lip pressure upon the reed was made possible by utilizing an externally-controlled "lower-lip" mechanism housed within the device. The mouthpiece end of the clarinet was inserted into the chamber and sealed at the barrel by means of a rubber gasket. The clarinet was supported on the outside by an adjustable stand which was designed to allow manipulation of its angle of entry into the embouchure chamber. Air pressure within the chamber was controlled by regulating a potentiometer connected to the motor of an air pump and monitored with a water manometer linked to the chamber.

A variable direct-current (DC) light source was placed opposite the bell of the clarinet and adjusted so as to

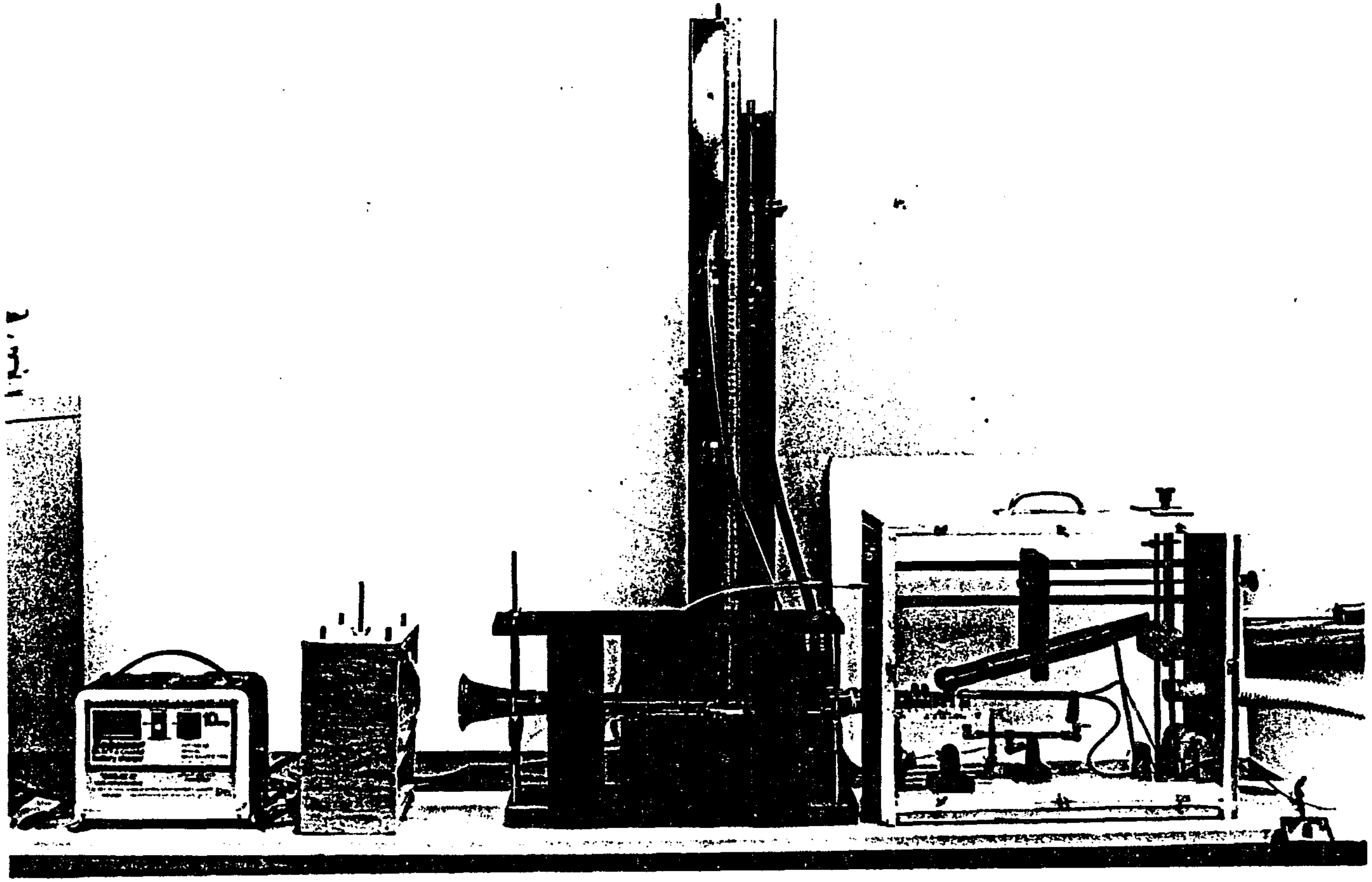


Figure 1. The Complete Apparatus

direct light through the length of the clarinet and into a photo transistor. Pitches were produced by removing keys from the instrument and inserting rubber plugs into appropriate holes. The clarinet was made to sound by slowly increasing air pressure and simultaneously adjusting the lower-lip mechanism. Motion of the reed was observed using computer-assisted observation of light-intensity variations received through the mouthpiece/reed aperture. Subsequent effects of air and lip-pressure variations upon the motion of the reed were studied.

Equipment

Specifications of the Artificial Embouchure and Lower-Lip Mechanism

Embouchure Chamber

An air-tight wooden chamber measuring 47 cm x 18.5 cm x 40.7 cm was constructed of 3/4-inch white pine. Foam insulation was used between all joints to provide an airtight seal. The ends of the chamber consisted of 1/4-inch plexiglass mounted on eight evenly distributed posts of threaded stock which were embedded and glued within the main chassis. Wing nuts, attached to the embedded posts, pressed the plexiglass against an insulating layer of 3/4-inch foam weatherstrip tape and provided an effective seal between the side plates and the chamber. This arrangement allowed the plexiglass to be easily removed when internal adjustments became necessary.

A hole three inches in diameter was drilled into one side of the chamber and was fitted with a three-inch rubber plug through which a smaller hole was cut to accomodate the barrel of the clarinet. In this way, the clarinet could be separated from the chamber quickly and easily for adjustments. Air was delivered from an air supply via a 1 1/2-inch diameter hose which was attached to the opposite side of the chamber and sealed with clear General Electric Silicone sealer.

Mechanism for Adjusting Pressure and Position of Lip Cushion

Multidirectional manipulation of lower-lip pressure upon the reed was made possible by utilizing an externally-controlled mechanism housed within the chamber (see Figure 2). Horizontal movement of the lip mechanism was achieved by mounting four 1/4-inch steel rods near the top of the chamber and spacing them in a square formation, each two inches apart. This provided a stable foundation upon which a wooden plate of 3/4-inch pine could slide horizontally through the chamber. External control was achieved by mounting an 8-inch screw rod parallel to the other steel rods, but connected to the pine plate with a sliding lock washer. The other end of the screw rod passed through a threaded nut secured within the opposite side of the

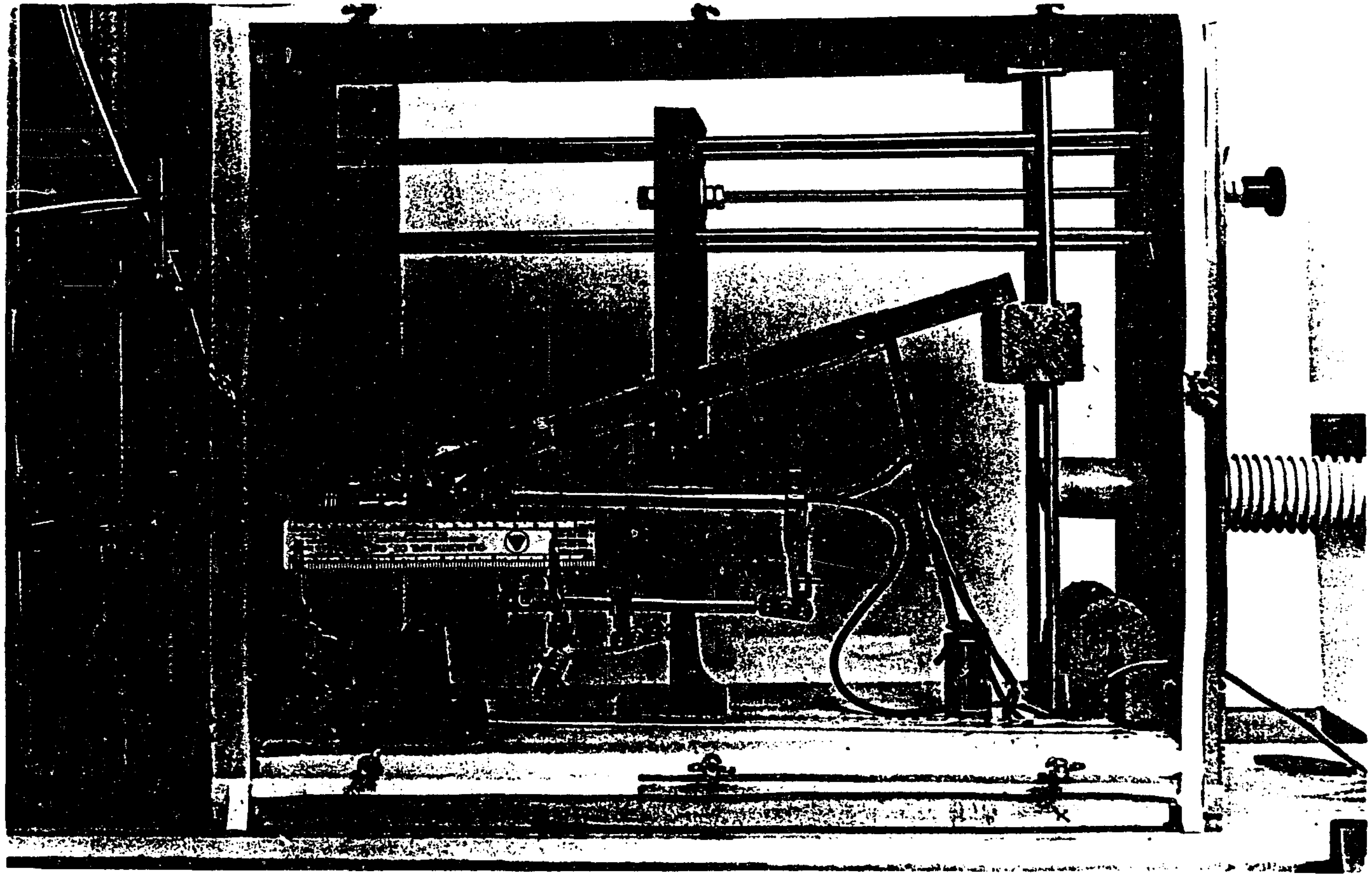


Figure 2. The Artificial Embouchure and Lower-Lip Mechanism

chamber and fitted with a beveled knob. A washer arrangement at each end of the screw rod allowed it to be turned forward or backward through a nut mounted in the side of the chamber, pushing it in a horizontal motion against the pine plate. This provided an accurate and efficient method of moving the pine plate left or right. The pine plate, in turn, extended into the lower part of the chamber and supported another 1/4-inch steel rod axle for the lip mechanism.

Vertical movement of the lip mechanism was achieved by a "see-saw" arrangement along the axle of the pine plate. A second pine plate supporting two brass strips was attached to the axle of the first pine plate. These brass strips extended beyond the length of the second plate by three inches in each direction. In one direction, they extended to an externally-controlled mechanism which provided vertical movement, while in the other direction, they extended to hold a steel axle supporting the lip mechanism.

The externally-controlled mechanism which provided vertical movement was similar in design to the horizontal mechanism described above. Two steel rods, extended from the top to the bottom of the chamber as sliding posts for a third pine plate. A rod of threaded stock was mounted to the plate and threaded through a nut mounted in the top of the chamber to accomodate a knurled knob. By turning the knurled knob, the rod and the pine plate could be moved vertically in either direction.

To achieve simultaneous movement in all directions, it was necessary to design the two mechanisms so that one movement did not interfere with the other. By placing the brass extenders from the first plate on top of the second plate, they were free to slide across it in a horizontal direction. At the same time, when the vertical plate was moved, it would lift or lower the brass extenders and provide a "see-saw" action across the other plate. By simultaneously adjusting the two external knobs, multi-directional movement of the brass extenders was possible without interference.

The Lip Mechanism

The brass extenders supported the lip mechanism which consisted of a 1/2-inch diameter rubber cylinder molded to a 1/4-inch steel axle (see Figure 3). The lip cushion was constructed from 1 1/4-inch adhesive-backed foam insulation. The adhesive allowed a 1-inch square section of insulation to be wrapped around the rubber cylinder. Rubber bands provided additional security to the insulation. After experimenting with a number of different materials, it was determined, by feel and touch, that this arrangement closely simulated the actual texture of a human lip.

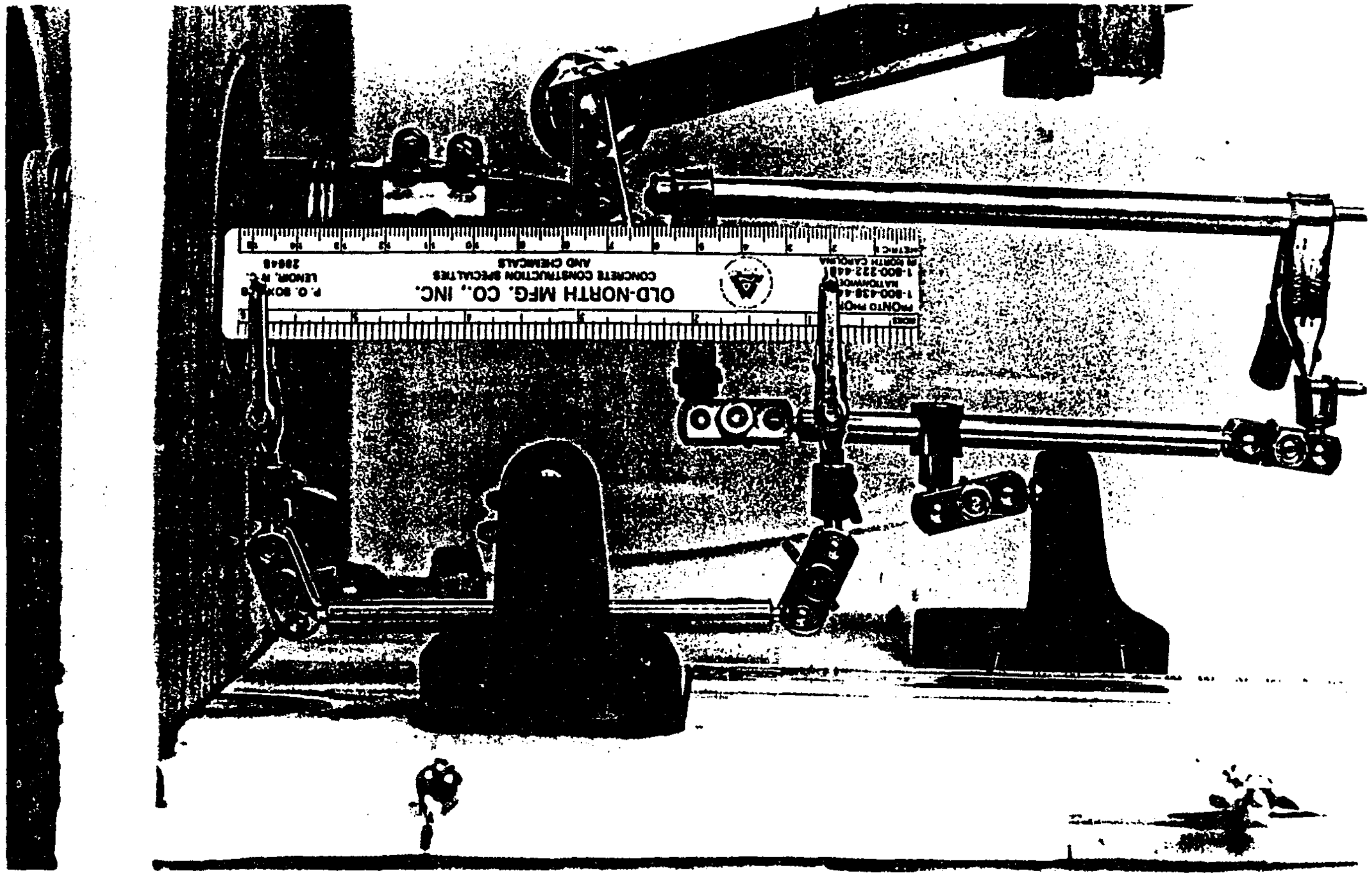


Figure 3. The Lip Mechanism

Four separate devices were attached to the floor of the chamber: an adjustable mounting for a Type FPT-100 photo transitor; an atomizer mounted so that when a rubber bulb was squeezed outside the chamber, moisture was sprayed toward the reed/mouthpiece aperture; a thermometer; and a ruler marked in millimeters mounted parallel to the inserted clarinet. A pointer fastened to the axle of the lip mechanism moved along the ruler in such a way that horizontal movement of the mechanism along the reed's surface could be accurately gauged.

Air Pressure and Regulation

The air supply consisted of an air pump housed within a sound-reducing box. The box was constructed from pine, measured 45.5 cm x 47.0 cm x 61.0 cm, and was lined internally with 2-inch thick rubber foam insulation. The speed of the air pump was regulated by a potentiometer. A hose with an inside diameter of 28 mm was used to distribute air to the chamber since both the volume of air and the air pressure have been determined to be important factors in producing a sound on the clarinet (Coppenbarger, 1970). A standard U-tube manometer was used to measure blowing pressures. Mercury is the most commonly employed liquid in manometers because of its low vapor pressure and its high density. This produces a generally negligible contamination of the gases whose pressures are being measured and permits the use of manometers of convenient dimensions (Reiman, 1971, p. 218). However, after pilot trials, it was determined that water gave a more sensitive measurement, due to its ability to move greater distance under a specific pressure. Consequently, all measurements were made in terms of centimeters of water displaced. As water lowered in one side of the manometer, it would rise in the other. Respective amounts of displacement in each side were noted and summed. Atmospheric pressure was considered a constant and did not enter into the calculations.

Equipment Used in Quantitative Analyses

Quantitative data were collected using an Apple IIe computer interfaced with a Type FPT-100 photo transistor via a Nalandata A2 Data Converter and a 6522 VIA card installed within the computer. The photo transistor was recessed and mounted within a 6-inch alumninum cylinder having an outside diameter of 1 cm and mounted on a base which permitted accurate alignment with the mouthpiece aperture. A wire from the photo transitor was connected to a nine-volt alkaline battery before it was passed through the wall of the chamber. A 12-volt direct-current light source was placed opposite the bell of the clarinet and adjusted so as to direct the light through the length of the clarinet and into the photo transistor. Power for the light source was provided by a Model 73P variable power supply. Direct current versus alternating current (AC) was used to control fluctuations in light intensity which occurred when alternating current was applied. The signal voltage produced by the photo transitor was amplified and directed to an 8-bit analog-to-digital converter interfaced with the computer. The analog-to-digital converter was used in conjunction with "Apple-Swiss" (1986) software (see Appendix A) to produce numeric and graphic representations of the variations in light intensity received by the photo transisitor. For purposes of comparison, a Technics Model RP-3500E Electret Condenser Microphone of 600 ohm impedence was used to record air-pressure variations.

Data Converter Specifications

The analog-signal output from the photo transitor was fed into an analog-to-digital converter (Nalandata A2A Data Converter) designed by Nicklin (1986) at Appalachian State University. The Nalandata A2A was a small unit placed outside the computer. The line from the photo transistor was connected to an input jack of the Nalandata A2A which fed the signal to a linear amplifier offering switch-selectable gains (amplifications) of .33, 1.0, 3.3, 10, 33, and 100 times the original signal voltage. Gain refers to the amount of amplification applied to the measured voltages. Amplification was used, in some trials, to increase the vertical aspect of the graphs for clarity.

After amplification, the signal was passed to an 8-bit analog-to-digital converter capable of discriminating a maximum of 256 voltage levels with accuracy within 0.4 percent. A Versatile Interface Adapter (VIA board) was plugged into the computer and interfaced the Data Converter to the Apple IIe. Accompanying the Nalandata A2A was a software program designed by Nicklin (1986). Graphs were printed on a Star NX-10 dot-matrix printer using a graphics dump program [Triple Dump (1984) by Beagle Brothers Micro Software, Inc.].

Control of the Variables

Vibrational patterns produced by a reed may have an important bearing upon the tone quality which is produced by a clarinet. Since lip pressure and air pressure are different for every player, manipulation of these variables is necessary to demonstrate the possiblility that reed vibrations are an important element in the production of specific tone qualities. Variables within the excitation mechanism which might affect tone quality are: air pressure, lip pressure, ligature tension, reed mass, reed density or stiffness, and the internal and external dimensions of the mouthpiece. By controlling all of these variables while manipulating air and lip pressure, the effects of the latter two variables upon the vibrational pattern of the reed may be observed.

The following variables were controlled during the experiment: applied air pressure, applied lip pressure; ligature pressure; reed mass; reed density; and dimensions of the mouthpiece. The independent variables were applied air and lip pressures. The dependent variable, which resulted from manipulation of applied air and lip pressure, was the vibrational pattern of the reed as shown by light-intensity variations received by the photo transistor. The artificial embouchure not only made it possible to visually observe the reed´s motion but allowed for precise control of the variables. Such control would have been impossible if a human subject had been used.

Position and Applied Pressure of Lower-lip Mechanism

The pressure exerted by the lower-lip mechanism was kept constant in some of the experimental tests. In others, it was varied, in conjunction with air pressure, to produce a sound on the clarinet as the reed was set into motion by the artificial-embouchure mechanism. Too much pressure exerted by the lower-lip mechanism resulted in a "choked" sound and too little pressure caused familiar "squeaks" or "squeals" that are often heard when beginners play the clarinet. Backus (1961) found that "the frequency of a clarinet tone is influenced to some extent by the lip pressure on the reed, giving the clarinetist some control over the intonation of the instrument" (p.862). Backus (1961) writes:

> The damping provided by the player's lip is important in reducing the tendency to produce high-frequency vibrations. The mass of the reed is an important factor determining the production of higher harmonics and is thus of considerable importance to the quality of the tone produced (p. 1652).

The horizontal position where the lower-lip mechanism touched the reed was controlled through the use of a ruler marked in millimeters and mounted close to the mechanism. A pointer attached to the lip mechanism moved along the ruler as its horizontal position was changed. The most advantageous position in this respect was located before any experiments began. This optimum position corresponded to the area where the reed left the facing of the mouthpiece when in its position of rest.

Applied Ligature Pressure

A standard French metal ligature was used during the experiment and was secured to the mouthpiece by tightening two equally-spaced ligature screws. Care was taken to tighten the screws the same amount for each trial. The ligature was aligned with markings on the mouthpiece to ensure constancy of position from trial to trial.

Mass and Density of the Reed

A Vandoren number 3 reed, carefully adjusted to respond well when played with a human embouchure, was used for all trials to ensure constancy in mass and density. The measure of elasticity of a mass, defined as the ratio of stress to strain (Reiman, 1971, p. 250) is a quantity known as "the modulus of elasticity." For linear deformations, as in the vertical movement of a vibrating reed, this modulus is known as Young´s modulus (Reiman, 1971, p.250). Backus (1961) found that a wet reed has a smaller modulus, or smaller ratio of stress to strain. He wrote:

> The Young´s modulus for the cane from which reeds are made varies by more than a factor of two among samples, even for strips of the same cane. The density also varies, but over a smaller range. These variations make finding a good clarinet reed an unpredictable matter. The reed, when wet (as under playing conditions), has a smaller modulus and larger density than when dry (p. 1652).

Thus, a wet reed can be moved, or deformed, with less strain, than one which is dry. For this reason, the reed was kept wet during the experiment to simulate normal playing conditions. To maintain the wet state of the reed, an externally-controlled atomizer bottle was placed within the chamber and directed toward the reed/mouthpiece aperture. Also, because of large amounts of air entering the chamber during each trial, a wet sponge was placed on the floor of the chamber to help stabilize humidity.

Mouthpiece, Instrument, and Pitch

A standard Portnoy BP-02 mouthpiece with a medium facing was coupled to a plastic Bb Boehm system Vito clarinet in the experiment. Various pitches were attained by wiring keys shut and stopping the holes with rubber plugs. Care was taken to ensure that the ends of the rubber plugs did not protrude into the bore of the clarinet and that the depth of their penetration was kept the same for all holes.

Loudness or Intensity

Intensity was monitored using a Realistic brand sound-level meter in a slow response mode. The slow response was selected since it presented an average intensity level over time, and, for purposes of this experiment, allowed more accurate measurements to be taken. Since the loudness sensation produced by a vibrational amplitude depends on frequency, an A-weighted scale was used to register sounds in a way human ears hear. The A scale causes the meter to respond to changes in frequency, so as to be less sensitive to low and high frequencies. Backus (1977) states: "It has been found that readings with the A network correspond well to the subjective impression of the listener to the sound measured" (p. 98).

For purposes of standardization in location, the sound-level meter was kept 30 cm from the clarinet bell and aimed directly at the instrument. The decibel levels chosen for the experiment were subjectively matched to music dynamic markings as follows: 90 dBA = pianissimo (pp), 96 dBA = mezzo-forte (mf), and 100 dBA = fortissimo (ff).

Detailed Procedures

To evaluate the many aspects of reed vibration at various air pressures, a number of different procedures were necessary. Workcharts for these procedures may be seen in Appendix B, Tables 1 through 12. For clarity, these procedures are described below and are grouped according to specific aspects of reed vibration under observation. The procedures were completed for one pitch before advancing to the next, since lip pressure and position had to be changed between pitch levels. The various procedures discussed below were conducted one pitch at a time and in the sequence appearing on the worksheets.

For clarity, the procedures are organized into two major categories: those centering around the effects of air-pressure variations and those centering around lip-pressure variations.

Air-Pressure Experiments

Preliminary Test of Natural Blowing Pressures

To compare air-pressure requirements of the artificial-embouchure chamber with those required in human performance, it was necessary to observe those pressures while the clarinet was being played in a natural manner, thus a preliminary test was conducted to determine natural air pressures required to produce tones throughout the range of the clarinet when blown by a human (see Appendix C). A plastic tube was inserted into a human mouth while playing the clarinet and connected to a U-tube water manometer. Air-pressure readings were observed for all pitches extending from E3 to G6 while an intensity level of 100 dBA was maintained.

Air-Pressure Variation and Intensity at Constant Lip Pressure

To determine the range of intensities possible through air pressure variations at constant lip pressure, two primary procedures were conducted.

In the first primary procedure, the lower-lip mechanism of the artificial embouchure was adjusted, in conjunction with air pressure, to produce a tone of high intensity (ff). With lip pressure held constant, air pressure was reduced in small increments (approximately 2 cm H20) and data were recorded at each increment. This procedure was conducted on three pitches: F3, F5, and F6.

In the second primary procedure, the lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a tone of low intensity (pp). With lip pressure held constant, air pressure was increased in small increments and data were recorded at each increment. This procedure was conducted on two pitches: F4 and B-flat 5.

To determine the influence selected lip-pressure settings might have on the results, the first primary procedure was repeated on F5 and the second primary procedure repeated on F4, both with new lip pressure settings. To determine the effects that presetting lip pressure to an optimum setting might have on the results, the lower-lip mechanism was adjusted to an optimum pressure, which, in conjunction with air pressure, produced a tone of high intensity (100 dBA) on B-flat 5. Air pressure was then reduced to produce a tone of low intensity and slowly reapplied in small increments. Intensities were recorded at each increment of air pressure.

Air Pressure and the Vibrational Frequency of the Reed at Constant Lip Pressure

To observe the effects of air-pressure variations on the reed´s frequency of vibration, the lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a tone of low intensity (90 dBA). Without changing the lower-lip mechanism, air pressure was increased to produce a tone of moderate intensity (96 dBA), and again to produce a tone of high intensity (100 dBA). Data were recorded at each intensity level. These tests were conducted on three pitches: F4, F5, and B-flat 5; and the data was presented in the form of a stripchart table. The reed´s frequency of vibration at each pitch and intensity level was determined by multiplying the data rate times the total number of samples recorded within each cycle as shown on the stripcharts. Frequencies were compared across intensities and with a standard table of frequencies of pitches in the tempered scale (Backus, 1977, p. 153). The objective was to confirm, through quantitative data, that the reed vibrates at the frequency of the air column, regardless of the amount of applied air pressure.

Reed Amplitude and Intensity at Constant Lip Pressure

Before proceeding with experiments focusing specifically upon the effects of air pressure and reed amplitude, it was first necessary to observe the relationship between reed amplitude and intensity at constant air pressure. To simultaneously observe effects of air-pressure increases on reed amplitude and intensity, numerical representations (stripcharts) were produced from data previously collected on F4 (See "Air Pressure and Intensity at Constant Lip Pressure," second primary procedure), and used to calculate voltage peaks (reed amplitudes). Reed amplitudes were then compared to observed intensity (sound pressure) changes.

Air Pressure and Amplitude of Reed Motion at Constant Lip Pressure

To observe the effects of air-pressure variations on amplitude of reed motion at constant lip pressure, the lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a high-intensity tone of F4. Since the lower-lip mechanism was now set at an optimum pressure for a wide intensity range, the reed was in essence "spring-loaded" by the mechanism into a position conducive to efficient vibration. Air pressure was then reduced until the sound was no longer audible to a human ear, but the pressure of the lower-lip mechanism was retained. Air pressure was then slowly increased in small increments of 2-3 cm H20 until a sound was produced at the subjective threshold of hearing. Light-intensity variations received by the photo transistor were monitored and reproduced as graphs. These graphs were superimposed upon one another and the graphed light intensities were compared with air-pressure measurements.

The transient.

An analysis of transient wave motion was made by combining two procedures. In the first procedure, a transient (a wave consisting of small reed vibrations which appear before an audible tone is initiated) was observed for the tone F4 by slowly increasing air pressure after the reed had been "spring-loaded" to a pressure conducive to efficient vibration. A microphone was connected to the AC port of the digital converter and used to monitor any transient air-pressure variations which were produced. In the second procedure, air pressure was increased to produce a tone of high intensity and then lip pressure was withdrawn completely. The reed was allowed to continue vibrating, but at its own natural frequency (a squeal), undamped by the pressure of the lower-lip mechanism. Data were then collected via the microphone.

Data from these two procedures were compared by superimposing graphs of resulting wave forms. In this way, data for the F4 transient and the reed's natural frequency of vibration were recorded for comparison.

Data on the steady state and air-column frequency.

Data from the F4 transient waveform demonstrated that it produced a fluctuation of greater wavelength than contained within the transient itself. To determine if this observed fluctuation might be an early product of the steady state (a tone, clearly of the vibrational frequency of F4, but not necessarily audible to the human ear), the waveform of the transient was superimposed over a waveform of air-pressure variations produced by the clarinet and measured with the microphone. The two waveforms were then compared. Graphs were also produced for four tones of low intensity (F3, F4, F5, and B-flat 5) in steady state.

Lip-Pressure Experiments

Lip Pressure and Intensity at Constant Air Pressure

Two procedures were conducted to observe the effects of lip pressure on intensity. In the first procedure (Appendix B, Table 1, pages 07-10; for explanation of Table 1, see Chapter IV, Data Forms), the lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a wide range of intensities on the tone F3. Pressure exerted by the lower-lip mechanism was then increased until the clarinet was producing a tone of low intensity (70 dBA). Lip pressure was slowly reduced until it became so weak that the tone could no longer be maintained and intensity variations were recorded.

After completing the first procedure, it was observed that with the application of a constant volume of air to the artificial-embouchure chamber; air pressure, as measured within the chamber, varied as lip pressure was reduced. Therefore, a second procedure was conducted on F4 (Appendix B, Table 4, pages 08-10) in which air pressure within the chamber was kept constant. This was achieved by adjusting the potentiometer which regulated the speed of the air pump. In this procedure, the lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a wide range of intensities. Pressure exerted by the lower-lip mechanism was then increased until the clarinet was producing a tone of low intensity (80 dBA). As applied lip pressure was reduced, air pressure within the chamber was maintained. Data were recorded at high and low lip pressures.

Lip Pressure and Amplitude of Reed Motion

Using data previously collected on F3 (Appendix B, Table 1, pages 07-10), observations were made of the effects of lip-pressure variations on amplitude of reed motion. Four graphs were produced of the reed's motion as lip pressure was reduced in four increments ranging from high pressure to low pressure. Variations in reed amplitude were observed at each lip-pressure increment.

Lip Pressure and Duration of Reed Closure

To observe effects of lip-pressure variations on duration of reed closure, two series of tests were conducted on the tone F3. In the first series, stripcharts were produced from data previously collected on F3 (Appendix B, Table 1, pages 07-10) in which lip pressure was slowly reduced in four increments. The lowest three voltages within each stripchart were selected as representing closure points. Air pressure and intensity were also monitored during the lip-pressure variations.

Graphs illustrating each waveform were produced.

In the second series of tests (Appendix B, Table 3, pages 00-11), two procedures were conducted on F3 using high and low lip-pressure settings. In the first procedure (Appendix B, Table 64, pages 06, 08, 10), pressure of the lower-lip mechanism was set on a high-pressure setting. Air pressure was manipulated via the potentiometer to produce three intensities: threshold sound level, 90 dBA (mf), and 100 dBA (ff). The effects of high lip pressure on closure times were observed as applied air pressure was increased. In the second procedure (Appendix B, Table 3, pages 07, 09, 11), pressure of the lower-lip mechanism was set on a low-pressure setting. Air pressure was manipulated via the potentiometer to produce three intensity levels; threshold sound level, 90 dBA (mf), and 100 dBA (ff). The effects of low lip-pressure variations on closure times were observed as applied air pressure was increased.

CHAPTER IV

EVALUATION OF THE DATA

Graphic Representation of the Data

Graphic representations of the reed's vibrational cycle were compared for specific pitches at different air and lip pressures. A graphic representation of light fluctuations produced by a vibrating reed is shown in Figure 4. The vertical axis of the graph represents a continuum of light intensities which passed between the reed and mouthpiece, measured in millivolts. Since the numeric range of the data converter was 0 to 255, voltages produced by the photo transitor were presented graphically along a vertical scale comprising 256 increments. For purposes of this study, only relative voltage comparisons were made; therefore, the graphic representations do not include specific increments of voltage.

The horizontal axis represents passage of time in milliseconds. The amount of time depicted by the horizontal axis was adjustable in "steps" to expand or contract the waveform for graphic clarity. All graphic illustrations reproduced for this study were created at "step 1:" that is, 256 samples taken at the rate

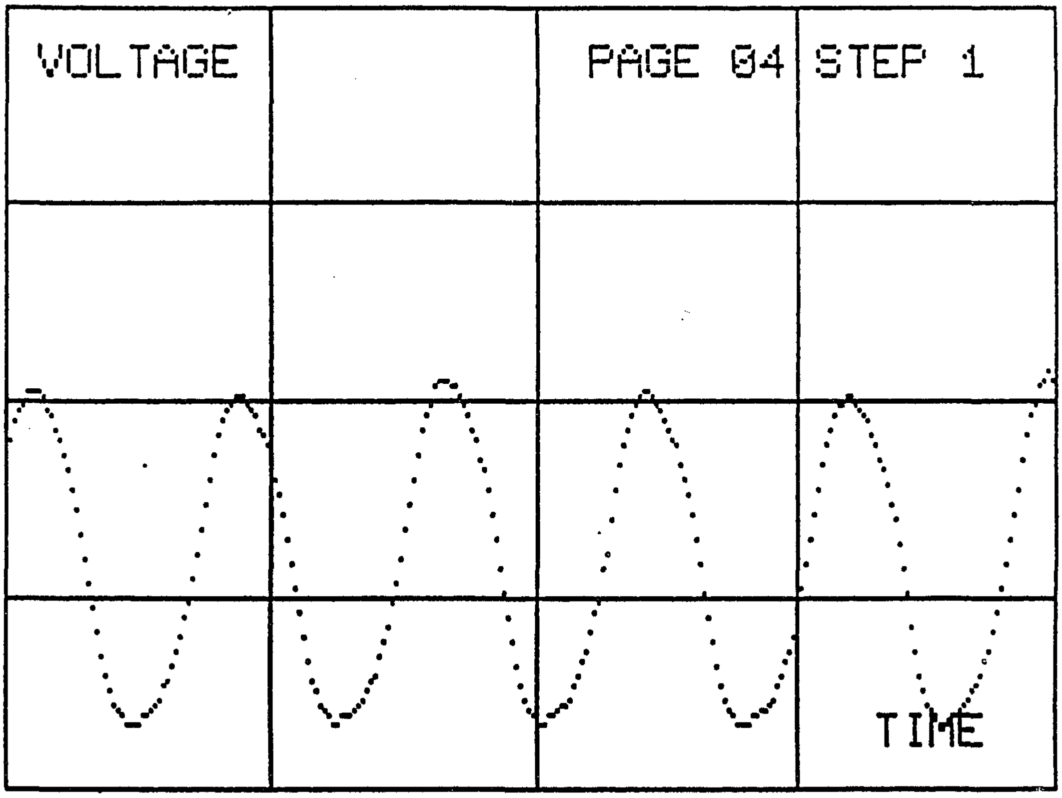


Figure 4

Light-Intensity Fluctuations for F4
33.0 cm H2O, 90 dBA, Gain = 3.3
F4 Tl 04

of 17,280 samples per second. Therefore, time separation between successive samples was 1/17,280 (or .0000579) of a second.

Each graph contains 256 samples or points, but since the Apple IIe computer could store 4096 samples at a time, samples were stored and presented in "sections" or "Pages," each containing 256 samples. The computer monitor could therefore be used to present a long stream of samples along the horizontal axis in sections of 256 samples each; i.e. page by page, or screen by screen. Page 5, for example, contained samples 1280 to 1535 (5 Pages x 256 samples per page, to 6 Pages x 256 samples per page, minus 1). Therefore, each graph contains 256 possible samples within its vertical range and 256 samples within its horizontal range. The graphs are presented in an oblong shape only to facilitate spreading of the wave form. The frequencies, or hertz, of the graphic representations, are consistent by pitch; that is, F4 in all graphs is equal to approximately 349.23 cycles per second (Backus, 1977, p. 153).

On the vertical scale, the analog-to-digital converter was designed to discriminate a maximum of 256 different voltage levels and to read these voltages to an accuracy of 0.4 percent of the total applied voltage. As light intensity received by the photo transitor increased, so did the voltage sent to the analog-to-digital converter. The converter also made switch-selectable gains available.

Gain refers to the amount of voltage amplification applied to the vertical scale of the graphs. The analog-to-digital converter offered gains of .33, 1.0, 3.3, 10, 33, and 100 times the incoming signal voltage received from the photo transistor. If the wave form was too flat for observation, it was possible to amplify the vertical aspect by increasing the gain on the converter. The objective was to adjust the gain control on the analog-to-digital converter until the voltage signal corresponded to the vertical range of the graph.

Numeric Representation of the Data

A numeric representation of Figure 4 is presented in Table 1. Each numeric representation is identified as a "stripchart" and begins and ends on a selected sample number or "address." Table 1 represents a stripchart for F4 which begins with sample number 1024 and ends with sample number 1227, inclusive. This stripchart was created by selecting a "starting address" and an "ending address." This particular analysis shows only samples 1024 through 1227 from a total of 4096 samples. Table 1 displays only a portion of the samples contained within its corresponding waveform pictured in Figure 4.

On each stripchart, data are shown in six double-columns as indicated by the dotted lines, each double-column being comprised of two columns of values.

Table 1

Stripchart for F4, Series III
33.0 cm H2O, 90 dBA, Page 04

```
STARTING ADDRESS = 1024  ENDING ADDRESS = 1224
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------     ---------     ---------     ---------     ---------     ---------
    1024   109    1058    25    1092    82    1126   127    1160    31    1194    56
    1025   115    1059    27    1093    74    1127   132    1161    35    1195    48
    1026   121    1060    29    1094    66    1128   134    1162    38    1196    41
    1027   125    1061    31    1095    58    1129   135    1163    42    1197    35
    1028   127    1062    34    1096    50    1130   135    1164    47    1198    30
    1029   131    1063    37    1097    43    1131   133    1165    53    1199    27
    1030   131    1064    41    1098    37    1132   132    1166    59    1200    25
    1031   131    1065    46    1099    32    1133   129    1167    63    1201    23
    1032   130    1066    51    1100    28    1134   126    1168    73    1202    23
    1033   128    1067    57    1101    26    1135   122    1169    79    1203    23
    1034   125    1068    63    1102    24    1136   118    1170    89    1204    23
    1035   122    1069    71    1103    23    1137   114    1171    98    1205    24
    1036   118    1070    79    1104    23    1138   109    1172   106    1206    25
    1037   114    1071    87    1105    24    1139   104    1173   113    1207    26
    1038   110    1072    95    1106    24    1140    98    1174   119    1208    27
    1039   104    1073   103    1107    25    1141    90    1175   123    1209    29
    1040    98    1074   111    1108    27    1142    82    1176   127    1210    31
    1041    93    1075   117    1109    28    1143    73    1177   129    1211    35
    1042    85    1076   121    1110    31    1144    64    1178   131    1212    38
    1043    77    1077   125    1111    33    1145    56    1179   131    1213    42
    1044    69    1078   127    1112    36    1146    48    1180   129    1214    47
    1045    61    1079   128    1113    39    1147    40    1181   127    1215    51
    1046    53    1080   129    1114    44    1148    34    1182   124    1216    59
    1047    45    1081   128    1115    49    1149    30    1183   121    1217    66
    1048    38    1082   126    1116    55    1150    27    1184   119    1218    74
    1049    33    1083   124    1117    62    1151    25    1185   115    1219    83
    1050    29    1084   122    1118    69    1152    24    1186   112    1220    91
    1051    26    1085   119    1119    77    1153    23    1187   107    1221    99
    1052    24    1086   116    1120    86    1154    23    1188   102    1222   107
    1053    23    1087   112    1121    95    1155    25    1189    96    1223   113
    1054    23    1088   109    1122   103    1156    25    1190    90    1224   119
    1055    23    1089   103    1123   111    1157    27    1191    82    1225   123
    1056    23    1090    97    1124   119    1158    28    1192    74    1226   126
    1057    24    1091    90    1125   123    1159    29    1193    64    1227   127
```

The first value in the first row of column 1 is the "point number" (sample number). The second value in the first row of column 1 represents light intensity in millivolts corresponding to each sample.

At the top of Table 1 are selected parameters prescribing the curve on page 04 of the entire data set of 4096 samples gathered. The starting address of 1024 denotes that samples from 0000 to 1023 are not shown. The ending address of 1227 denotes that samples beyond 1227 are not shown. This table, therefore, represents only the 1024th sample through the 1227th sample and their respective voltage values in millivolts. For purposes of symmetry in printing the tables, the ending address designated at the top of each table is three sample numbers lower than the sample number ending each table of data.

Each stripchart presented in this study begins with a starting address from which each corresponding graphic representation was developed. Therefore, each graph and its corresponding stripchart begins with the same sample number. The stripcharts, however, only present a representative portion of the 256 samples shown within each graph.

A survey of the sample values in Table 1 describes a fluctuation which corresponds to the sine curve in Figure 4. By carefully prescribing starting and ending addresses, any part of a graph may be scrutinized in much greater detail with such a value representation. By noting time values and voltages shown within the graphs, accurate real-time measurements to 1/17,280 of a second could be made of various positions of the reed. In this respect, this study was more comprehensive and microscopic than any presented to date.

Data Forms

A data form was constructed (see Figure 5) to facilitate location of specific wave forms and to provide a log for each sampling. The heading of the form provided a space for indicating the pitch of the tone being studied. Because many tests were often run at the same pitch, a space was also provided for test number and date. The column designated as "Page" designated data Pages containing pertinent values which were briefly described by written observations notated at the end of each row. "Par" designated parameters (page numbers) which were entered into the computer to "call up" a specific data set. "L" and "R" designated water height in inches in the left and right columns of the U-tube manometer, respectively. "T" represented temperature within the embouchure chamber in degrees Centigrade. Sound pressure levels were notated in the column labeled "dBA." The column labeled "R-L, mm H2O" was used to notate air pressure derived by subtracting the water-level measurement observed within the left column of

Pitch ______ Test No. ______ Date ____________

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256						
01	01-02	512						
02	02-03	768						
03	03-04	1024						
04	04-05	1280						
05	05-06	1536						
06	06-07	1792						
07	07-08	2048						
08	08-09	2304						
09	09-10	2560						
10	10-11	2816						
11	11-12	3072						

Disk Title ____________________

Data Name ____________________

Starting Address ________________

Ending Address _________________

Data Step ______

Date __________

Figure 5

Data Form

the manometer from the water-level measurement observed within the right column. "EA" represented the "ending address" needed to observe the data set representative of a specific row or observation on the data form. Below the data form, "Disk Title, Data Name, Starting Address, Ending Address, Data Step, and Date" are found. This information allowed access to a data set via the computer. For example, a representative data form from which data in Figure 4 were extracted is shown in Appendix B, Table 6, Page 04.

Analysis of Data Measurements

Air Pressure and Intensity at Constant Lip Pressure

Analyses of intensity data showed that many intensities were attainable by increasing or decreasing air pressure within the embouchure chamber while keeping position and pressure of the lower-lip mechanism constant. To determine the range of intensities possible at constant lip pressure, intensity variations were monitored as air pressure was both increased and decreased in small increments (See Table 2).

In the first series of tests, the lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a tone of high intensity (ff) before air pressure was reduced. This procedure was conducted at three pitch

Test	Pitch	Range AP	High/Low dBA	Range dBA	Procedure
T1	F3	36.5-24.5	98-68	30 dBA	Decreasing
T2	F5	36.5-31.5	100-90	10 dBA	Decreasing
T3	F6	29.5-23.5	100-96	04 dBA	Decreasing
T1	F4	21.5-29.0	80-93	13 dBA	Increasing
T2	Bb5	24.0-31.0	90-100	10 dBA	Increasing

Additional tests at new lip pressure settings:

	F5	31.5-29.0	96-86	10 dBA	Decreasing
	F4	25.0-27.0	72-90	18 dBA	Increasing
	Bb5	25.0-39.0	90-105	15 dBA	Increasing

Table 2

Tests Using Two Primary Procedures

levels: F3, F5, and F6. Test 1 was conducted on the pitch F3 (Appendix B, Table 1, Pages 00-03). The clarinet was made to sound F3 at an intensity level of 98 dBA. Air pressure was reduced in small increments until the sound produced was at the threshold of audibility for a human ear. The resulting intensities ranged from 98 dBA to 68 dBA at constant lip pressure. If air pressure was reduced below 24.5 cm H20, the tone became inaudible; therefore, intensity range varied by 30 dBA for F3 as air pressure was decreased at constant lip pressure.

Test 2 was conducted on F5 (Appendix B, Table 9, Pages 03-05). The clarinet was made to sound F5 at 100 dBA with an applied air pressure of 36.5 cm H20. It was possible to reduce air pressure to 31.5 cm H20 before the tone faded to inaudibility. This yielded a 10 dBA intensity range. When this test was repeated on F5 at a different lip-pressure setting (Appendix B, Table 9, Pages 06-07), similar results were attained. The intensity range available at constant lip pressure was again 10 dBA for F5.

Test 3 was conducted on F6 (Appendix B, Table 10, Pages 00-01). Air pressure varied from 29.5 cm H20 to 23.5 cm H20 while intensity varied from 100 dBA to 96 dBA; a range of only 4 dBA. A further decrease in air pressure caused the sound to suddenly become inaudible. There was, therefore, a sharp decline in intensity level for F6 when air pressure was reduced below 23.5 cm H20. It was not possible, at the selected lip pressure, to sustain a tone at less than 96 dBA at F6. The data from these three tests suggest that at constant lip pressure, the intensity range available from air-pressure reduction diminishes at higher frequencies.

To evaluate the effects of increases in air pressure on intensity at constant lip pressure, another series of tests were conducted. The lower-lip mechanism was adjusted, in conjunction with air pressure, to produce a tone of low intensity. With lower-lip pressure constant, air pressure was increased in small increments and data were recorded at two pitch levels: F4 and B-flat 5. Two tests were conducted at each pitch.

The first test was conducted on F4 (Appendix B, Table 5, Pages 00-05). Applied air pressure ranged from 21.5 cm H20 to 29.0 cm H20 and produced intensities ranging from 80 dBA to 93 dBA; a range of 13 dBA at constant lip pressure. When this test was repeated on F4 at a different lip-pressure setting (Appendix B, Table 5, Pages 06-08), intensities ranged from from 72 dBA to 90 dBA; a range of 18 dBA at constant lip pressure.

Test 2, on B-flat 5 (Appendix B, Table 11, Pages 08-11), allowed variations in air pressure ranging from 24 cm H20 to 31 cm H20, and produced intensities ranging from 90 dBA to 100 dBA; a range of 10 dBA at constant lip pressure. These data suggest that at constant lip pressure, the intensity range available by increasing air pressure diminishes at higher frequencies. In a second test on B-flat 5 (Appendix B, Table 12, Pages 02-08), the lower-lip mechanism was adjusted, in conjunction with air pressure (34.0 cm H20), to produce a high-intensity tone of 100 dBA. Air pressure was lowered from 34.0 cm H20 to 25.0 cm H20 to produce a tone of the lowest intensity audible to the human ear. As air pressure was then increased, a greater range of intensities resulted: from 90 dBA to 105 dBA; a range of 15 dBA at constant lip pressure. These data suggest that at constant lip pressure, intensity range may increase if lip pressure is preadjusted to a pressure conducive to the production of tones of high intensity. In summary (see Table 2), at constant lip pressure: a) intensity range available through air-pressure variations may increase if lip pressure is preadjusted to an optimum pressure, and b) intensity range available through air-pressure variations diminishes in the higher frequencies.

Air Pressure and the Reed´s Frequency of Vibration at Constant Lip Pressure

To observe the effects of air-pressure variations on the reed´s frequency of vibration at constant lip pressure, data were recorded at three intensity levels (90 dBA, 96 dBA, 100 dBA) and at three pitch levels (F4, F5, B-flat 5).

Stripcharts were produced for each pitch (Appendix B, Tables 13-21).

Test 1 was conducted on F4 (Appendix B, Table 6, Pages 00, 02, 04). Stripcharts were produced at three intensity levels (90 dBA, 96 dBA, 100 dBA) as shown in Appendix B, Tables 13, 14, and 15. To determine the frequency of reed vibration at each intensity, it was first necessary to determine wavelengths. Wavelengths were determined by choosing a "starting-sample" number at a specific location within a wave and counting the total number of samples contained within one complete cycle of the wave. In Appendix B, Table 13, for example, sample number 19 was chosen as the starting sample since it was observed from the accompanying voltages that amplitude increased at this point. Sample number 19 became an arbitrary reference point within Table 13 where counting began. Additionally, observations showed that one cycle of vibration was completed at sample number 68, where voltages increased again to begin the second cycle. The total number of samples observed within this cycle was 50 samples. Since the data rate was 17,280 samples per second, the frequency of vibration was (17,280/50), or 345.6 cycles per second. Utilizing this method of calculation, frequencies were determined for each pitch at each intensity level. A summary of these data is shown in Table 3.

When F4 was sounded at an intensity of 100 dBA, each

Pitch	Intensity dBA	Pressure cm.H20	Samples Chosen	Samples/ Cycle	Data Form	Freq Hz	Freq Hz Standard
F4	100	35.5	16-68	50	F4 T3 00	345.6	349.2
F4	96	34.0	566-614	49	F4 T3 02	352.6	
F4	90	33.0	1073-1122	50	F4 T3 04	345.6	
F5	100	36.5	781-806	26	F5 T1 03	664.6	698.4
F5	96	33.5	1050-1074	25	F5 T1 04	691.2	
F5	90	31.5	1298-1323	26	F5 T1 05	664.6	
Bb5	100	25.0	02-21	19	Bb5 T1 00	909.4	932.3
Bb5	96	24.0	269-286	18	Bb5 T1 01	960.0	
Bb5	90	22.5	522-540	18	Bb5 T1 02	960.0	

Table 3

Air Pressure vs. Reed Frequency

cycle of reed vibration contained 50 samples, representing a frequency of 345.6 cycles per second. When F4 was sounded at an intensity of 90 dBA, each cycle of reed vibration also contained 50 samples, again representing a frequency of 345.6 cycles per second. When these findings were compared with a frequency standard for F4 within a tempered scale (349.2 cycles per second), it was observed that the reed consistently vibrated at a frequency for F4. Similar results were observed for F5 and B-flat 5. Figures 6 and 7 illustrate the reed's vibrational patterns for B-flat 5 at 100 dBA and 96 dBA respectively. It can be observed from these figures that as air pressure decreased, amplitude decreased but wavelength remained the same.

These data indicate that the reed vibrated at the frequency of the pitch being produced by the air column, and was not affected by air-pressure (intensity) increases. The slight differences between observed reed frequencies and the standard frequencies are negligible, indicating only slight intonation discrepencies which may have been produced by temperature variations within the chamber of the artificial embouchure or within the instrument.

Reed Amplitude and Intensity at Constant Lip Pressure

To observe the relatioinship between reed amplitude and intensity, graphs were produced (Figures 8-13) from data previously collected on F4 (See Appendix B,

Figure 6

Vibrational Pattern for Bb5
25.0 cm H2O, 100 dBA, Gain = 1.0
Bb5 Tl 00

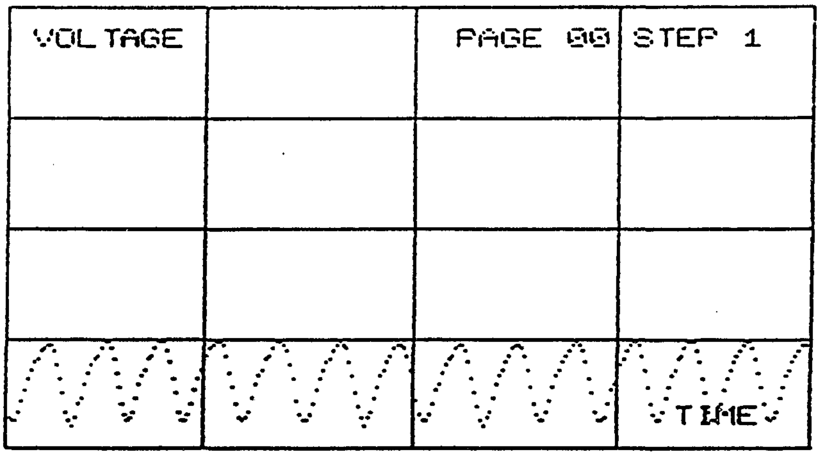


Figure 7

Vibrational Pattern for Bb5
24.0 cm H2O, 96 dBA, Gain = 1.0
Bb5 Tl 01

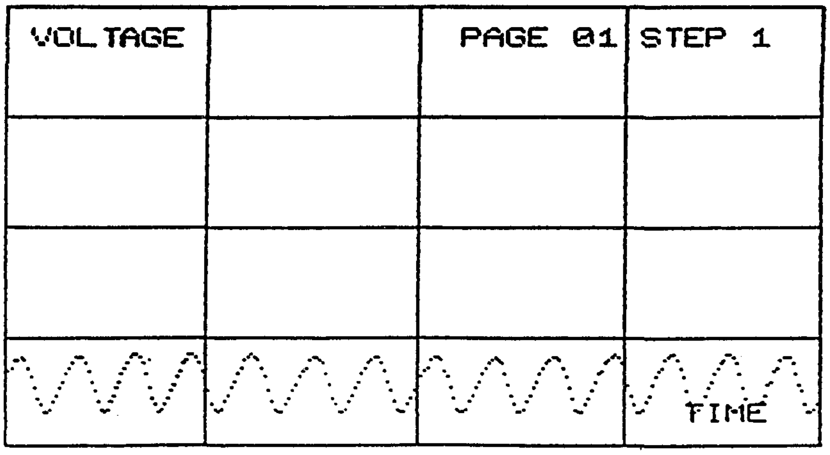


Figure 8

Air Pressure Variation on F4
21.5 cm H2O, 80 dBA, Gain = 33
F4 T2 00

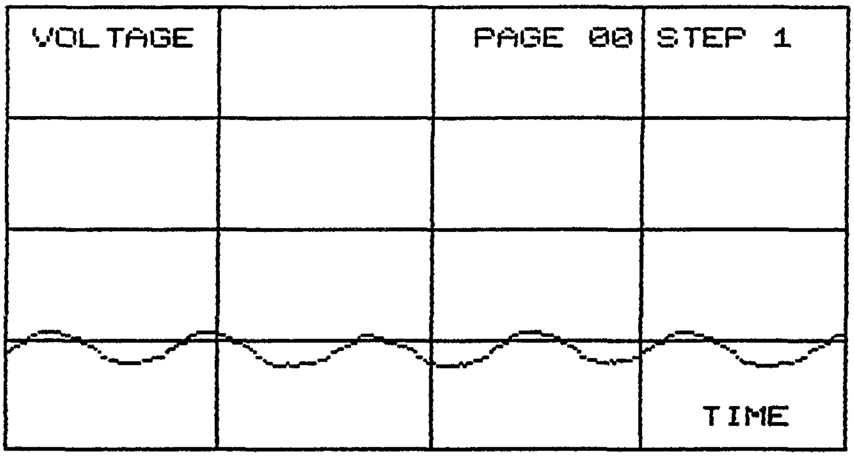


Figure 9

Air Pressure Variation on F4
24.5 cm H2O, 80 dBA, Gain = 33
F4 T2 01

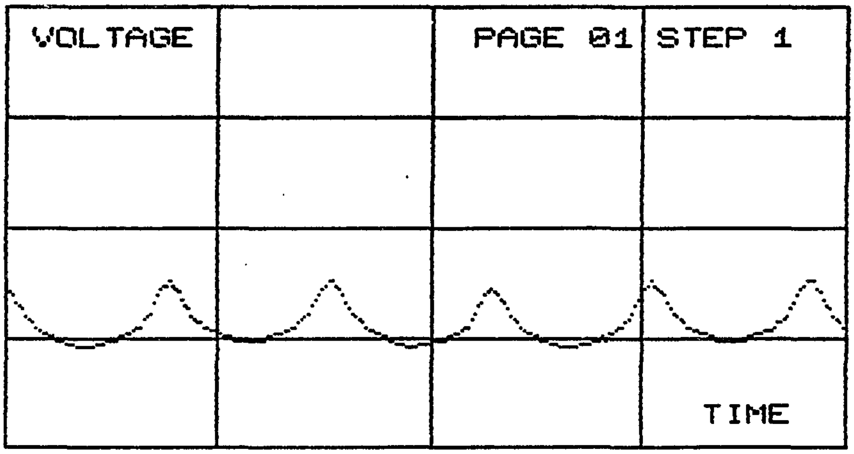


Figure 10

Air Pressure Variation on F4
26.0 cm H2O, 88 dBA, Gain = 33
F4 T2 02

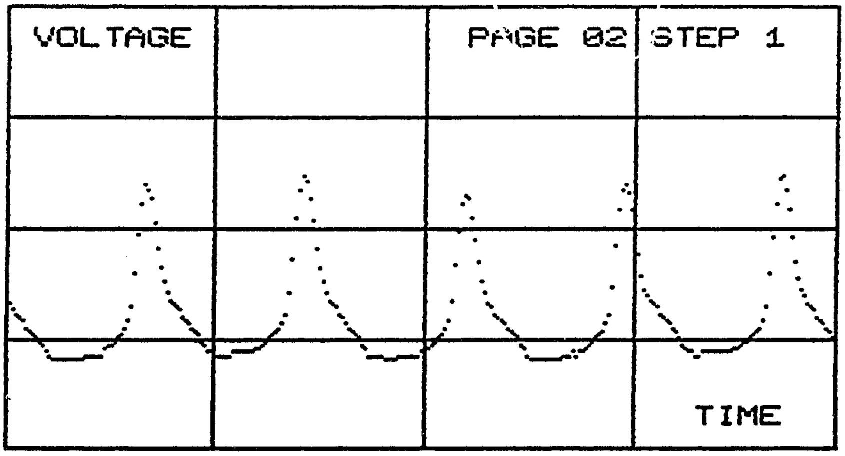


Figure 11

Air Pressure Variation on F4
27.0 cm H2O, 92 dBA, Gain = 33
F4 T2 03

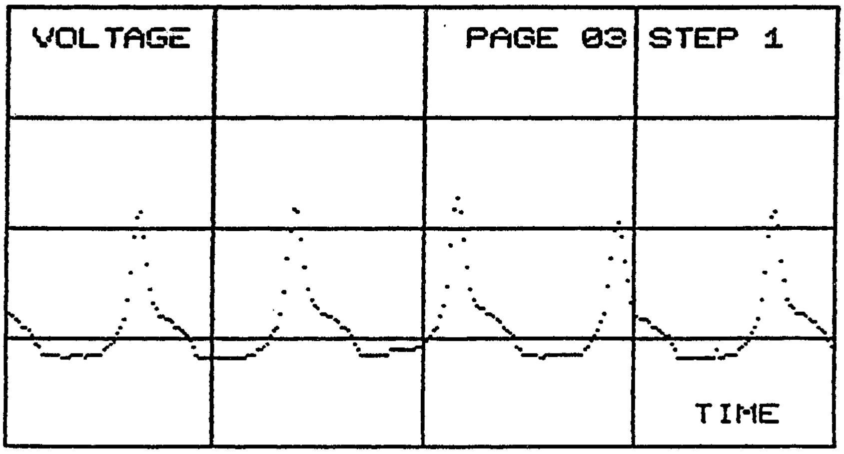


Figure 12

High Intensity Closure for F4
28.0 cm H2O, 93 dBA, Gain = 33
F4 T2 04

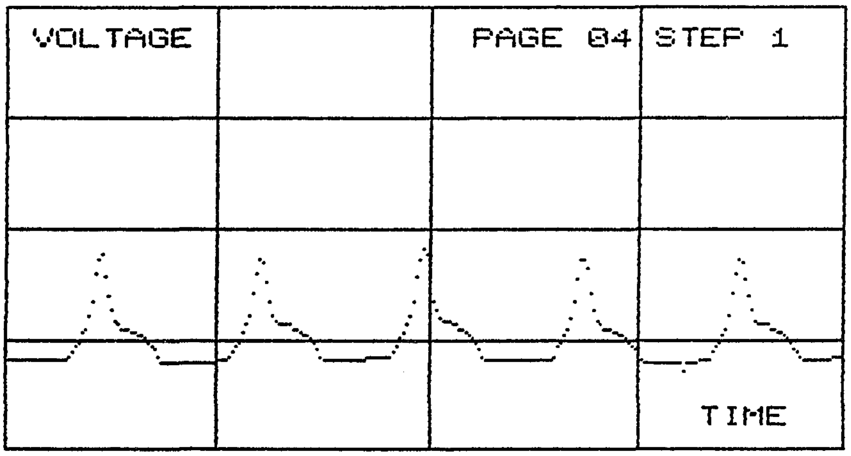


Figure 13

High Intensity Closure for F4
29.0 cm H2O, 93 dBA, Gain = 33
F4 T2 05

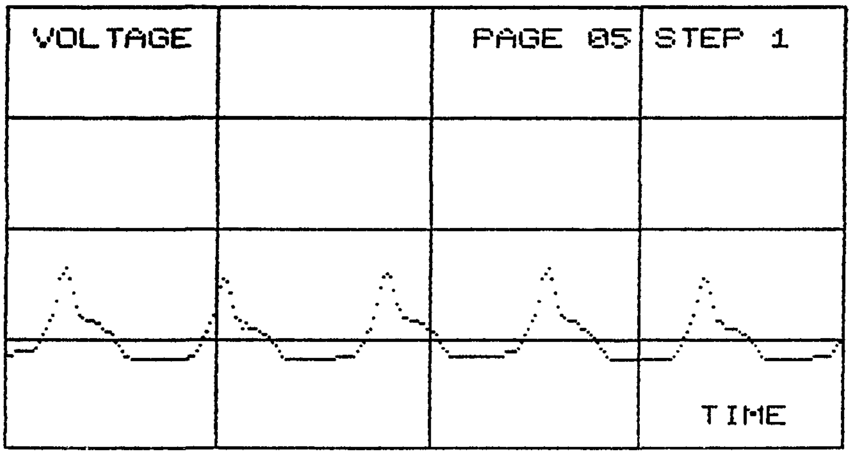


Table 5, Pages 00-05) in which air pressure was increased in small increments. As air pressure was increased, intensity levels were monitored on the sound-level meter. Figure 8 illustrates the reed´s vibrational cycles at 80 dBA which required an air pressure of 21.5 cm H20. In Figure 9, air pressure had been increased to 24.5 cm H20 but produced only a slight increase in reed amplitude. An increase in intensity level was not observed. Figure 10 shows a dramatic increase in amplitude of the reed´s motion as well as an increase in intensity level. In this case, a pressure of 26.0 cm H20 produced an intensity level of 88 dBA. This trend continues in Figure 11. When an intensity of 93 dBA was reached, additional increases in air pressure did not produce subsequent increases in intensity. Figures 12 and 13 illustrate further increases in air pressure but lower reed amplitudes. Apparently, a saturation point was reached; further increases in air pressure only restricted the reed´s movement. Intensity stablilized at 93 dBA for both air pressures.

Numeric representations of Figures 8 through 13 (and a second trial shown in Appendix B, Table 5, Pages 06-08), may be seen in Appendix B, Tables 22 through 30. Using these tables, comparisons were made between air-pressure increases and voltage peaks (reed amplitudes). For example, in Appendix B, Table 22, the highest voltage produced between sample number (point number) 0 and 203 was

69 millivolts. This voltage represents the voltage peak for F4 at 21.5 cm H20. Voltage peaks were collected in this way from Tables 22 through 30. These data are summarized in Table 4.

Figure, Table	Intensity (dBA)	Peak Voltage (millivolts)	Pressure (cm H2O)
F08, T22	80	69	21.5
F09, T23	80	96	24.5
F10, T24	88	158	26.0
F11, T25	92	144	27.0
F12, T26	93	116	28.0
F13, T27	93	104	29.0

Table 4. Air Pressures vs. Peak Voltages for F4

These data suggest that as applied air pressure increases, amplitude of reed motion increases until a saturation point is reached, and that an increase in intensity does not always produce an increase in reed amplitude.

Data observed earlier regarding air pressure and the reed´s frequency of vibration may explain these increases in amplitude. As air pressure within the player´s mouth increases, more air must pass through the reed/mouthpiece aperture per unit time to equalize the pressure difference between the player´s mouth and the air column of the clarinet. Because the reed vibrates at the frequency of the air column to which it is attached, it cannot increase its frequency to accomodate the additional pressure of air molecules trying to escape through the aperture. Therefore the size of the aperture must increase in proportion to applied air pressure. This can be observed as an increase in reed amplitude. The compressibility of air molecules may play a minor role in this equation.

Air Pressure and Amplitude of Reed Motion at Constant Lip Pressure

To observe the effects of air-pressure variations on reed amplitude, as opposed to intensity, it was necessary to keep the pressure exerted by the lower lip, as well as its position on the reed´s surface, constant; since both factors might affect the reed´s amplitude at a specific air pressure. In the following tests, where pressure and position of the lower lip were optimum for producing a wide intensity range, a gradual increase in applied air pressure caused the reed to react with a series of motions which were common to all pitches tested. Four stages were observable: the loading stage, the transient stage, the sinusoidal stage, and the closing stage.

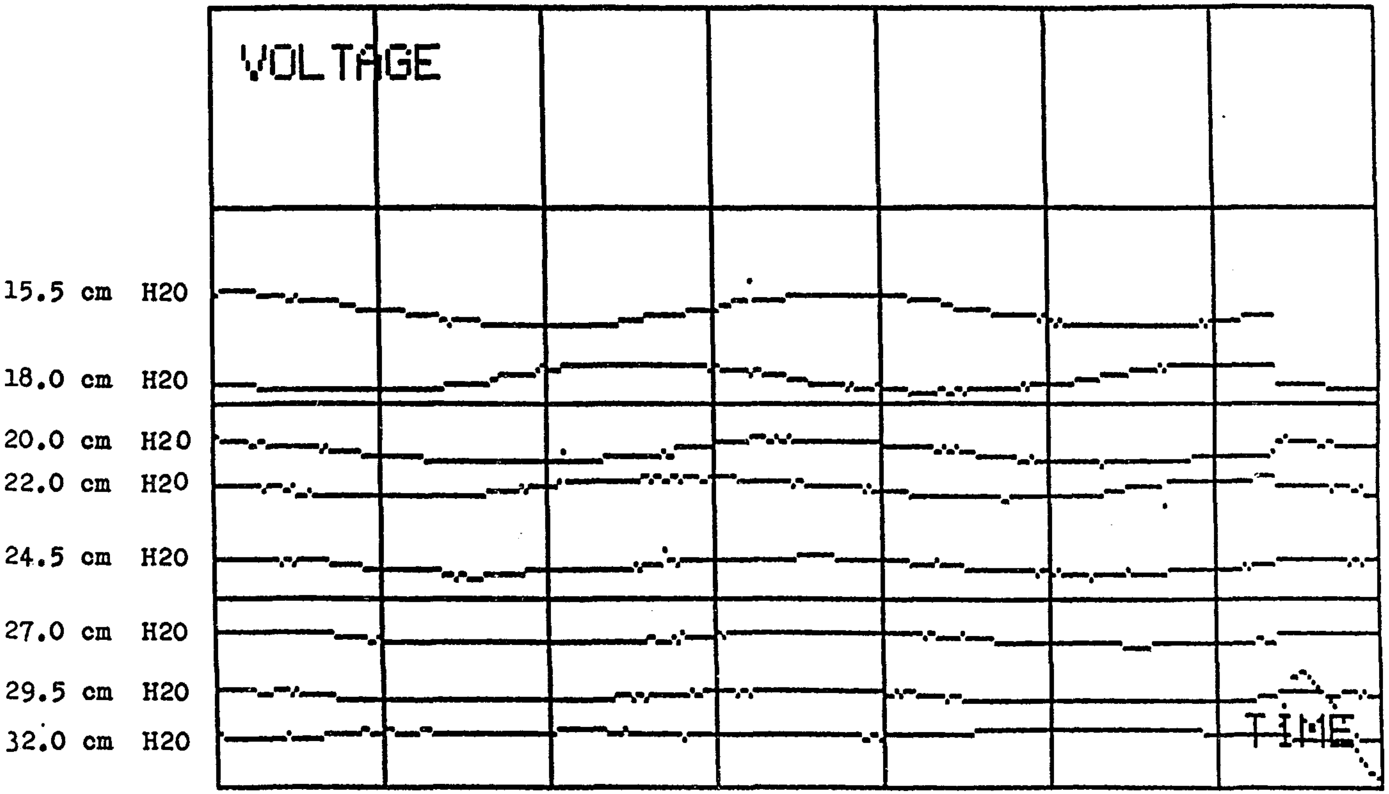
The loading stage

The loading stage was so-named because it described movements made by the reed before it began its vibrational cycle. The loading stage could not be successfully initiated until the reed was first "spring-loaded" into playing position by pressure from the lower-lip mechanism. This pressure bent the reed closer to the mouthpiece and held it there until air pressure was applied, at which point molecules of air rushed through the opening between the reed and the mouthpiece. As the velocity of air molecules past the tip of the reed increased, air pressure within the mouthpiece chamber was lowered as described by a principle of fluid mechanics first stated by Bernoulli (1700-1782). Zebrowski (1974) describes Bernoulli´s principle as follows: "The pressure in a moving fluid depends on its elevation and on its velocity (p. 277)" i.e. the faster the rate of flow, the lower the pressure. Air pressure reduction within the mouthpiece chamber pulled the reed toward the mouthpiece at a rate which was proportional to the amount of applied air pressure. This can be clearly seen in Figure 14, created by superimposing eight different plots of light intensity passing between the reed and mouthpiece at various air pressures.

The reed was bent, or "spring-loaded" into position by pressure from the lower-lip mechanism before the experiment began. This preset pressure, necessary to engage the

Figure 14

Light Intensities at Various Air Pressures
as Reed Moves Towards the Mouthpiece
F4, Gain = 10, ADC DATA XV



Bernoulli effect, was kept constant throughout the procedure. As air pressure was slowly increased, light intensity decreased proportionally, as shown in Figure 14. As the reed was drawn closer to the mouthpiece by the Bernoulli effect, the opening grew smaller, causing a proportional increase in molecular velocity through the venturi. When applied air pressure was stabilized, molecular velocity through the venturi also stabilized and the reed became motionless. This stabilization may be the consequence of a balance between applied air pressure, the "Young's Modulus" or elasticity of the reed, and the Bernoulli effect. As air pressure was stabilized, light intensity passing through the mouthpiece-reed aperture was recorded, producing light-intensity levels as shown in Figure 14. These levels represented distances the reed moved at various air pressures due to the Bernoulli effect and might therefore be used as proportional indicators of molecular velocity within the venturi at a specfic lip pressure. A direct relationship between voltage (light intensity) and applied air pressure can be seen in Table 5, comprised of voltage averages taken from Appendix B, Stripchart Tables 31 through 36. As air pressure increased, voltage averages decreased due to a reduction in reed/mouthpiece aperture.

	Voltages			
Page	High	Low	Average	Air Pressure (cm H2O)
02	164	153	158.5	15.5
03	141	132	136.5	18.0
04	116	108	112	20.0
05	103	97	100	22.0
06	77	71	74	24.5
07	53	49	51	27.0
08	34	30	32	29.5
09	20	18	19	32.0

Table 5

Voltage Averages vs. Applied Air Pressures

The transient stage

To fully describe the tones produced by musical instruments, it was necessary to explore the initiation of tones. The beginning of any tone can be scrutinized very closely by observing its transient state; the sound-wave pattern produced by the tone in the moments before the tone becomes stabilized or fully audible to the human ear. The transient stage exhibited the least amplitude of reed motion and formed quickly within a relatively narrow range of air pressures. In one cycle of vibration observed, applied air pressure caused the reed to move closer to the mouthpiece, thus reducing the opening between the reed and mouthpiece. As a result of this reduction in aperture, air pressure within the venturi equalized with air pressure within the instrument and the elasticity of the reed began to pull it back to its primary position of rest. This position of rest was never quite reached however, due to force of the air pressure which was still being applied. Instead, the reed returned only part of this distance until it reached the point where the increasing velocity of air molecules through the venturi began to pull it back toward the mouthpiece again. These findings support visual observations made by Coppenbarger (1971), who stated: "Once the sound wave begins, the reed is affected by a Bernoulli condition. The excursion of the reed's tip from the mouthpiece during a vibration is not as large as the mouthpiece-reed gap with the playing embouchure pressure without sound" (p. 119). The reed/mouthpiece aperture levels observed during the loading stage in Figure 14 were characteristic of one specific lower-lip pressure setting. If lower-lip pressure had been increased, the reed would have been pushed into a preset position closer to the mouthpiece and greater air pressure would have been required to initiate the transient stage (See "Lip Pressure and Duration of Reed Closure").

The transient stage encompassed the transition from a non-vibrating state to one of vibration. A microphone was connected to the AC port on the digital converter and low air pressure applied to the artificial embouchure (Appendix

B, Table 8, Page 09). A transient for F4 was observed as shown in Figure 15. At low air pressure, the first vibrations to be observed were small, inaudible vibrations of the reed at its natural frequency. A regular fluctuation in amplitude is noticeable within the transient which matches the reed´s natural frequency, shown in Figure 16. It can be seen from Figures 15 and 16 and their accompanying stripcharts in Appendix B, Tables 37 and 38, that amplitude fluctuations within the transient are partly comprised of the reed´s natural frequency of vibration.

As the transient began to reach the steady state, a slight fluctuation of greater wave length became evident as shown in Figure 17. The voltage peaks of this wave form may seen in Appendix B, Table 39. When the wave form of the transient was superimposed over the waveform of a steady state F4, it became evident that these longer wavelengths were the early products of the steady state. Figure 18 illustrates the steady state of F4, and Figure 19, the superimposition. Although slightly out of phase, the early stages of the harmonic fundamental can be seen clearly. These observations support findings of Aschoff (1936) and Richardson (1954) that the reed´s natural frequency is distinguishable within the steady state. Richardson (1954) writes: "Few wind instruments have transients which are exact copies of their steady states; either ´underblown tones´ or ´reed partials´ occur in the

Figure 15

F4 Transient Stage

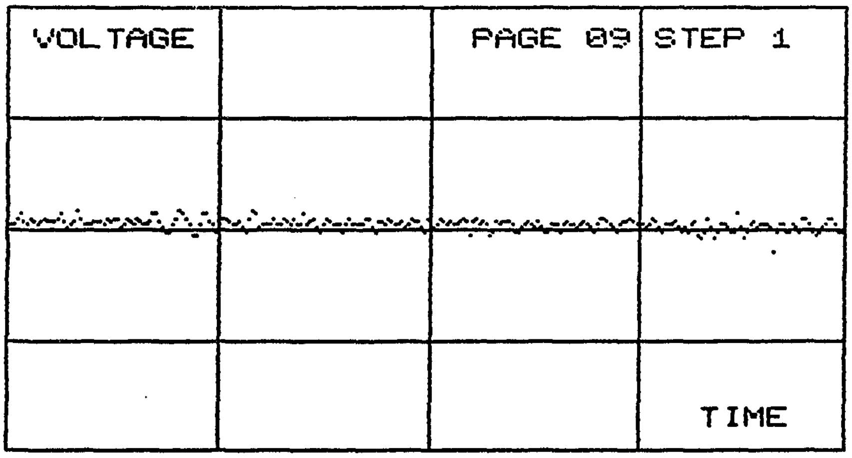


Figure 16

Natural Frequency of the Reed

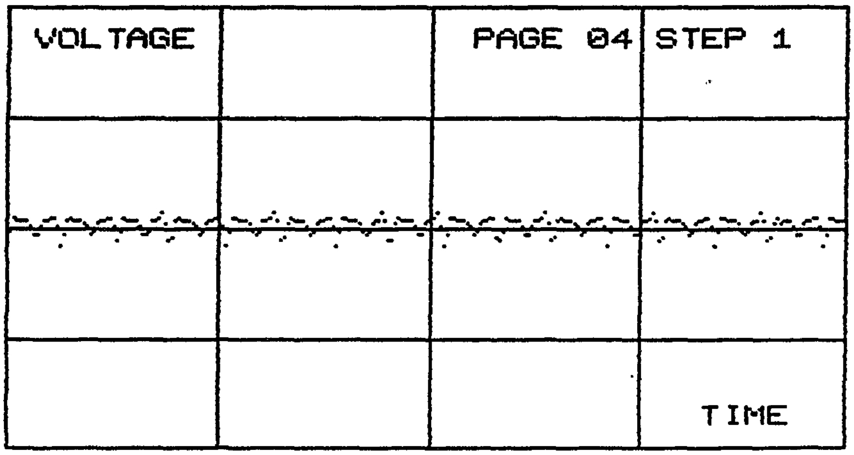


Figure 17

Transient Containing Steady State
37.0 cm H2O, Gain = 100, Page 03
F4, Series V

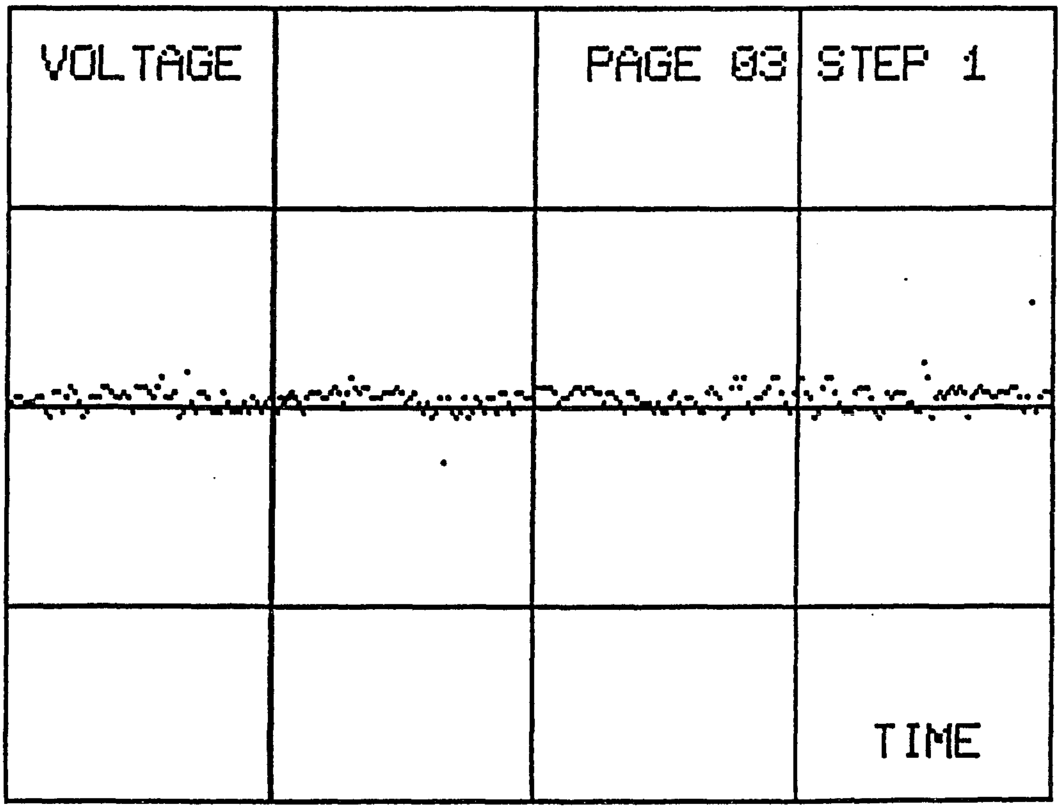


Figure 18

F4 Steady State

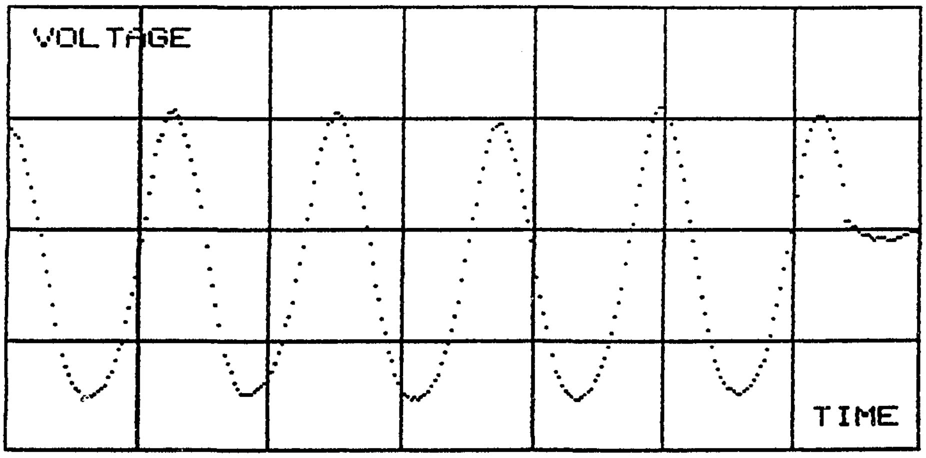
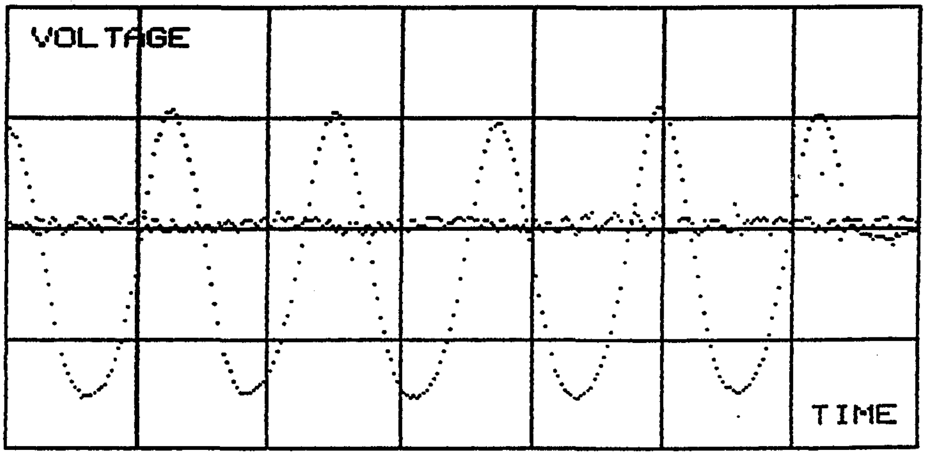


Figure 19

Superimposition of F4 Transient on
F4 Steady State as shown in Figure 18



first tenth of a second until overlaid by the principal tones of the column in its steady state" (p. 962).

The vibrations of the reed must eventually match the resonance mode of the instrument to which it is attached. Stubbins (1969) writes:

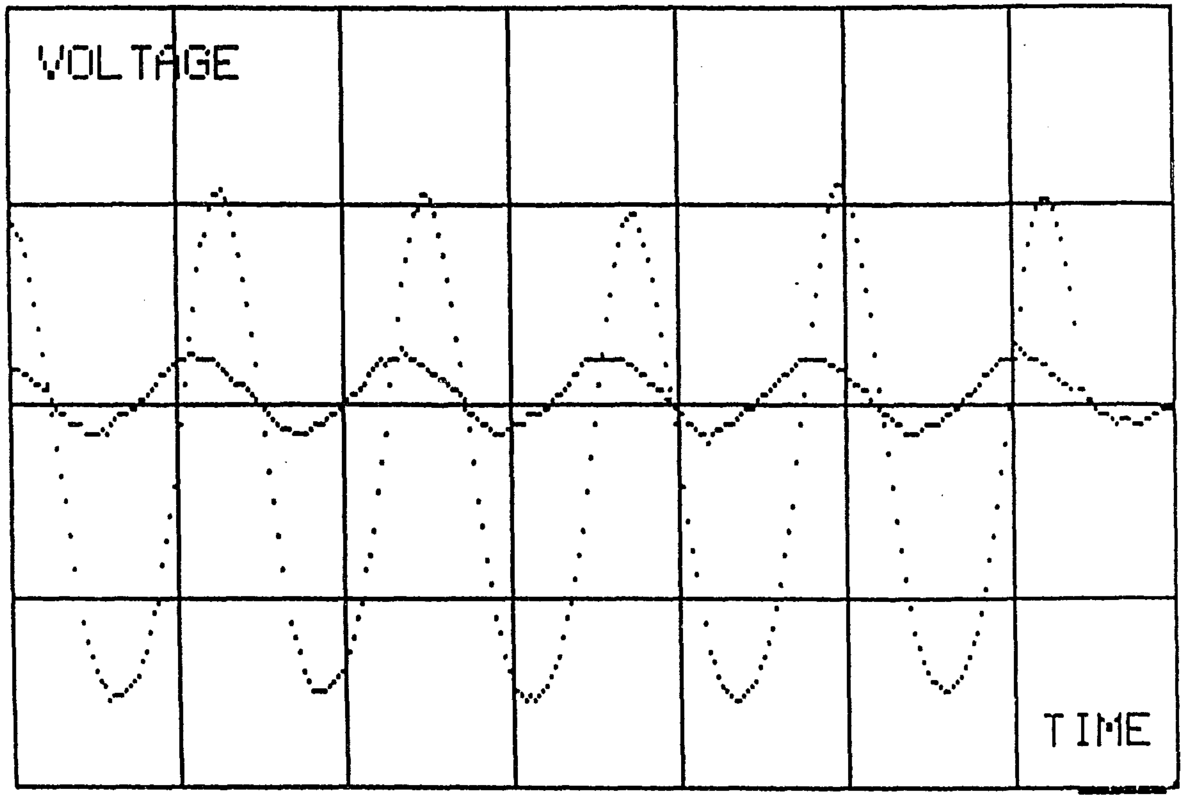
> Because the harmonic frequency supplied by the tone generating system of the clarinet, matches the resonating or vibrational mode potential of a musical horn, all of the vibrational modes of the air column system are excited by the reed. However, the musical result is that which is obtained by the dampening effect of each of these modes, according to the shape of the air column involved. The shape of the air column reacts in turn, on the vibration pattern of the reed, which is the energy supplier for the sustaining system, and is so dominant, that in practice the tone-generating system of the clarinet is absolutely required to match the requirements of the clarinet to which it is attached, or the results are extremely inefficient (p. 59).

Evidence of this reactance may be seen in Figure 20. The tone of F4 was produced with the artificial embouchure and measurements of light fluctuations produced by the reed were plotted. A plot of air-pressure variations produced within the clarinet sounding F4 was made by connecting the microphone to the analog-to-digital converter. This plot of air-pressure variations was then superimposed over the plot of light-intensity fluctuations as shown in Figure 20. The reed's mode of vibration in the steady state closely matched the frequency produced by the air column.

Figure 20

Light Fluctuations for F4
Superimposed with Microphone
Fluctuations for F4

F4, Gain = 33, ADC DATA XVI



The sinusoidal stage

The third stage of reed motion was the sinusoidal stage. It was produced by the cycle of events described above. For tones of low intensity, the wave forms appeared to be sinusoidal for all frequencies tested. Figures 21 through 24 provide examples of sinusoidal reed movement for low-intensity tones produced at four pitch levels at various air pressures.

The closing Stage

When lip and air pressure were increased to specific degrees, the reed began to close on the mouthpiece. Two graphs were produced on F5 as illustrative examples. Figure 25 shows the reed just beginning to close completely, causing a flat line to appear within the cycle. With increased air pressure, the reed remained against the lay of the mouthpiece for a proportionally longer amount of time during each cycle. In Figure 26, for example, the reed closed for almost half of its cycle. Eventually, at constant lip pressure, a saturation point was reached and closure time remained constant, regardless of further increases in air pressure. If lip pressure was subsequently increased, the reed was suddenly forced against the mouthpiece 100 percent of the cycle,

Figure 21

F3 Reed Not Closing
27.0 cm H2O, 84 dBA, Gain = 3.3
F3 T2 06

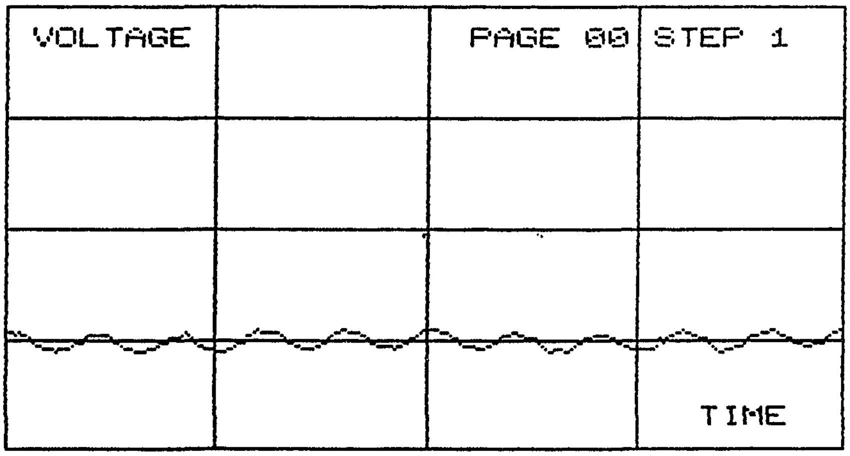


Figure 22

F4 Reed Not Closing
25.0 cm H2O, 75 dBA, Gain = 10
F4 T1 06

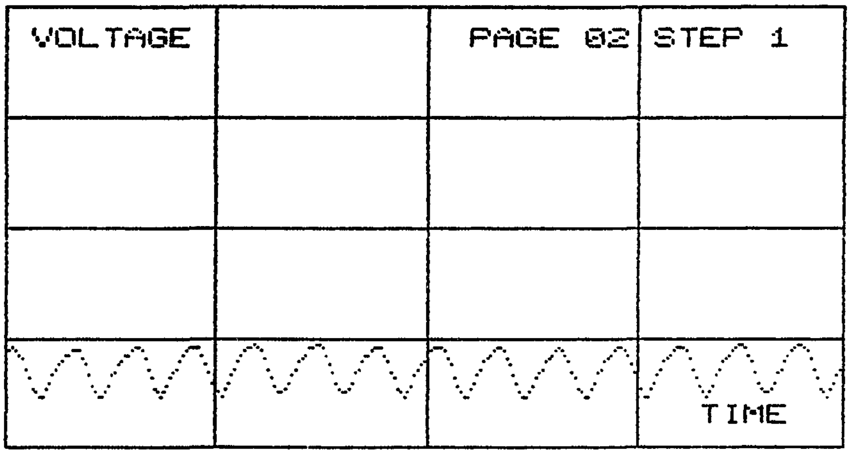


Figure 23

F5 Reed Not Closing
32.5 cm H2O, 78 dBA, Gain = 10
F5 T1 00

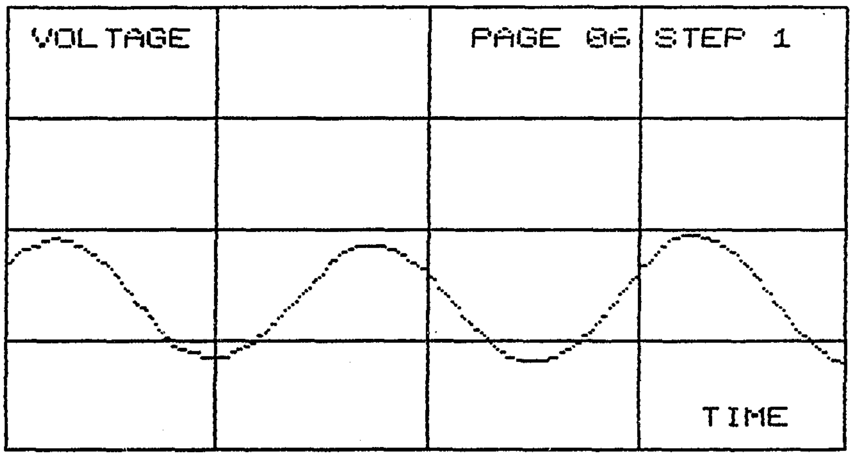


Figure 24

Bb5 Reed Not Closing
25.0 cm H2O, 90 dBA, Gain = 10
Bb5 T2 02

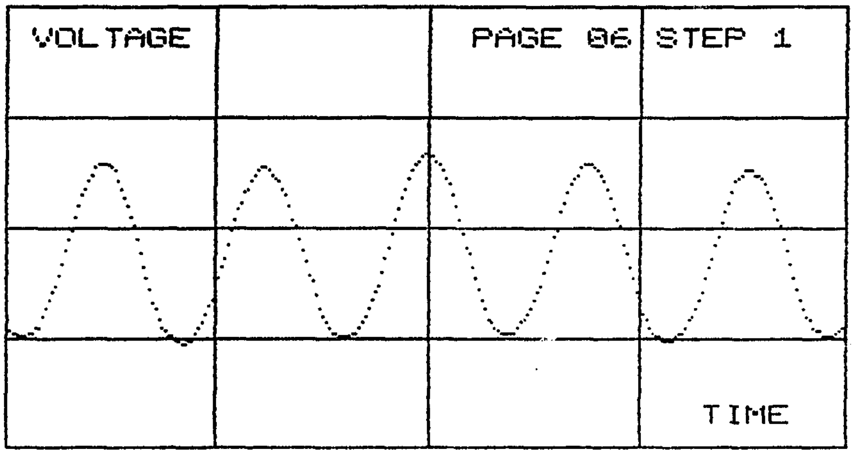


Figure 25

F5 Reed At Threshold of Closing
34.0 cm H2O, 86 dBA, Gain = 10
F5 Tl 02

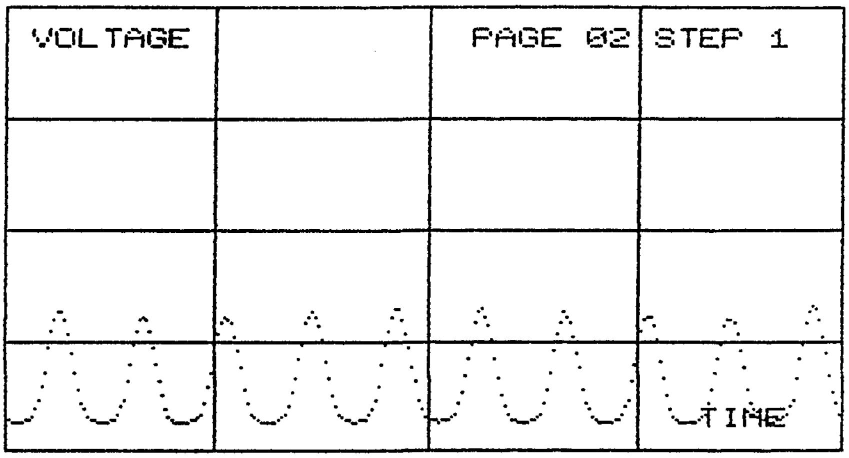
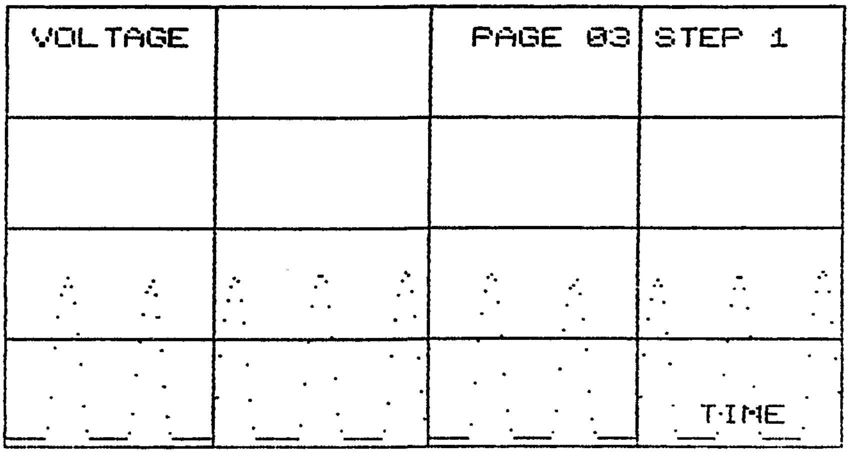


Figure 26

F5 Reed Closing on Mouthpiece
36.5 cm H2O, 100 dBA, Gain = 3.3
F5 Tl 03



terminating the sound completely.

It was observed that when the reed closed against the mouthpiece, other vibrations were sometimes superimposed upon the reed when it reached maximum displacement. Apparently, these vibrations were caused by a physical reaction to the abrupt interruption of the reed's more efficient sinusoidal movement. These additional movements undoubtably contribute to the increased harmonic content of tones of greater intensity. Two graphs were produced on F3 as examples. Figures 27 and 28 show harmonic disturbances for F3 at two different intensity levels. Harmonic disturbance and amplitude increased as air pressure increased. This was found to be true for all pitches tested.

Analyses of closure times

When air pressure was increased to a specific degree, the reed began to close completely on the mouthpiece during part of each cycle. It was observed from Figures 10 through 13 (see "The Effects of Air-Pressure Variations on Reed Amplitude and Intensity at Constant Lip Pressure") that application of greater air pressure increased the duration of time the reed remained closed.

Figure 27

F3 Harmonic Disturbance
32.5 cm H2O, 90 dBA, Gain = 3.3
F3 Tl 02

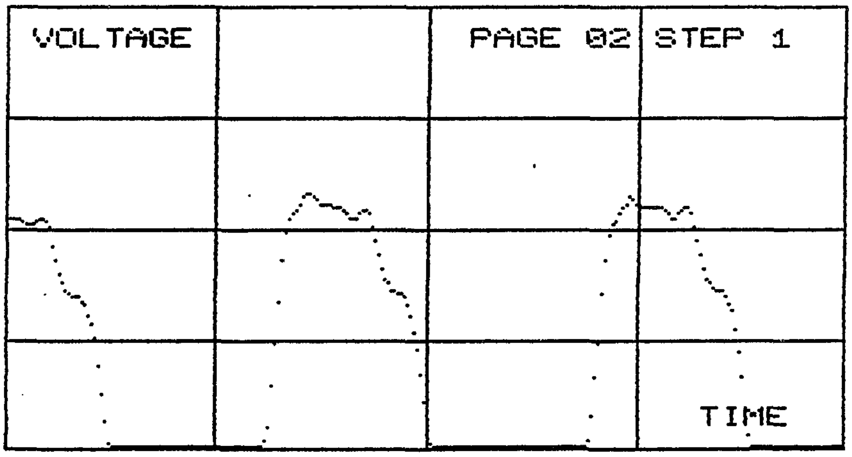
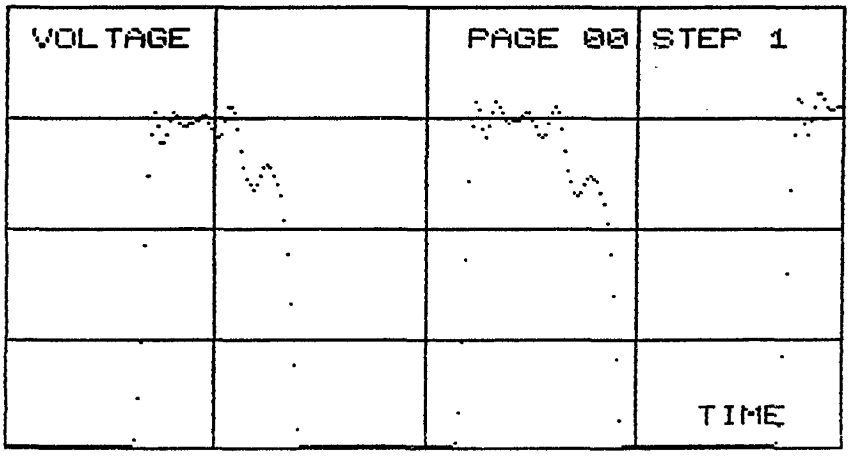


Figure 28

F3 Harmonic Disturbance
36.5 cm H2O, 98 dBA, Gain = 3.3
F3 Tl 00



For this reason, subsequent data were obtained on four pitches (F3, F4, F5, and B-flat 5) sounded at high intensity to determine the maximum percent of each cycle the reed can remain closed. Four tests were conducted on F3, four on F4, one on F5, and one on B-flat 5. The results are shown in Table 6. Figures 29 through 36, 12 and 13 are visual representations of these tests and Appendix B, Tables 40 through 49, their accompanying stripcharts. By counting samples included in the closed portion of each cycle, reed closure times were calculated for each wave period and compared across wave periods and pitches.

In Table 6, for example, contains four separate tests of F4. Results of the first test are included in the stripchart number found in the row below the pitch designation: F4 T1 04. This stripchart is located via the <u>List of Tables</u> found at the beginning of Appendix B which indicates the location as Table 44 (Appendix B). The third, fourth, and fifth rows under the pitch name in Table 6 indicate, respectively: applied air pressure, intensity level, and vertical gain used in producing the graphs.

By consulting the appropriate stripchart in Appendix B, Table 44, the sample (point) values may be seen to fluctuate in regular intervals. For example, in column 1 of Appendix B, Table 44, a column of point numbers can be

Figure 29

High-Intensity Closure for F3
36.5 cm H2O, 98 dBA, Gain = 3.3
F3 Tl 00

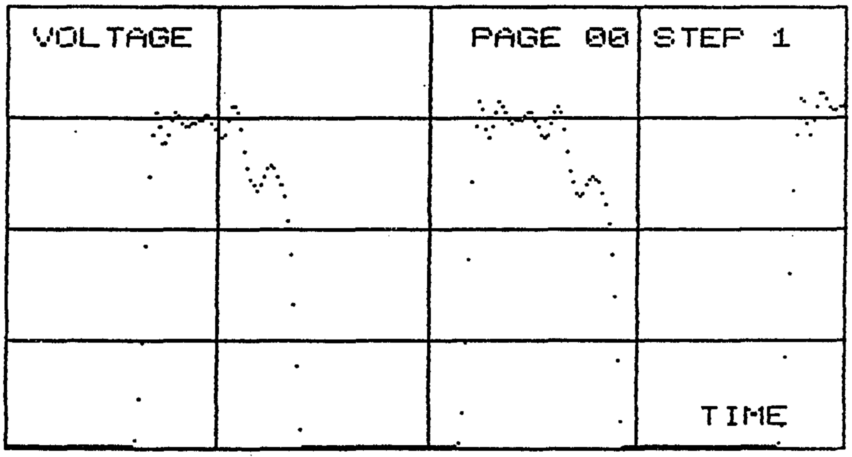


Figure 30

High-Intensity Closure for F3
27.5 cm H2O, 90 dBA, Gain = 3.3
F3 Tl 09

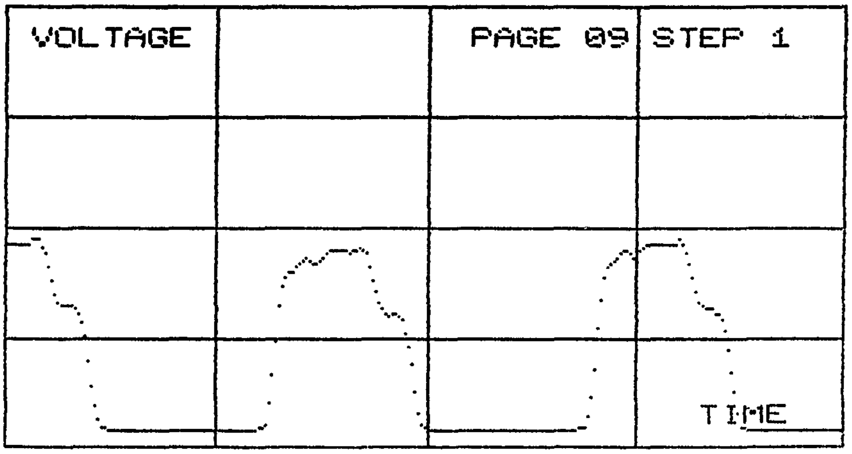


Figure 31

High-Intensity Closure for F3
24.5 cm H2O, 100 dBA, Gain = 1.0
F3 T2 00

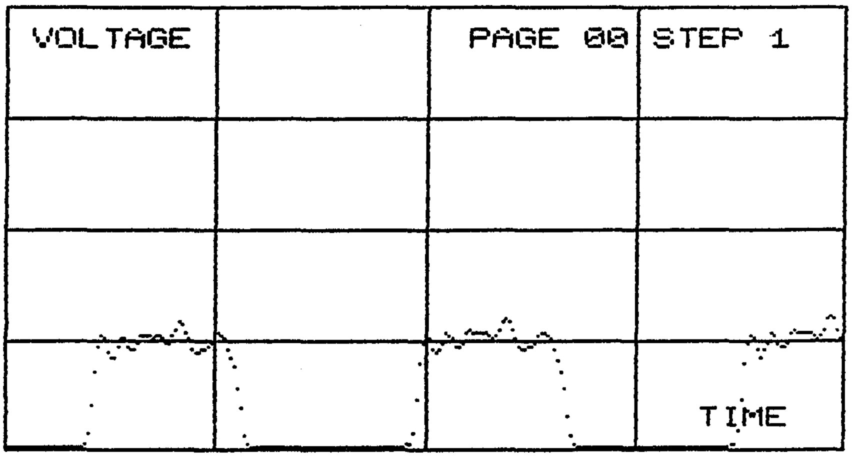


Figure 32

High-Intensity Closure for F3
25.5 cm H2O, 88 dBA, Gain = 3.3
F3 T1 05

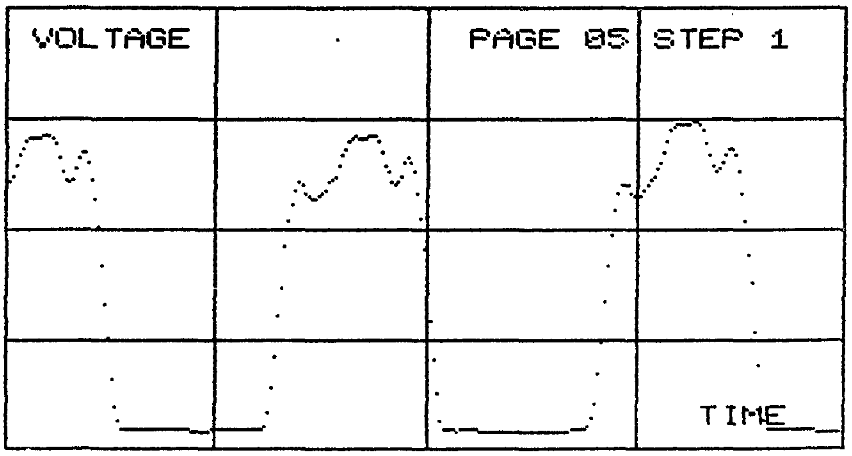


Figure 33

High-Intensity Closure for F4
38.5 cm H2O, 100 dBA, Gain = 3.3
F4 Tl 04

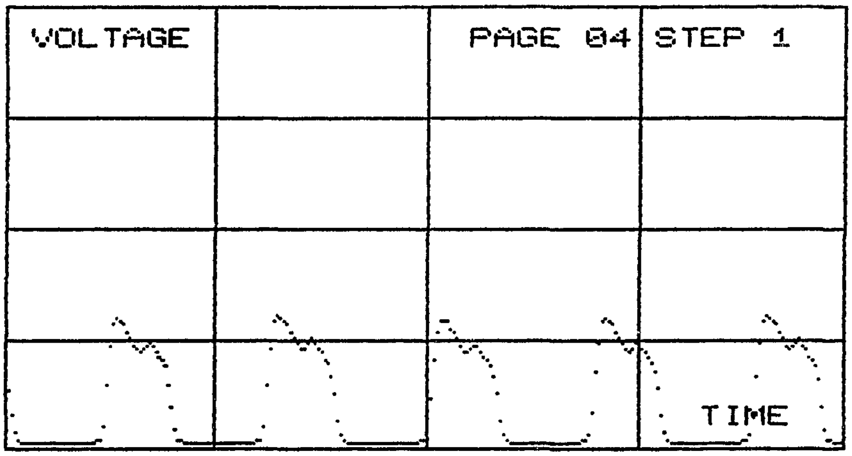


Figure 34

High-Intensity Closure for F4
34.0 cm H2O, 106 dBA, Gain = 3.3
F4 Tl 10

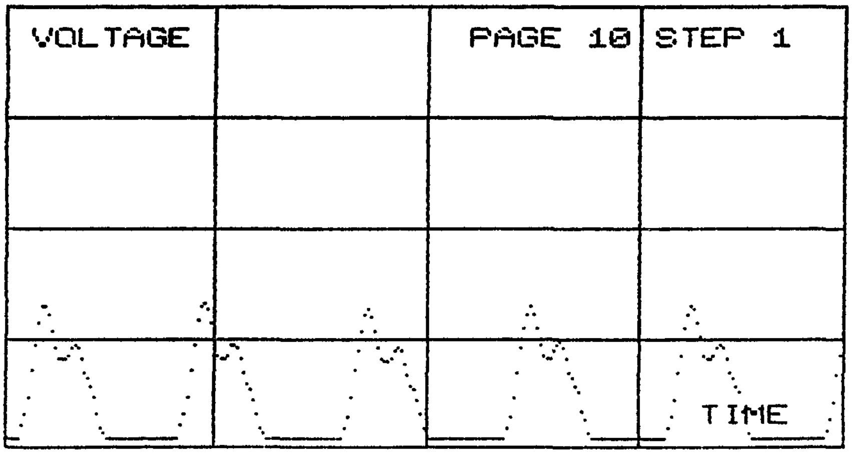


Figure 35

High-Intensity Closure for F5
36.5 cm H2O, 100 dBA, Gain = 3.3
F5 Tl 03

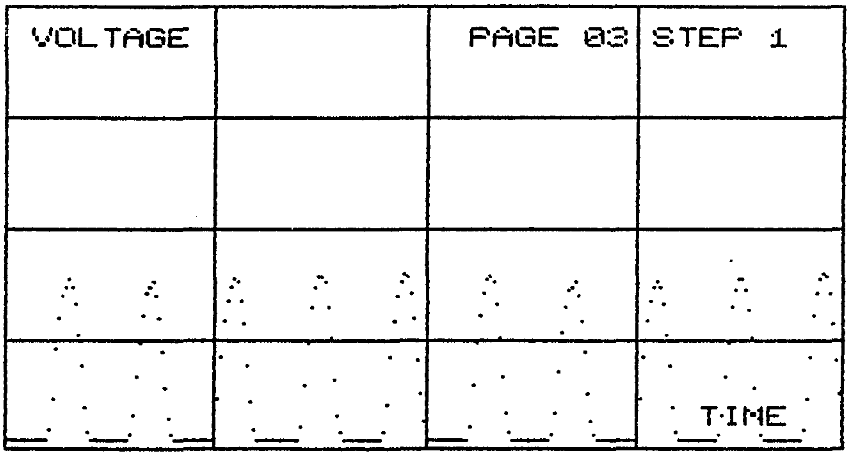


Figure 36

High-Intensity Closure for Bb5
34.0 cm H2O, 100 dBA, Gain = 3.3
Bb5 Tl 03

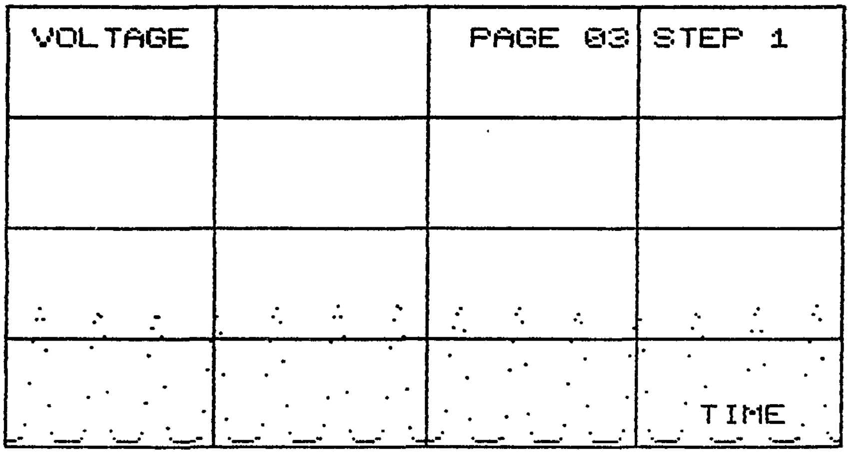


Table 6

High-Intensity Closure Times at Four Pitch Levels

Pitch	F3	F3	F3	F3	F4	F4	F4	F4	F5	Bb5
Stripchart Number	F3 T1 00	F3 T1 09	F3 T2 00	F3 T1 05	F4 T1 04	F4 T1 10	F4 T2 04	F4 T2 05	F5 T1 03	Bb5 T1 03
cm. H2O	36.5	27.5	24.5	25.5	38.5	34.0	28.0	29.0	36.5	34.0
dBA	98	90	100	88	100	106	93	93	100	100
Gain	3.3	3.3	1.0	3.3	3.3	3.3	33	33	3.3	3.3
Total Points Period 1	98	98	98	—	50	48	49	48	25	19
Total Points Period 2	—	—	—	99	49	50	49	48	26	18
Points Closing Period 1	47	46	47	—	23	21	18	18	10	8
Points Closing Period 2	47	46	—	41	22	22	18	19	11	7
Raw Percentage	.4795918	.4693877	.4795918	.424242	.4489795	.4375	.367347	.375	.40	.4210526
Percent of Cycle Closed	48	47	48	42	45	44	37	38	40	42

seen starting with 1025. To the right of each point number is a corresponding voltage, beginning with 34. These voltages decrease as follows: 34, 20, 10, 6, 5, 5, 5, etc. The repeated values of 5 indicate that the reed stopped moving and closed on the mouthpiece. At point 1052, voltages began to increase, reaching a peak at point 1058 with a voltage value of 76. Voltages stabilized again at point 1079 and the cycle, or period, was complete. A graphic illustration of this stripchart may be located by referring to the List of Figures and matching the stripchart number with the figure title. Therefore, a graphic representation of Appendix B, Table 44 may be seen in Figure 33. The first four dots or values at the left side of Figure 33 correspond to the first four values seen in the stripchart: 34, 20, 10, 6. The repeated values of 5 correspond to the flat portion of the wave as seen in the first quadrant of Figure 33.

The fourth row beneath F4 T1 04 in Table 6 indicates that 50 samples were collected within the first period or cycle observed in the stripchart (Appendix B, Table 44). The fifth row indicates that 49 samples were collected within the second period. It can be seen from Table 6 that the number of samples comprising the first period of each wave closely matched the number of samples comprising the second period.

Samples also were counted within the flat portions of each wave. These values are shown in the sixth and seventh rows of Table 6 as "Points Closing." As shown in Table 6, the number of samples comprising the closed portion of the first period closely matched the number of samples comprising the second period. By comparing samples comprising the closed portion of the first period with samples comprising an entire cycle, the percentage of time the reed remained closed on the mouthpiece was calculated and listed in the last row of Table 6.

These tests reflected a remarkable consistency when sample totals were compared between consecutive closure times and periods. F3 produced the longest closure time of the pitches tested, that being 48 percent. It was observed from Table 6 that for tones of high intensity, the reed remained closed on the mouthpiece for 37 to 48 percent of its cycle. For tones produced with a preselected lip pressure conducive to the production of a wide intensity range, no evidence was obtained that indicated the reed closes more than 48 percent of its cycle.

Specific time values were calculated for the closures. Appendix B, Table 44, indicates that a data rate of 6983 points (samples) per second were used when collecting these data for F4. The data step was 1, indicating that samples were collected one at a time; therefore, the time between successive points on this stripchart is (1/6983) seconds, or 0.0001432 seconds, or .14 milliseconds. Referring to

Table 6, it was found that for F3 Tl 00, the first period lasted for a total of 98 points, or 14 milliseconds (98 pts. x 0.0001432 sec./pt. = 0.0140336 sec.). Closure time for the reed during this period was 6.73 milliseconds (47 pts. x 0.0001432 sec./pt. = 0.0067304 sec.), or 48 percent of the first period (6.73/14 = 0.4807142 = 48 percent).

As shown above (See "Air Pressure and Amplitude of Reed Motion at Constant Lip Pressure"), when closure time for F4 reached a certain percent, the system stabilized and amplitude remained constant, regardless of further increases in air pressure. Similar stabilizations are noticeable in Table 6. For example, in F3 T2 00, an applied air pressure of 24.5 cm H20 produced a reed closure of 48 percent. In F3 Tl 00, air pressure was increased to 36.5 cm H20 but reed closure remained at 48 percent.

These data (Table 6) indicate that at constant lip pressure and sufficient air pressure to cause reed closure, increases in air pressure can produce increases in reed closure times, until a closure time of 48 percent is reached. When closure time reaches 48 percent of a cycle, further increases in air pressure do not produce subsequent increases in closure, amplitude, or intensity, at constant lip pressure. Closure times of longest duration were observed for pitches of lower frequencies.

Lip Pressure and Intensity at Constant Air Pressure

To observe the effects of lip pressure on intensity, two procedures were conducted. In the first procedure, F3 was sounded at very low intensity (70 dBA) as shown in Appendix B, Table 1, Page 07). Pressure exerted by the lower-lip mechanism was reduced in four stages and intensity variations were recorded. It was observed that as lip pressure was reduced, intensity increased from 70 dBA to 90 dBA; a range of 20 dBA. Further reductions in lip pressure did not allow sufficient reed vibration and the tone was no longer sustained. The reed then entered its natural frequency of vibration and squeaking began. The investigator also observed that although the volume of air entering the chamber was constant, air pressure within the chamber decreased from 31.0 cm H20 to 27.5 cm H20 as lip pressure was reduced. Therefore, a second procedure was conducted on the tone F4 (Appendix B, Table 4, Pages 08-10). In this procedure, air pressure within the chamber was kept constant by adjusting the potentiometer which regulated the air pump. At a constant air pressure of 34.0 cm H20, lip-pressure reduction produced intensities from 80 dBA to 106 dBA; a range of 26 dBA.

These data show that intensity range may be increased if air pressure is maintained within the chamber. Apparently, a player instinctively adjusts lip pressure upon the reed as air pressure is varied. The range of intensity levels available through variations of lip pressure are impressive. Results support that intensity levels are controllable through a combination of lip and air-pressure variations.

Lip-Pressure and Amplitude of Reed Motion

Using the same data collected previously on F3 (Appendix B, Table 1, pages 07-10), graphs of the reed's amplitude were produced at each lip-pressure increment as shown in Figures 37 through 40. In Figure 37, produced at maximum lip pressure, the reed appeared to be closing on the mouthpiece and exhibited a relatively small amplitude between closures. As lip pressure was reduced, reed amplitude increased dramatically as shown in Figure 38. Although a constant volume of air was applied to the artificial-embouchure chamber, air pressure within the chamber decreased from 31.0 cm H20 to 29.0 cm H20 when lip pressure was reduced. This reduction in air pressure may have resulted from a reduction of lip pressure on the reed and the subsequent increase of the aperture between the reed and mouthpiece, thus allowing more air to pass through the aperture during the open part of each cycle. Apparently, a direct relationship exists between the total area under the curve of Figures 37 and 38, and the volume of air passing through the reed/mouthpiece aperture.

Figure 37

Lip-Pressure Variation for F3
31.0 cm H2O, 70 dBA, Gain = 33
F3 T1 07

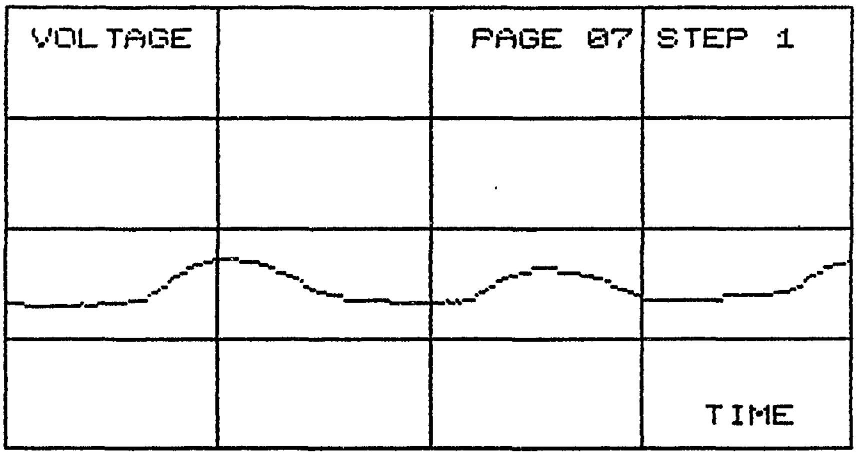


Figure 38

Lip-Pressure Variation for F3
29.0 cm H2O, 80 dBA, Gain = 33
F3 T1 08

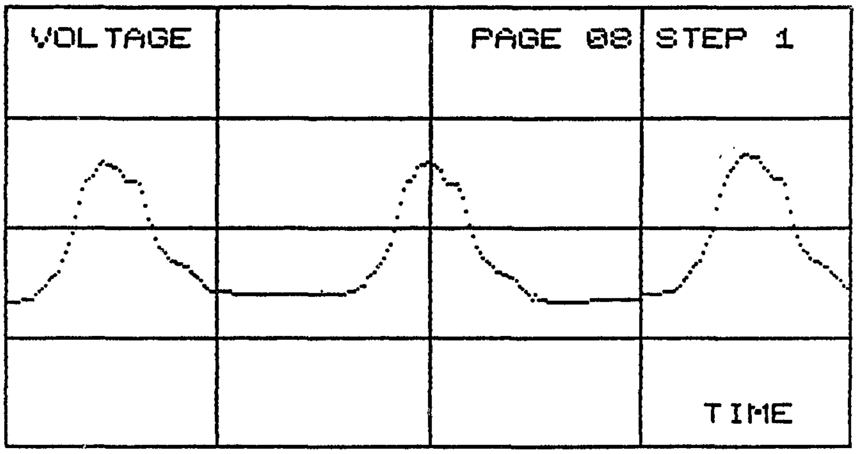


Figure 39

Lip-Pressure Variation for F3
27.5 cm H2O, 90 dBA, Gain = 3.3
F3 Tl 09

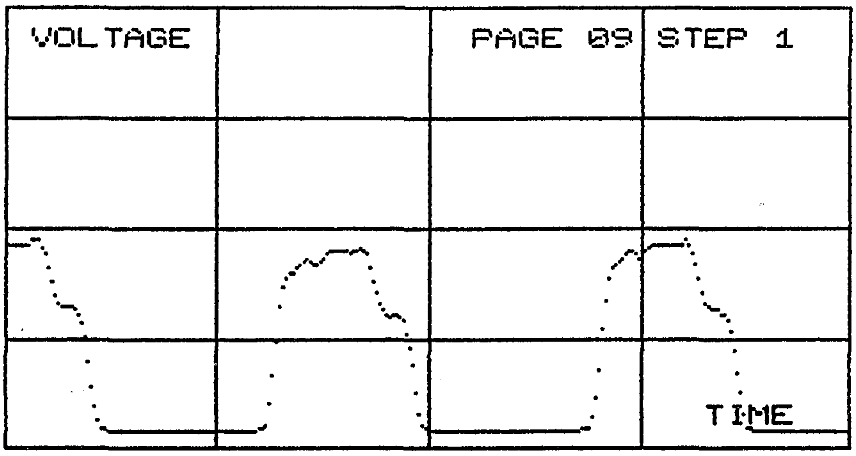
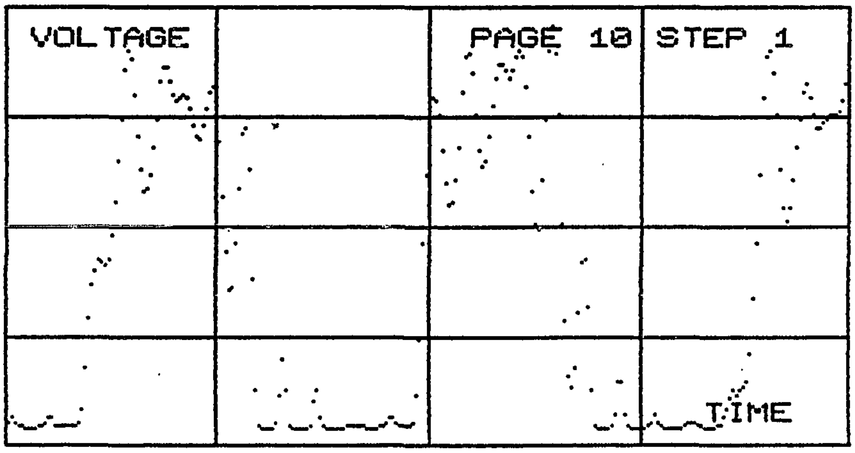


Figure 40

Lip-Pressure Variation for F3
27.5 cm H2O, 90 dBA, Gain = 3.3
F3 Tl 10



Therefore, an increase in the quantity of air passing through the aperture would simultaneously increase the Bernoulli effect.

A further decrease in lip pressure (Figures 39 and 40) increased reed amplitude to such an extent that the wave peaks were no longer within the scope of the graph. For this reason, gain (amplification of the vertical aspect of the graphs) was reduced from 33 to 3.3, reducing the vertical aspect of the graphs by ten times. This second reduction in lip pessure increased amplitude of reed motion tenfold, increased harmonic disturbance within the waveform, and decreased air pressure within the artificial-embouchure chamber from 29.0 cm H20 to 27.5 cm H20.

A third reduction in lip pressure (Figure 40) did not reduce air pressure within the chamber, but increased reed amplitude and harmonic disturbance. These findings support the following observations: that with application of a constant volume of air, a reduction in lip pressure caused a lowering of air pressure within the chamber and produced an increase in reed amplitude and harmonic disturbance.

Lip Pressure and Duration of Reed Closure

Using data collected previously on F3 (Appendix B, Table 1, pages 07-10), stripcharts were produced to observe the effects of lip pressure on reed closure times. These stripcharts, which pertain to Figures 37 through 40, are found in Appendix B, Tables 50 through 53. The lowest three voltages in each stripchart were examined as representations of closure voltages since high sensitivity of the photo transistor caused these voltages to fluctuate slightly. These millivolt values are listed in the fourth column of the Table 7.

Figure	cm H20	dBA	Voltages Selected	Points Closing
37	31.0	70	85,86,87	40
38	29.0	80	91,90,89	43
39	27.5	90	10,11,12	47
40	27.5	90	10,11,12	44

Table 7

Point Totals for Reed Closures
During Lip-Pressure Reductions

The point (sample voltage) totals illustrate that closure time was affected minimally by variations in lip pressure at a specific air pressure. Figures 37 through 40 seem to indicate that a reed's closure time on the mouthpiece is directly related to applied air pressure and is not dependent upon air pressure within the chamber or amplitude of the reed's motion. The resultant comparison is that applied air pressure exerted by the lungs of the player determines the closure time for a reed and this time is not appreciably affected by the amount of air being passed through the mouthpiece/reed aperture. These findings seem to indicate that an optimum resistance can be found when playing the clarinet if lip pressure is adjusted.

A second series of tests comprising two procedures were conducted on F3 (Appendix B, Table 3, pages 00-11) in which two lip-pressure settings (high and low) were used at three intensity levels: threshold sound level, 90 dBA (mf), and 100 dBA (ff). In the first procedure, pressure of the lower-lip mechanism was set on a high-pressure setting. Air pressure was manipulated via the potentiometer to produce three intensities. In the second procedure, pressure of the lower-lip mechanism was reduced and set to the low-pressure setting. Air pressure was again manipulated to produce three intensities. Therefore, high and low lip-pressure settings were kept constant across intensities and only applied air pressure was varied.

Figures 41 through 46 (from Appendix B, Table 3, pages 06-11) and their accompanying stripcharts in Appendix B,

Figure 41

High Lip Pressure for F3 Threshold Sound
26.0 cm H20, Gain = 10
F3 T3 06

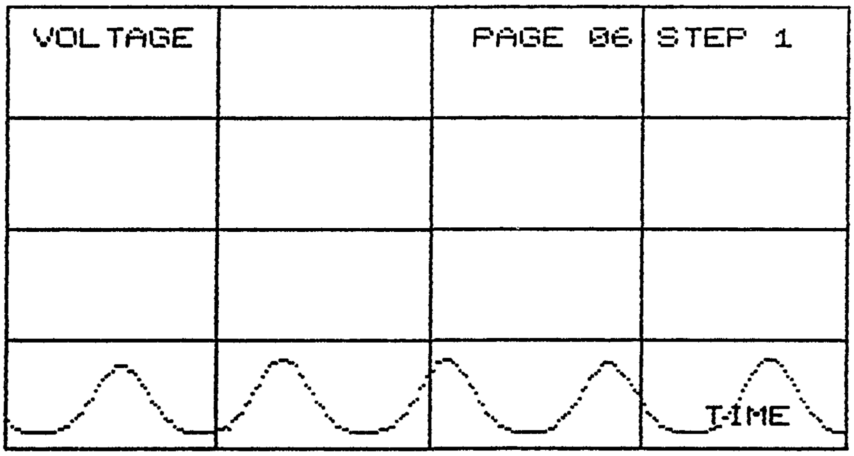


Figure 42

Low Lip Pressure for F3 Threshold Sound
24.5 cm H20, Gain = 10
F3 T3 07

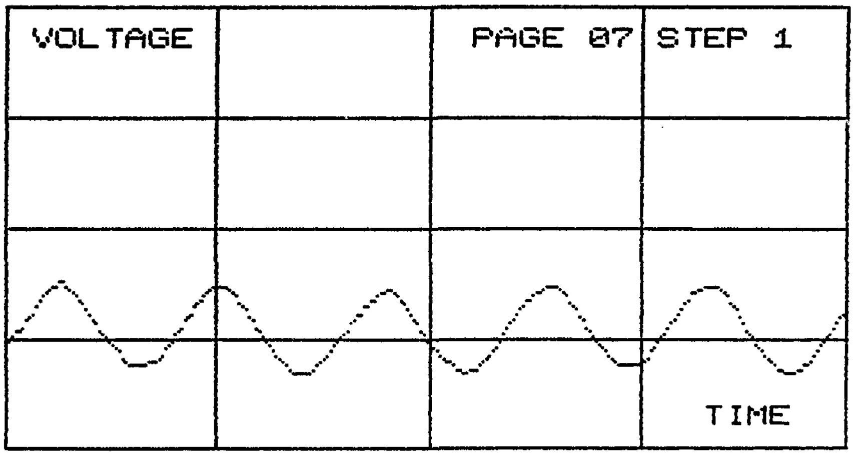


Figure 43

High Lip Pressure for F3
27.5 cm H20, 90 dBA, Gain = 10
F3 T3 08

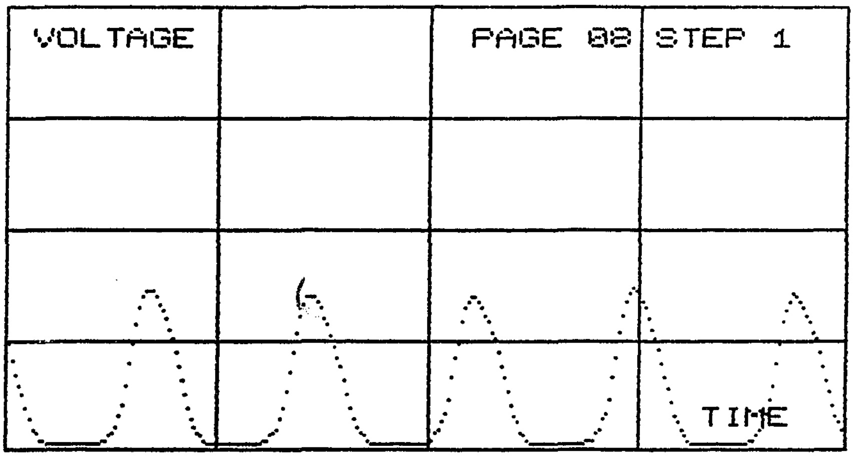


Figure 44

Low Lip Pressure for F3
26.0 cm H20, 90 dBA, Gain = 10
F3 T3 09

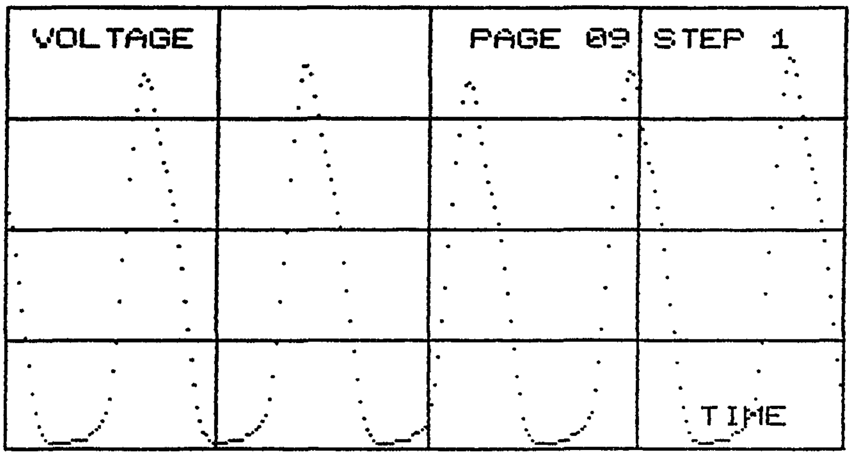


Figure 45

High Lip Pressure for F3
33.5 cm H20, 100 dBA, Gain = 10
F3 T3 10

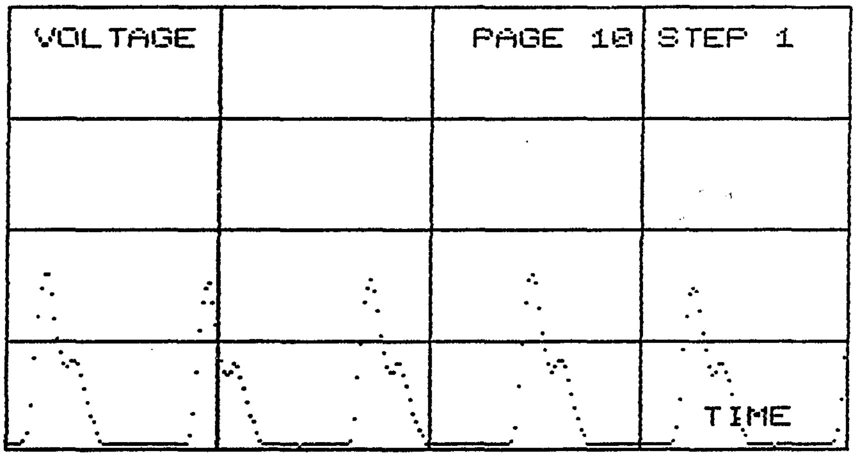
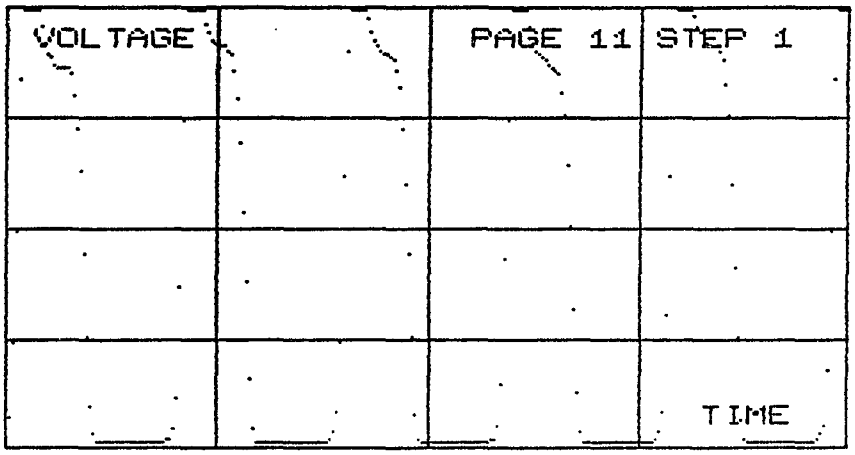


Figure 46

Low Lip Pressure for F3
29.5 cm H20, 100 dBA, Gain = 10
F3 T3 11



Tables 54 through 57 were used in the analyses. These graphs were produced using a gain (amplification) level of 10. The column designated "Voltages Selected" indicates voltages selected as representing the duration of closure. Table 8 is a summary of closure times for each trial.

Figure	cm H20	dBA	Voltages Selected	Lip Pressure	Points Closing
41	26.0	--	10,11	high	11
42	24.5	--	48,49	low	6
43	27.5	90	4	high	14
44	26.0	90	5,6	low	10
45	33.5	100	4	high	24
46	29.5	100	4	low	19-20

Table 8

Point Totals for Reed Closures
At Two Lip-Pressure Settings for F3

Only a slight reduction in closure points is noticeable when lip pressure is reduced and the intensity level is maintained. As expected, air pressure within the chamber dropped slightly as lip pressure was reduced and amplitudes rose dramatically as seen in Figures 43, 44, 45 and 46. The data support that an increase in reed amplitude does not always produce an increase in intensity level. Pressure exerted by the lower lip is a critical factor. If pressure of the lip is decreased, slightly less air pressure is required to maintain the same intensity level, and conversely.

Figures 45 and 46 illustrate F3 at 100 dBA but with different lip pressures. In Figure 45, amplitude was much less than in Figure 46, yet intensity level remained the same. These findings may indicate that as more lip pressure is applied, lip tissue flattens out and exerts a dampening effect on amplitude of reed vibration. At the same time, closure time is slightly increased as if the dampening effect has transformed lost amplitude into a relatively small amount of closure time. Duration of closure exhibited by the reed must therefore be viewed as one of high pressure, which, when finally released, produces a relative amplitude which is proportional to the time and pressure exerted upon it during the duration of its closure.

Air-Pressure Requirements for Low-Intensity Tones at Two Lip-Pressure Settings

Using data collected previously on F3 (Appendix B, Table 3, pages 07-11), air-pressure requirements for producing tones at the threshold of hearing were observed at high and low lip-pressure settings. Figures 41 and 42 (see "Lip Pressure and Duration of Reed Closure") illustrate threshold sounds which are bordering on closure. The wave form in Figure 41 was lower than that in Figure 42 because higher lip pressure had almost forced the reed closed. These wave forms clearly indicate that a low-intensity tone (ppp) may be initiated with less loss of air pressure from the mouth (more resistance) by closing off the reed with more lip pressure. These findings support those of Backus (1962). He stated:

> The threshold blowing pressure is directly proportional to the reed opening and reed stiffness, and is modified somewhat by the Q [air friction on the internal walls] of the instrument. It does not vary with the reed damping, for example, and should therefore not depend on the condition of the player's lip (p. 312).

If a low-intensity tone is initiated at low lip pressure, persistent loss of air pressure in the mouth and the rush of air into the mouthpiece aperture produces a tone often described by clarinetists as being "spread." A more "focused" low-intensity tone may be produced by closing off the reed with more lip pressure as shown in Figure 41. Since most low-intensity tones, especially in the low register of the clarinet, consist largely of the fundamental, the "spread" feeling described by clarinetists could be due to air loss through the reed/mouthpiece aperture when lip pressure is insufficient to reduce this aperture to a minimum. These findings support those of Ghosh (1938), who provided mathematical evidence showing that a clarinetist can control clarinet tone quality by slightly increasing or decreasing the pressure of the lip upon the reed. According to Ghosh, this varied the width of the "chink" or space between the reed and the mouthpiece and in turn varied the effective vibrating length of the reed. He hypothesized that this variance in the effective vibrating length may alter the series of harmonics which are produced, thus increasing or decreasing the number and strengths of harmonics present in the tone.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to observe effects of air and lip-pressure variations on the vibrational patterns of a single reed. In the interest of investigating specific characteristics of reed motion such as intensity, amplitude, and closure, the study was not meant to be statistically conclusive. To facilitate observations, a blowing chamber containing an artificial-embouchure device was constructed into which a clarinet could be inserted and sealed at the barrel joint. A direct-current light source was focused through the bell end of a clarinet, through the reed-mouthpiece aperture, and into a photo transitor mounted within the chamber 2 millimeters from the aperture of the reed and mouthpiece. Light fluctuations produced by the reed's movement on the mouthpiece were detected by the photo transitor and converted into voltages, which were then converted to digital signals by a Nalandata analog-to-digital converter. The analog-to-digital converter was interfaced with an Apple IIe computer and used in conjunction with "Apple-Swiss" softwear developed by Nicklin (1986) to produce graphic representations of the variations in light intensity received by the photo transistor. The procedures were divided into two major categories: air-pressure experiments and lip-pressure experiments.

Air-Pressure Experiments

Natural Blowing Pressures

A preliminary test was conducted to determine natural air pressures required throughout the range of the clarinet (See Appendix C). A plastic tube was inserted into a human mouth while playing the clarinet and connected to a U-tube water manometer. Air-pressure measurements were observed for all pitches from E3 to G6 while maintaining an intensity level of 100 dBA. This test was conducted to compare blowing pressures required when a human plays the clarinet with those required by the artificial-embouchure device.

Air-Pressure Variation and Intensity at Constant Lip Pressure

Two primary procedures were conducted to determine the range of intensities possible by multidirectional manipulation of air pressure at constant lip pressure. In the first procedure, the lower-lip mechanism of the artificial-embouchure chamber was adjusted, in conjunction with air pressure, to produce a tone of high intensity. Air pressure was then reduced in small increments and the range of intensities was observed. This procedure was conducted on three tones (F3, F5, and F6) and provided baseline data on functional intensities. In the second procedure, the lower-lip mechanism of the artificial-embouchure chamber was adjusted, in conjunction with air pressure, to produce a tone of low intensity. Air pressure was then increased in small increments and the range of intensities was observed. This procedure was conducted on two tones: F4, B-flat 5. These two primary procedures were conducted to determine the range of intensities possible through air-pressure variations at constant lip pressure and were repeated on F4, F5, and B-flat 5 to determine the influence selected lip-pressure settings might have on the results.

Air Pressure and the Vibrational Frequency of the Reed at Constant Lip Pressure

To observe effects of air-pressure variations on the reed´s frequency of vibration at constant lip pressure, air pressure was manipulated to produce three intensities (90 dBA, 96 dBA, and 100 dBA) on three tones: F4, F5, and B-flat 5. Using stripcharts of voltages produced by the photo transistor, the reed´s frequency of vibration at each pitch and intensity level were determined. Frequencies were compared across intensities and with a standard table of frequencies for pitches in the tempered scale (Backus, 1977, p. 153) to determine whether the reed's frequency of vibration was the same frequency as the tone being produced.

Reed Amplitude and Intensity at Constant Lip Pressure

To observe the relationship between reed amplitude and intensity, stripcharts were produced from data previously collected on F4 and used to calculate voltage peaks (reed amplitudes). Reed amplitudes were then compared to intensity changes as monitored on a sound-level meter. This procedure was conducted to observe variations in reed amplitude and intensity as air pressure was varied so that a relationship between reed amplitude and intensity might be established before further, and more focused, investigations were initiated.

Air Pressure and Amplitude of Reed Motion at Constant Lip Pressure

To observe the effects of air-pressure variations on amplitude of reed motion at constant lip pressure, the lower-lip mechanism was set at an optimum pressure for producing a high-intensity tone of F4. Air pressure was then reduced until the sound was no longer audible to a human ear, but the pressure of the lower-lip mechanism was retained. Air pressure was slowly increased in small increments until a sound was produced at the subjective threshold of hearing. Light-intensity variations received by the photo transistor were produced as graphs and superimposed upon one another. The charted levels of light intensity were compared with air-pressure measurements to determine the effects air pressure might have upon reed amplitude.

The Transient

Data were collected for light fluctuations on a transient tone for F4 and compared with air-pressure variations of the reed´s natural frequency of vibration collected via a microphone interfaced with the computer. By superimposing graphs of the resulting wave forms, data for the F4 transient were compared with the reed´s natural frequency of vibration and the steady-state wave form for F4.

Lip-Pressure Experiments

Lip Pressure and Intensity at Constant Air Pressure

Two procedures were conducted to observe the effects of lip pressure on intensity. In the first procedure, without keeping the air pressure within the chamber constant, applied lip pressure was reduced from a high setting to a low setting and intensity range was observed. Upon the determination, from observations of the results, that air pressure within the artificial-embouchure chamber varied as lip pressure was reduced, a second procedure was conducted. In the second procedure, air pressure within the chamber was kept constant, and applied lip pressure was again reduced from a high setting to a low setting. Intensity changes were observed and compared with the findings in the first procedure.

Lip Pressure and Amplitude of Reed Motion

Using data previously collected on F3 in which lip pressure was reduced in four increments, observations were made of the effects of lip-pressure variations on amplitude of reed motion. Graphs were produced and amplitudes were visually compared at each lip-pressure increment.

Lip Pressure and Duration of Reed Closure

To observe effects of lip-pressure variations on duration of reed closure, two series of tests were conducted on the tone F3. In the first series, using stripcharts produced from data previously collected on F3, closure times were studied by observing selected voltages representing closure as shown on the stripcharts. In the second series of tests, air pressure was manipulated to produce three intensities (threshold sound level, 90 dBA, and 100 dBA) at two lip-pressure settings. Stripchart voltages were then studied to observe duration of reed closure at two lip-pressure settings.

Conclusions

Based upon observations, conclusions are categorized and listed below.

General Observations of Reed Motion

1. At specific air and lip pressures, the reed completely closed on the mouthpiece during its cycle of vibration.
2. For low-intensity tones in all registers, the motion of the reed produced a wave form which was sinusoidal.
3. For high-intensity tones in all registers, the motion of the reed produced a square-wave form, showing that

the reed closed on the mouthpiece for a portion of its cycle.

4. When the reed closed against the mouthpiece with a specific force, smaller vibrations were superimposed upon the reed´s waveform when it reached maximum displacement. These additional movements undoubtably contributed to increased harmonic content in tones of greater intensity.
5. The reed´s mode of vibration in the steady state matched closely the mode of the air column.
6. The reed´s natural frequency of vibration was distinguishable within the steady state.
7. Small inaudible vibrations of the reed at its natural frequency, combined with reed partials, were evident before the reed began to follow the requirements of the air column.

Air-Pressure Experiments

1. At constant lip pressure, an increase in air pressure increased amplitude of reed motion but did not affect the reed´s frequency of vibration.
2. At constant lip pressure, a continual increase in air pressure eventually caused the reed to close on the mouthpiece during its cycle of vibration, but its frequency of vibration remained constant.
3. At constant lip pressure, an increase in air pressure

produced an increase in closure time.

4. Four stages were observable when air pressure was applied to the reed: the loading stage, the transient stage, the sinusoidal stage, and the closing stage.
   a. The loading stage, necessary to engage the Bernoulli effect while preventing the reed from vibrating at its own natural frequency, was created by pressure exerted on the reed by the lower lip before playing began.
   b. The transient stage was observed to have the least amplitude of reed motion and formed quickly within a relatively narrow range of air pressures. The reed's frequency of vibration remained constant as the transient formed.
   c. The sinusoidal stage was observed to be a characteristic model of the vibrational cycle of the reed before closure began.
   d. The closing stage was the observed motion of the reed when it closed completely on the mouthpiece. In this stage, reed motion produced a wave form which closely resembled a square wave.
5. When the clarinet was played by a person, there was a noticeable decrease in air pressure required to maintain the same intensity level in the low register as in the high register, thus specific pitches required more air pressure to maintain an equal intensity level

with neighboring pitches.

Lip-Pressure Experiments

1. With the application of constant air pressure, a reduction in lip pressure caused a decrease in air pressure within the artificial-embouchure chamber and an increase in reed amplitude and intensity level. The frequency of reed vibration remained constant as lip pressure was reduced.
2. There was minimal change in closure time observed when air pressure was held constant and lip pressure was reduced. Lip-pressure reduction did not appreciably affect closure times and the frequency of reed vibration remained constant.
3. Lip pressure influenced hearing-threshold sound pressures only slightly and not to the degree that it affected sounds of greater intensity. Often, the same air pressure initiated a sound at different lip pressures.
4. Air pressure increased within the artificial-embouchure chamber as lip pressure increased because less air escaped between the reed and mouthpiece.
5. A low-intensity tone (ppp) was initiated with less loss of air pressure from within the artificial-embouchure chamber when the reed/mouthpiece aperture was reduced with more lip pressure. This, in effect, created more

resistance within the system. Therefore, lip pressure becomes an important factor in regulating the amount of resistance a player desires for a specific tone quality.

Duration of Closure

1. Reed closure began at lower air pressures for tones of higher frequency.
2. At specific air and lip-pressures, the reed never closed more than 48 percent of a cycle, regardless of frequency or intensity level.
3. There was great consistency in closure times from cycle to cycle within the same wave.

Amplitude and Intensity

1. An increase in reed amplitude did not always produce an increase in intensity level, therefore, lip pressure may be an important factor affecting amplitude at specific air pressures.

Implications of the Study and Pedagogical Applications

At present, the pedagogy of the clarinet is comprised of a complex, often confusing, variety of teaching strategies. Teachers of the clarinet remain very individualistic in their ideas regarding the proper parameters leading to success in performance. Some teachers may concentrate on tone quality at the expense of technique, while others may insist on technical agility at the expense of tone quality. This dichotomy may have emerged from a lack of understanding among players as to how the many physical aspects of tone production must be tempered to work together. The findings of the present study indicate that the parameters for lip and air pressure, when considering the simple production of sound, are rather broad. With the ever-increasing body of scientific research literature regarding the clarinet, very specific physical criteria must be researched to verify the success of pedagogical practices. More research is needed to bring these physical criteria into focus for the teacher of the clarinet so that some of the subjectivity which surrounds highly successful clarinet teaching and performance may be eliminated.

Recommendations for Further Research

As shown in the present study, the interaction of air and lip pressure in producing a specific pattern of reed motion is crucial; consequently, specific theories presented in the past need to be reevaluated in the light of these new findings. New questions have emerged which invite further inquiries into the characteristics of reed motion at different lip positions. Lip position, held constant in the present study, may add another dimension to our present understanding of reed motion at specific air and lip pressures. When a mouthpiece is inserted further into the player´s mouth, the lower lip comes into contact with the reed at a lower point, thus leaving more of the reed´s surface free to vibrate. Might a practical method be discovered, through empirical means, of predicting and locating an ideal lip position, which takes into consideration the internal and external dimensions of the mouthpiece? Might different lip positions on the mouthpiece and reed alter the findings of the present study regarding air and lip-pressure requirements under specific conditions? Questions also remain unanswered concerning damping effects of the lip upon the reed. Might damping effects contribute to closure times at specific air and lip pressures?

Interesting theories have abounded regarding the pedagogy of tongue position and its relation to the production of tone quality when playing the clarinet. One curious aspect of these theories is the presumption on the part of some teachers that the shape of the tongue increases the velocity of air across the reed/mouthpiece aperture and changes, possibly through damping effects, the "color" of the tone which is produced. To date, accurate measurements of air velocity across the tip of the reed have been impossible; partly because of a lack of technology which is damanded for such a measurement, and partly because of difficulties encountered when attempting to acquire measurements in an area as small as the oral cavity. Even with the availability of highly sensitive transducers, artificial-embouchure devices, and computers, the feasibility of acquiring such a measurement is limited. The present study, however, opened some interesting alternatives regarding the measurement of velocity across the reed whch might be expanded into a functional method of measurement. For example, when applying a slow increase of air pressure to a reed which was preset into playing position (loading stage), a reduction in reed/mouthpiece aperture was directly proportional to the amount of applied air pressure. Would not the reverse be true? Might this observation be used in reverse, so that observable changes in the reed/mouthpiece aperture, under specific conditions, could be used as an indicator of variations in molecular velocity across the reed? Mooney (1968) used an artificial-embouchure device to study wave forms of the tones produced when an artificial tongue was placed near the reed. In conjunction with the theory presented above, this method might be used to determine whether tongue placement has an effect on the tone quality which is produced. Such an investigation would have important pedagogical implications.

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APPENDIX A

DESCRIPTION OF SOFTWARE

Description of "Apple Swiss" Software

The "Apple Swiss" software used in this study was produced by Nicklin (1986) at Appalachian State University and is distributed by Nalan Computer Specialties (106 Highland Park Lane, Boone, N.C., 28607). The software program is designed to accompany the Nalandata A2 Data Converter Unit (see description in text in Chapter III, "Data Converter Specifications"). Using this software, digitized signals from the data converter can be manipulated (integrated, differentiated, normalized, compared with another signal, or simply stored) for printout, for storage on disk or tape, or for display on the video screen. The brief description of "Apple Swiss" applications which follow are only a small sample of possible applications offered within the software program.

The main menu of the software program offers a variety of visual formats for the data. One may select parameters of the data set, the rate of samples to be collected per second, and memory range to be used. The menu offers a "scope" option which converts the screen of the computer into a real-time oscilloscope so that data being received from a transducer may be observed directly. By pushing any key on the computer´s keyboard, data is taken, under preselected parameters, and stored within the computer. Via another memu option, data collected may be graphed, page by page (for description of "pages," see Chapter IV, "Graphic Representation of the Data"), or screen by screen. Using "Triple Dump" (1984) by Beagle Bros. Inc., any "screen" of data may be converted to hard copy via a variety of parameter settings. Another menu option offers hard copy of data in the form of "stripcharts." Data may also be observed in a low-resolution plot called a "glass stripchart." Screens (or pages) of data may be superimposed upon one another for comparison, and hard copy is available of the superimpositions. The versatility of the program is notable. The softwear package is available with a manual and an Nalandata A2 Data Converer Unit from the address shown above.

APPENDIX B

TABLES

LIST OF TABLES

Table Page

Table 1-B

Artificial Embouchure Tests for F3
Series I

Pitch F3 Test No. 1 Date 6-1-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	37/73.5	36.5	98	26	3.3	ff
01	01-02	512	39.5/70	30.5	96	26	3.3	mf
02	02-03	768	38.5/71	32.5	90	28	3.3	pp
03	03-04	1024	42/66.5	24.5	68	28	3.3	Threshold sound pressure
04	04-05	1280	40.5/68	27.5	74	28	3.3	Threshold closing pressure
05	05-06	1536	41.5/67	25.5	88	28	3.3	Varied air pressure Loudest tone possible
06	06-07	1792	43/65	22.0	68	28	3.3	Varied air pressure Softest tone possible
07	07-08	2048	39/70	31.0	70	28	33	Constant air pressure Maximum lip pressure, ppp
08	08-09	2304	40/69	29.0	80	28	33	Less lip pressure, mf
09	09-10	2560	41/68.5	27.5	90	28	3.3	Less lip pressure, ff
10	10-11	2816	41/68.5	27.5	90	28	3.3	Least amt. lip pressure possible before squeaking
11	11-12	3072						

Disk Title ADC Data IX

Data Name F3 TEST 1

Starting Address 0000

Ending Address 2816

Data Step 01

Date 010687

Table 2-B

Artificial Embouchure Tests for F3
Series II

Pitch F3

Test No. 2

Date 6-1-87

Page	Par	EA	L-R	cm H2O	dBA	T	Gain	Observations
00	00-01	256	74.5/50	24.5	100	26	1.0	Varying air pressure inch by inch, starting 100 dBA
01	01-02	512	37/73	36.0	98	26	3.3	
02	02-03	768	38/72	34.0	97.5	26	3.3	
03	03-04	1024	38.5/71	32.5	98	26	3.3	
04	04-05	1280	39.5/70	30.5	94	28	3.3	
05	05-06	1536	40/69	29.0	88	28	3.3	Became necessary to tighten lip pressure to maintain
06	06-07	1792	41/68	27.0	84	28	3.3	Reed not closing
07	07-08	2048	42/67	25.0	78	28	3.3	
08	08-09	2304	42.5/66	23.5	71	28	3.3	
09	09-10	2560	43/65.5	22.5	68	28	3.3	Very soft, almost inaudible
10	10-11	2816						
11	11-12	3072						

Disk Title ADC Data IX

Data Name F3 TEST 2

Starting Address 0000

Ending Address 2560

Data Step 01

Date 010687

Table 3-B

Artificial Embouchure Tests for F3
Series III

Pitch F3 Test No. 3 Date 6-1-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	41.5/ 66.5	25.0	—	26	3.3	Threshold Sound High Lip Pressure
01	01-02	512	41.5/ 66.5	25.0	—	26	3.3	Threshold Sound Low Lip Pressure
02	02-03	768	39.5/ 68.0	28.5	90	26	3.3	High Lip Pressure 90 dBA
03	03-04	1024	40.0/ 67.5	27.5	90	26	3.3	Low Lip Pressure 90 dBA
04	04-05	1280	38.0/ 69.5	31.5	100	26	3.3	High Lip Pressure 100 dBA
05	05-06	1536	40.0/ 67.5	27.5	100	26	3.3	Low Lip Pressure 100 dBA
06	06-07	1792	40.5/ 66.5	26.0	—	26	10	Threshold Sound High Lip Pressure
07	07-08	2048	41.5/ 66.0	24.5	—	26	10	Threshold Sound Low Lip Pressure
08	08-09	2304	40.0/ 67.5	27.5	90	26	10	High Lip Pressure 90 dBA
09	09-10	2560	40.5/ 66.5	26.0	90	26	10	Low Lip Pressure 90 dBA
10	10-11	2816	37.5/ 71.0	33.5	100	26	10	High Lip Pressure 100 dBA
11	11-12	3072	39.0/ 68.5	29.5	100	26	10	Low Lip Pressure 100 dBA

Disk Title ADC DATA XVII

Data Name F3 Test 3

Starting Address 0000

Ending Address 3072

Data Step 01

Date 010687

Table 4-B

Artificial Embouchure Tests for F4
Series I

Pitch F4 Test No. 1 Date 5-30-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	41/69	28.0	90	25	3.3	pp, reed closing on mp
01	01-02	512						
02	02-03	768	39/71	32.0	96	25	3.3	mf, reed closing on mp
03	03-04	1024						
04	04-05	1280	36/74.5	38.5	100	25	3.3	ff, moved LL mech. to left
05	05-06	1536						
06	06-07	1792	42/67	25.0	75	25	10	ppp, reed not closing on mp
07	07-08	2048						
08	08-09	2304	38/72	34.0	80	25	100	mf, maximum lip pressure
09	09-10	2560						
10	10-11	2816	38/72	34.0	106	25	3.3	ff, minimum lip pressure
11	11-12	3072						

Disk Title ADC Data V & VI
Data Name F4 TEST 1
Starting Address 0000
Ending Address 3072
Data Step 01
Date 300587

Table 5-B

Artificial Embouchure Tests for F4
Series II

Pitch F4 Test No. 2 Date 5-30-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	43.5/65	21.5	80	27	33	Threshold sound, ppp
01	01-02	512	42/66.5	24.5	80	27	33	
02	02-03	768	41.5/67.5	26.0	88	27	33	mp
03	03-04	1024	41/68	27.0	92	27	33	
04	04-05	1280	40.5/68.5	28.0	93	27	33	
05	05-06	1536	40/69	29.0	93	32	33	
06	06-07	1792	42/67	25.0	72	30	33	Threshold sound, ppp
07	07-08	2048	41.5/67.5	26.0	85	32	33	mp
08	08-09	2304	41/68	27.0	90	32	33	mf
09	09-10	2560						
10	10-11	2816						
11	11-12	3072						

Disk Title ADC Data V

Data Name F4 TEST 2

Starting Address 0000

Ending Address 2304

Data Step 01

Date 300587

Table 6-B

Artificial Embouchure Tests for F4
Series III

Pitch F4 Test No. 3 Date 3-30-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00.	00-01	256	43.5/ 79	35.5	100	26	3.3	ff, reed closing on mp
01	01-02	512						
02	02-03	768	44.5/ 78.5	34.0	96	26	3.3	mf, reed not closing on mp
03	03-04	1024						
04	04-05	1280	45/78	33.0	90	26	3.3	p, reed not closing on mp
05	05-06	1536						
06	06-07	1792						
07	07-08	2048						
08	08-09	2304						
09	09-10	2560						
10	10-11	2816						
11	11-12	3072						

Disk Title ADC DATA IV
Data Name F4 Test 1
Starting Address 0000
Ending Address 1536
Data Step 01
Date 300387

Table 7-B

Artificial Embouchure Tests for F4
Series IV

Pitch F4 Test No. 4 Date 6-3-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	37/73	36.0	100	26	10	ff
01	01-02	512	37.5/72	34.5	98	26	10	ff
02	02-03	768	46/61.5	15.5	—	26	10	
03	03-04	1024	45/63	18.0	—	26	10	
04	04-05	1280	44/64	20.0	—	26	10	
05	05-06	1536	43/65	22.0	—	26	10	
06	06-07	1792	42/66.5	24.5	—	26	10	
07	07-08	2048	41/68	27.0	—	26	10	
08	08-09	2304	40/69.5	29.5	—	26	10	
09	09-10	2560	39/71	32.0	—	26	10	
10	10-11	2816	37.5/72	32.5	96	26	10	
11	11-12	3072	38/72	34.0	86	26	10	sine - not closing - ppp

Disk Title ADC DATA XV

Data Name F4 TRANS

Starting Address 0000

Ending Address 3072

Data Step 01

Date 30687

Table 8-B

Artificial Embouchure Tests for F4
Series V

Pitch F4   Test No. 5   Date 5-30-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	36.5/ 73.5	37.0				mic = AC
01	01-02	512	36.5/ 73.5	37.0	—			mic = AC
02	02-03	768	36.5/ 73.5	37.0	—	26	100	
03	03-04	1024	36.5/ 73.5	37.0	--	26	100	Transient containing steady state (light)
04	04-05	1280	36.5/ 73.5	37.0	--	26	1.0	Reed's natural frequency (mic)
05	05-06	1536						
06	06-07	1792						
07	07-08	2048						
08	08-09	2304						
09	09-10	2560		36.0	—		100	Transient containing Reed's Nat. Freq. of V (mic
10	10-11	2816						
11	11-12	3072						

Disk Title ADC DATA XVI

Data Name F4 Trans 2

Starting Address 0000

Ending Address 2560

Data Step 01

Date 5-30-87

Table 9-B

Artificial Embouchure Tests for F5
Series I

Pitch F5 Test No. 1 Date 6-2-87

Page	Par	EA	L-R	cm H2O	dBA	T	Gain	Observations
00	00-01	256	38.5/71	32.5	78	26	10	Threshold sound pressure
01	01-02	512	38/72	34.0	84	26	10	Threshold Closing Pressure
02	02-03	768	38/72	34.0	86	26	10	Threshold Closing Pressure
03	03-04	1024	37/73.5	36.5	100	26	3.3	ff, reed closing on mp
04	04-05	1280	38/71.5	33.5	96	26	3.3	mf, reed closing on mp
05	05-06	1536	39/70.5	31.5	90	26	3.3	p, reed closing on mp
06	06-07	1792	39/70.5	31.5	96	26	3.3	mf, maximum air pressure
07	07-08	2048	40/69	29.0	86	26	3.3	p (about 1 cm. range, then tone stopped.)
08	08-09	2304						
09	09-10	2560						
10	10-11	2816						
11	11-12	3072						

Disk Title ADC Data XIII

Data Name F5 TEST 1

Starting Address 0000

Ending Address 2048

Data Step 01

Date 020687

Table 10-B

Artificial Embouchure Tests for F6
Series I

Pitch F6 Test No. 1 Date 6-2-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	40/ 69.5	29.5	100	26	33	ff
01	01-02	512	42.5/ 66	23.5	96	26	33	mf (decrease in dynamic level not possible)
02	02-03	768						
03	03-04	1024						
04	04-05	1280						
05	05-06	1536						
06	06-07	1792						
07	07-08	2048						
08	08-09	2304						
09	09-10	2560						
10	10-11	2816						
11	11-12	3072						

Disk Title ADC Data XIV

Data Name F6 TEST 1

Starting Address 0000

Ending Address 0512

Data Step 01

Date 020687

Table 11-B

Artificial Embouchure Tests for Bb5
Series I

Pitch Bb5 Test No. 1 Date 5-31-87

Page	Par	EA	L-R	cm H2O	dBA	T	Gain	Observations
00	00-01	256	42/67	25	100	26	1.0	ff
01	01-02	512	42.5/ 66.5	24	96	26	1.0	mf
02	02-03	768	43.0/ 65.5	22.5	90	26	1.0	pp
03	03-04	1024	38/72	34	100	28	3.3	ff: Least amount of lip pressure possible, closing
04	04-05	1280	40/70	30	103	32	3.3	ff: Squeak when lip pressure reduced past certain point
05	05-06	1536	40.5/ 68.5	28	80	32	3.3	Most lip pressure possible without choking sound, pp closing. Less=subtone
06	06-07	1792	40/69	29	105	26	1.0	Threshold closing pressure
07	07-08	2048	41/68	27	90	28	1.0	Threshold sound level = mf Unable to get very soft
08	08-09	2304	42.5/ 66.5	24	90	30	1.0	Threshold sound pressure
09	09-10	2560	42.5/ 66.5	24	90	30	1.0	pp: Lip pressure constant
10	10-11	2816	42/67	25	100	30	1.0	mf: Lip pressure constant
11	11-12	3072	39/70	31	100	30	1.0	same mf dynamic even with increase in pressure

Disk Title ADC Data VII & VIII

Data Name B FLAT 5 T1

Starting Address 0000

Ending Address 3072

Data Step 01

Date 310587

Table 12-B

Artificial Embouchure Tests for Bb5
Series II

Pitch Bb5 Test No. 2 Date 3-30-87

Page	Par	EA	L-R	cm H20	dBA	T	Gain	Observations
00	00-01	256	44/78	34.0	100	25	10	ff, reed closing on mp
01	01-02	512						
02	02-03	768	48/73	25.0	90	25	10	pp, reed not closing on mp
03	03-04	1024						
04	04-05	1280	47.7/ 73.3	25.6	96	25	10	mf, same lip position as 02
05	05-06	1536						
06	06-07	1792	47.5/ 73.5	26.0	100	25	10	ff, reed not closing on mp same lip position as 02
07	07-08	2048						
08	08-09	2304	42/81	39.0	105	25	10	ff, reed closing on mp same lip position as 02
09	09-10	2560						
10	10-11	2816						
11	11-12	3072						

Disk Title ADC Data III

Data Name B FLAT 5 TEST 3

Starting Address 0000

Ending Address 2560

Data Step 01

Date 033087

Table 13-B

Stripchart for F4, Series III
35.5 cm H2O, 100 dBA, Gain 3.3
F4 T3 00

```
STARTING ADDRESS = 0  ENDING ADDRESS = 200
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------     ---------     ---------     ---------     ---------     ---------
     0    24      34   162      68     5     102     5     136   162     170    15
     1     8      35   158      69     7     103     5     137   162     171    23
     2     5      36   157      70    14     104     5     138   161     172    31
     3     5      37   157      71    23     105     5     139   160     173    41
     4     5      38   157      72    31     106     6     140   158     174    59
     5     5      39   157      73    39     107     6     141   156     175    79
     6     5      40   156      74    55     108     5     142   152     176   111
     7     6      41   153      75    79     109     5     143   148     177   143
     8     5      42   150      76   111     110     5     144   144     178   167
     9     5      43   146      77   151     111     5     145   134     179   175
    10     5      44   141      78   173     112     5     146   120     180   179
    11     5      45   132      79   185     113     6     147   100     181   176
    12     5      46   118      80   188     114     6     148    72     182   170
    13     5      47   100      81   185     115     6     149    40     183   167
    14     6      48    80      82   180     116     5     150    18     184   164
    15     5      49    48      83   175     117     5     151     7     185   161
    16     5      50    20      84   172     118     6     152     5     186   160
    17     5      51     8      85   170     119     7     153     5     187   160
    18     5      52     5      86   169     120    15     154     5     188   160
    19     7      53     5      87   168     121    23     155     5     189   159
    20    13      54     5      88   168     122    31     156     5     190   159
    21    21      55     5      89   168     123    42     157     5     191   154
    22    29      56     5      90   166     124    55     158     5     192   152
    23    39      57     6      91   163     125    79     159     5     193   148
    24    51      58     5      92   160     126   111     160     5     194   142
    25    75      59     5      93   156     127   151     161     5     195   134
    26   107      60     5      94   150     128   171     162     5     196   120
    27   139      61     5      95   142     129   183     163     6     197   100
    28   159      62     5      96   128     130   186     164     6     198    72
    29   175      63     6      97   108     131   182     165     5     199    44
    30   180      64     6      98    80     132   176     166     5     200    18
    31   177      65     6      99    48     133   171     167     5     201     7
    32   171      66     5     100    20     134   167     168     5     202     5
    33   166      67     5     101     8     135   164     169     7     203     5
```

Table 14-B

Stripchart for F4, Series III
34.0 cm H2O, 96 dBA, Gain 3.3
F4 T3 02

```
STARTING ADDRESS = 512  ENDING ADDRESS = 712
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------       ---------       ---------       ---------       ---------       ---------
    512     11      546    117      580    127      614     11      648     92      682    161
    513     11      547    108      581    141      615     13      649     80      683    164
    514     11      548     98      582    151      616     15      650     66      684    163
    515     12      549     88      583    156      617     17      651     52      685    158
    516     13      550     76      584    157      618     20      652     36      686    153
    517     15      551     64      585    155      619     22      653     24      687    148
    518     19      552     44      586    150      620     23      654     16      688    144
    519     21      553     32      587    145      621     27      655     10      689    141
    520     23      554     18      588    140      622     31      656      8      690    138
    521     25      555     12      589    136      623     39      657      8      691    136
    522     29      556      9      590    134      624     51      658      9      692    133
    523     37      557      7      591    132      625     63      659     10      693    128
    524     47      558      7      592    129      626     79      660     11      694    122
    525     59      559      9      593    126      627     91      661     11      695    116
    526     71      560     10      594    122      628    103      662     12      696    108
    527     87      561     11      595    116      629    119      663     12      697     98
    528     99      562     11      596    108      630    133      664     12      698     88
    529    115      563     11      597    100      631    142      665     14      699     74
    530    127      564     11      598     90      632    153      666     17      700     60
    531    143      565     11      599     80      633    158      667     19      701     44
    532    155      566     13      600     68      634    158      668     21      702     32
    533    163      567     15      601     52      635    156      669     23      703     20
    534    165      568     19      602     40      636    152      670     25      704     12
    535    164      569     21      603     26      637    147      671     29      705      9
    536    160      570     23      604     16      638    143      672     35      706      7
    537    155      571     25      605     11      639    140      673     46      707      8
    538    150      572     29      606      8      640    138      674     59      708      9
    539    146      573     37      607      7      641    136      675     71      709     10
    540    142      574     47      608      7      642    133      676     85      710     11
    541    140      575     59      609      9      643    130      677     95      711     11
    542    138      576     71      610     10      644    124      678    111      712     11
    543    135      577     85      611     11      645    118      679    127      713     11
    544    131      578     95      612     11      646    112      680    143      714     12
    545    124      579    111      613     11      647    102      681    155      715     14
```

Table 15-B

Stripchart for F4, Series III
33.0 cm H2O, 90 dBA, Gain 3.3
F4 T3 04

```
STARTING ADDRESS = 1024  ENDING ADDRESS = 1224
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------       ---------       ---------       ---------       ---------       ---------
    1024   109      1058    25      1092    82      1126   127      1160    31      1194    56
    1025   115      1059    27      1093    74      1127   132      1161    35      1195    48
    1026   121      1060    29      1094    66      1128   134      1162    38      1196    41
    1027   125      1061    31      1095    58      1129   135      1163    42      1197    35
    1028   127      1062    34      1096    50      1130   135      1164    47      1198    30
    1029   131      1063    37      1097    43      1131   133      1165    53      1199    27
    1030   131      1064    41      1098    37      1132   132      1166    59      1200    25
    1031   131      1065    46      1099    32      1133   129      1167    63      1201    23
    1032   130      1066    51      1100    28      1134   126      1168    73      1202    23
    1033   128      1067    57      1101    26      1135   122      1169    79      1203    23
    1034   125      1068    63      1102    24      1136   118      1170    89      1204    23
    1035   122      1069    71      1103    23      1137   114      1171    98      1205    24
    1036   118      1070    79      1104    23      1138   109      1172   106      1206    25
    1037   114      1071    87      1105    24      1139   104      1173   113      1207    26
    1038   110      1072    95      1106    24      1140    98      1174   119      1208    27
    1039   104      1073   103      1107    25      1141    90      1175   123      1209    29
    1040    98      1074   111      1108    27      1142    82      1176   127      1210    31
    1041    93      1075   117      1109    28      1143    73      1177   129      1211    35
    1042    85      1076   121      1110    31      1144    64      1178   131      1212    38
    1043    77      1077   125      1111    33      1145    56      1179   131      1213    42
    1044    69      1078   127      1112    36      1146    48      1180   129      1214    47
    1045    61      1079   128      1113    39      1147    40      1181   127      1215    51
    1046    53      1080   129      1114    44      1148    34      1182   124      1216    59
    1047    45      1081   128      1115    49      1149    30      1183   121      1217    66
    1048    38      1082   126      1116    55      1150    27      1184   119      1218    74
    1049    33      1083   124      1117    62      1151    25      1185   115      1219    83
    1050    29      1084   122      1118    69      1152    24      1186   112      1220    91
    1051    26      1085   119      1119    77      1153    23      1187   107      1221    99
    1052    24      1086   116      1120    86      1154    23      1188   102      1222   107
    1053    23      1087   112      1121    95      1155    25      1189    96      1223   113
    1054    23      1088   109      1122   103      1156    25      1190    90      1224   119
    1055    23      1089   103      1123   111      1157    27      1191    82      1225   123
    1056    23      1090    97      1124   119      1158    28      1192    74      1226   126
    1057    24      1091    90      1125   123      1159    29      1193    64      1227   127
```

Table 16-B

Stripchart for F5, Series I
36.5 cm H2O, 100 dBA, Gain 3.3
F5 Tl 03

```
STARTING ADDRESS = 768  ENDING ADDRESS = 968
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------      ---------      ---------      ---------      ---------      ---------
    768      8     802      6     836     87     870     10     904      6     938     83
    769      6     803      6     837     95     871      7     905      6     939     92
    770      6     804      6     838     98     872      6     906      6     940     95
    771      6     805      7     839     96     873      6     907      7     941     96
    772      6     806      9     840     86     874      6     908      7     942     88
    773      6     807     21     841     72     875      6     909     15     943     74
    774      6     808     43     842     48     876      6     910     39     944     56
    775      6     809     63     843     28     877      6     911     63     945     32
    776      6     810     79     844     12     878      6     912     79     946     16
    777      6     811     91     845      7     879      6     913     91     947      8
    778      6     812     95     846      6     880      6     914     99     948      6
    779      6     813     96     847      6     881      6     915    100     949      6
    780      7     814     89     848      6     882      7     916     96     950      6
    781     13     815     76     849      6     883     11     917     84     951      6
    782     31     816     56     850      6     884     27     918     64     952      6
    783     59     817     36     851      6     885     55     919     42     953      6
    784     77     818     18     852      6     886     75     920     22     954      6
    785     89     819      8     853      6     887     89     921     10     955      6
    786     95     820      6     854      6     888     97     922      7     956      6
    787     98     821      6     855      6     889    102     923      6     957      6
    788     94     822      6     856      7     890    100     924      6     958      6
    789     84     823      6     857      7     891     90     925      6     959      7
    790     66     824      6     858     15     892     76     926      6     960     13
    791     48     825      6     859     39     893     52     927      6     961     31
    792     24     826      6     860     63     894     32     928      6     962     55
    793     11     827      6     861     83     895     16     929      6     963     75
    794      7     828      6     862     94     896      8     930      6     964     87
    795      6     829      6     863    100     897      7     931      6     965     95
    796      6     830      6     864    101     898      6     932      6     966     97
    797      6     831      7     865     96     899      6     933      7     967     94
    798      6     832     11     866     82     900      6     934      9     968     84
    799      6     833     31     867     64     901      6     935     23     969     66
    800      6     834     55     868     40     902      6     936     47     970     48
    801      6     835     75     869     20     903      6     937     69     971     24
```

Table 17-B

Stripchart for F5, Series I
33.5 cm H2O, 96 dBA, Gain 3.3
F5 Tl 04

```
STARTING ADDRESS = 1024  ENDING ADDRESS = 1224
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------     ---------     ---------     ---------     ---------     ---------
  1024    11    1058    70    1092     6    1126    10    1160    72    1194     6
  1025    19    1059    57    1093     6    1127    19    1161    64    1195     6
  1026    35    1060    42    1094     6    1128    31    1162    44    1196     6
  1027    53    1061    26    1095     6    1129    55    1163    28    1197     6
  1028    67    1062    14    1096     6    1130    70    1164    16    1198     6
  1029    77    1063     8    1097     6    1131    79    1165     9    1199     6
  1030    81    1064     7    1098     7    1132    85    1166     7    1200     6
  1031    80    1065     6    1099     7    1133    85    1167     6    1201     7
  1032    74    1066     6    1100     8    1134    80    1168     6    1202     7
  1033    64    1067     6    1101    14    1135    70    1169     6    1203    11
  1034    48    1068     6    1102    27    1136    56    1170     6    1204    23
  1035    32    1069     6    1103    43    1137    36    1171     6    1205    39
  1036    18    1070     6    1104    61    1138    21    1172     6    1206    55
  1037    10    1071     6    1105    75    1139    12    1173     6    1207    69
  1038     7    1072     6    1106    83    1140     7    1174     6    1208    77
  1039     6    1073     7    1107    85    1141     7    1175     6    1209    80
  1040     6    1074     7    1108    82    1142     6    1176     7    1210    79
  1041     6    1075    10    1109    74    1143     6    1177     9    1211    73
  1042     6    1076    19    1110    64    1144     6    1178    15    1212    64
  1043     6    1077    31    1111    44    1145     6    1179    31    1213    48
  1044     6    1078    54    1112    28    1146     6    1180    47    1214    32
  1045     6    1079    69    1113    16    1147     6    1181    63    1215    16
  1046     6    1080    79    1114     9    1148     6    1182    75    1216     9
  1047     6    1081    83    1115     7    1149     7    1183    80    1217     7
  1048     7    1082    83    1116     7    1150     7    1184    81    1218     6
  1049     7    1083    77    1117     6    1151     7    1185    76    1219     6
  1050    13    1084    66    1118     6    1152    13    1186    66    1220     6
  1051    27    1085    52    1119     6    1153    23    1187    52    1221     6
  1052    43    1086    34    1120     6    1154    39    1188    36    1222     6
  1053    59    1087    20    1121     6    1155    58    1189    21    1223     6
  1054    71    1088    10    1122     6    1156    71    1190    11    1224     6
  1055    79    1089     7    1123     7    1157    79    1191     7    1225     6
  1056    81    1090     7    1124     7    1158    83    1192     6    1226     7
  1057    78    1091     6    1125     7    1159    80    1193     6    1227     7
```

Table 18-B

Stripchart for F5, Series I
31.5 cm H2O, 90 dBA, Gain 3.3
F5 T1 05

```
STARTING ADDRESS = 1280  ENDING ADDRESS = 1480
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------     ---------     ---------     ---------     ---------     ---------
    1280     48   1314      9   1348      8   1382     48   1416      9   1450      8
    1281     48   1315      8   1349     10   1383     48   1417      7   1451     10
    1282     46   1316      7   1350     12   1384     45   1418      7   1452     12
    1283     41   1317      7   1351     15   1385     41   1419      7   1453     15
    1284     34   1318      7   1352     23   1386     34   1420      7   1454     23
    1285     27   1319      7   1353     30   1387     27   1421      7   1455     30
    1286     20   1320      7   1354     37   1388     20   1422      7   1456     39
    1287     14   1321      7   1355     43   1389     14   1423      7   1457     45
    1288     10   1322      8   1356     47   1390     10   1424      7   1458     49
    1289      8   1323      9   1357     50   1391      8   1425      9   1459     50
    1290      7   1324     11   1358     48   1392      7   1426     10   1460     49
    1291      7   1325     15   1359     44   1393      7   1427     13   1461     45
    1292      7   1326     21   1360     38   1394      7   1428     18   1462     40
    1293      7   1327     27   1361     32   1395      7   1429     25   1463     32
    1294      7   1328     35   1362     24   1396      7   1430     31   1464     24
    1295      7   1329     42   1363     16   1397      7   1431     39   1465     18
    1296      7   1330     47   1364     12   1398      7   1432     45   1466     13
    1297      8   1331     50   1365      9   1399      7   1433     47   1467     10
    1298     10   1332     50   1366      8   1400      9   1434     47   1468      8
    1299     13   1333     48   1367      7   1401     11   1435     45   1469      7
    1300     17   1334     42   1368      7   1402     15   1436     41   1470      7
    1301     23   1335     36   1369      7   1403     21   1437     34   1471      7
    1302     30   1336     28   1370      7   1404     28   1438     26   1472      7
    1303     38   1337     20   1371      7   1405     35   1439     20   1473      7
    1304     44   1338     14   1372      7   1406     41   1440     14   1474      7
    1305     47   1339     11   1373      7   1407     46   1441     10   1475      7
    1306     49   1340      8   1374      9   1408     47   1442      8   1476      9
    1307     48   1341      7   1375     11   1409     46   1443      7   1477     11
    1308     44   1342      7   1376     14   1410     42   1444      7   1478     14
    1309     38   1343      7   1377     19   1411     37   1445      7   1479     19
    1310     32   1344      7   1378     25   1412     30   1446      7   1480     25
    1311     24   1345      7   1379     31   1413     22   1447      7   1481     31
    1312     17   1346      7   1380     39   1414     16   1448      7   1482     39
    1313     12   1347      7   1381     45   1415     12   1449      7   1483     45
```

Table 19-B

Stripchart for Bb5, Series I
25.0 cm H2O, 100 dBA, Gain 1.0
Bb5 T1 00

```
STARTING ADDRESS = 0  ENDING ADDRESS = 200
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------    ---------    ---------    ---------    ---------    ---------
    0   26      34   53      68   63     102   53     136   39     170   22
    1   19      35   45      69   63     103   57     137   45     171   29
    2   16      36   36      70   60     104   60     138   49     172   36
    3   17      37   26      71   54     105   62     139   53     173   42
    4   22      38   20      72   45     106   61     140   55     174   47
    5   29      39   16      73   36     107   58     141   59     175   51
    6   35      40   18      74   26     108   51     142   61     176   54
    7   41      41   23      75   19     109   42     143   60     177   57
    8   46      42   31      76   16     110   32     144   56     178   61
    9   50      43   38      77   19     111   24     145   50     179   62
   10   53      44   43      78   23     112   18     146   41     180   61
   11   57      45   47      79   31     113   15     147   32     181   57
   12   59      46   52      80   39     114   18     148   24     182   50
   13   61      47   55      81   43     115   23     149   17     183   41
   14   60      48   59      82   47     116   31     150   15     184   32
   15   56      49   62      83   53     117   37     151   18     185   23
   16   49      50   63      84   55     118   43     152   23     186   17
   17   40      51   62      85   59     119   47     153   31     187   16
   18   32      52   57      86   62     120   51     154   38     188   19
   19   22      53   50      87   63     121   55     155   43     189   27
   20   17      54   40      88   61     122   58     156   47     190   34
   21   15      55   32      89   56     123   61     157   51     191   39
   22   19      56   22      90   48     124   61     158   55     192   45
   23   26      57   17      91   40     125   59     159   58     193   49
   24   31      58   16      92   29     126   54     160   61     194   53
   25   39      59   21      93   21     127   46     161   61     195   57
   26   45      60   27      94   16     128   37     162   59     196   60
   27   49      61   35      95   17     129   28     163   54     197   63
   28   53      62   41      96   21     130   20     164   46     198   63
   29   55      63   46      97   27     131   16     165   36     199   60
   30   59      64   51      98   35     132   16     166   27     200   54
   31   62      65   55      99   41     133   21     167   20     201   46
   32   62      66   58     100   46     134   27     168   16     202   36
   33   59      67   61     101   50     135   35     169   17     203   26
```

Table 20-B

Stripchart for Bb5, Series I
24.0 cm H2O, 96 dBA, Gain 1.0
Bb5 T1 01

```
STARTING ADDRESS = 256  ENDING ADDRESS = 456
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------     ---------     ---------     ---------     ---------     ---------
    256    41     290    30     324    21     358    29     392    45     426    53
    257    45     291    35     325    23     359    24     393    40     427    53
    258    47     292    39     326    27     360    21     394    34     428    50
    259    50     293    43     327    31     361    20     395    28     429    46
    260    51     294    46     328    35     362    23     396    23     430    40
    261    52     295    49     329    39     363    27     397    20     431    34
    262    50     296    52     330    43     364    31     398    20     432    28
    263    46     297    54     331    47     365    35     399    23     433    23
    264    41     298    54     332    50     366    39     400    27     434    21
    265    35     299    52     333    53     367    43     401    31     435    21
    266    29     300    48     334    54     368    46     402    35     436    25
    267    24     301    42     335    53     369    49     403    39     437    29
    268    21     302    35     336    50     370    51     404    43     438    33
    269    20     303    28     337    46     371    52     405    46     439    38
    270    23     304    24     338    40     372    52     406    49     440    42
    271    27     305    21     339    33     373    48     407    51     441    45
    272    31     306    22     340    27     374    44     408    52     442    49
    273    35     307    25     341    23     375    38     409    51     443    51
    274    39     308    29     342    21     376    32     410    48     444    53
    275    43     309    33     343    21     377    26     411    42     445    54
    276    47     310    37     344    24     378    22     412    36     446    52
    277    49     311    41     345    29     379    20     413    30     447    48
    278    52     312    45     346    33     380    21     414    25     448    43
    279    53     313    49     347    37     381    25     415    21     449    37
    280    52     314    51     348    41     382    29     416    20     450    30
    281    49     315    54     349    45     383    33     417    22     451    25
    282    44     316    55     350    47     384    37     418    26     452    21
    283    38     317    53     351    51     385    41     419    30     453    21
    284    32     318    49     352    53     386    45     420    34     454    23
    285    26     319    44     353    53     387    47     421    39     455    27
    286    22     320    38     354    51     388    50     422    43     456    31
    287    20     321    32     355    48     389    52     423    46     457    37
    288    22     322    25     356    42     390    52     424    49     458    41
    289    26     323    22     357    36     391    50     425    51     459    45
```

Table 21-B

Stripchart for Bb5, Series I
22.5 cm H2O, 90 dBA, Gain 1.0
Bb5 Tl 02

```
STARTING ADDRESS = 512  ENDING ADDRESS = 712
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------    ---------    ---------    ---------    ---------    ---------
    512    55    546    49    580    39    614    32    648    41    682    55
    513    57    547    51    581    43    615    32    649    36    683    50
    514    58    548    54    582    47    616    35    650    32    684    45
    515    57    549    55    583    51    617    39    651    30    685    40
    516    55    550    57    584    54    618    45    652    31    686    35
    517    52    551    58    585    56    619    47    653    35    687    32
    518    46    552    58    586    58    620    51    654    39    688    30
    519    40    553    56    587    59    621    54    655    43    689    31
    520    35    554    52    588    60    622    55    656    47    690    35
    521    32    555    46    589    59    623    57    657    50    691    39
    522    30    556    40    590    56    624    59    658    53    692    44
    523    31    557    35    591    52    625    59    659    55    693    47
    524    34    558    32    592    46    626    58    660    56    694    51
    525    39    559    31    593    41    627    55    661    58    695    53
    526    43    560    33    594    36    628    51    662    58    696    55
    527    47    561    37    595    33    629    45    663    56    697    57
    528    49    562    41    596    32    630    40    664    53    698    58
    529    51    563    45    597    34    631    35    665    48    699    58
    530    54    564    47    598    38    632    32    666    43    700    57
    531    55    565    51    599    42    633    31    667    38    701    54
    532    57    566    54    600    46    634    33    668    33    702    49
    533    57    567    56    601    50    635    37    669    30    703    44
    534    56    568    58    602    53    636    42    670    31    704    38
    535    53    569    59    603    55    637    46    671    33    705    34
    536    48    570    59    604    58    638    49    672    37    706    31
    537    42    571    58    605    59    639    51    673    41    707    31
    538    37    572    54    606    60    640    54    674    45    708    34
    539    32    573    49    607    60    641    56    675    47    709    39
    540    30    574    44    608    58    642    58    676    51    710    43
    541    30    575    38    609    54    643    59    677    53    711    47
    542    33    576    34    610    49    644    58    678    55    712    50
    543    37    577    32    611    44    645    56    679    57    713    53
    544    42    578    31    612    38    646    52    680    58    714    55
    545    45    579    35    613    34    647    48    681    57    715    57
```

Table 22-B

Stripchart for F4, Series II
21.5 cm H2O, 80 dBA, Page 00

```
STARTING ADDRESS = 0  ENDING ADDRESS = 200
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------     ---------     ---------     ---------     ---------     ---------
    0    55       34    51       68    64      102    60      136    49      170    61
    1    57       35    51       69    63      103    61      137    50      171    60
    2    59       36    51       70    62      104    62      138    48      172    59
    3    60       37    51       71    62      105    63      139    51      173    57
    4    61       38    51       72    61      106    65      140    51      174    55
    5    62       39    51       73    60      107    66      141    52      175    54
    6    63       40    51       74    58      108    66      142    53      176    53
    7    65       41    52       75    57      109    66      143    53      177    52
    8    66       42    52       76    55      110    66      144    54      178    52
    9    67       43    53       77    54      111    65      145    55      179    51
   10    68       44    54       78    52      112    65      146    57      180    51
   11    69       45    54       79    51      113    64      147    59      181    51
   12    69       46    55       80    50      114    63      148    60      182    51
   13    69       47    55       81    49      115    63      149    61      183    52
   14    69       48    57       82    49      116    62      150    62      184    51
   15    68       49    58       83    49      117    62      151    63      185    52
   16    68       50    59       84    49      118    61      152    64      186    52
   17    67       51    61       85    50      119    60      153    66      187    52
   18    67       52    62       86    49      120    60      154    67      188    53
   19    66       53    63       87    49      121    59      155    68      189    53
   20    65       54    63       88    49      122    58      156    69      190    54
   21    64       55    65       89    50      123    56      157    69      191    55
   22    64       56    66       90    50      124    55      158    69      192    55
   23    63       57    67       91    50      125    54      159    69      193    57
   24    62       58    68       92    51      126    52      160    68      194    58
   25    61       59    69       93    51      127    51      161    68      195    59
   26    60       60    69       94    52      128    50      162    67      196    61
   27    58       61    69       95    53      129    50      163    67      197    62
   28    57       62    68       96    53      130    49      164    67      198    63
   29    55       63    68       97    55      131    49      165    66      199    63
   30    54       64    67       98    56      132    49      166    65      200    65
   31    53       65    67       99    57      133    49      167    64      201    66
   32    52       66    66      100    59      134    49      168    63      202    67
   33    52       67    65      101    59      135    49      169    62      203    68
```

Table 23-B

Stripchart for F4, Series II
24.5 cm H2O, 80 dBA, Page 01

```
STARTING ADDRESS = 257  ENDING ADDRESS = 457
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------     ---------     ---------     ---------     ---------     ---------
   257     90    291     65    325     63    359     81    393     69    427     59
   258     88    292     67    326     63    360     78    394     70    428     59
   259     85    293     67    327     62    361     76    395     71    429     60
   260     82    294     69    328     62    362     74    396     75    430     60
   261     80    295     70    329     62    363     72    397     78    431     61
   262     76    296     71    330     62    364     70    398     82    432     61
   263     74    297     74    331     62    365     69    399     85    433     62
   264     72    298     77    332     63    366     68    400     89    434     63
   265     70    299     79    333     63    367     67    401     91    435     63
   266     68    300     85    334     63    368     66    402     92    436     65
   267     67    301     89    335     65    369     64    403     91    437     63
   268     66    302     92    336     65    370     64    404     89    438     66
   269     65    303     94    337     66    371     63    405     87    439     67
   270     64    304     95    338     67    372     62    406     84    440     68
   271     63    305     96    339     67    373     61    407     80    441     70
   272     62    306     95    340     68    374     60    408     77    442     71
   273     62    307     93    341     69    375     60    409     74    443     73
   274     61    308     90    342     70    376     59    410     72    444     75
   275     60    309     86    343     71    377     59    411     70    445     79
   276     60    310     83    344     72    378     59    412     69    446     83
   277     59    311     80    345     74    379     59    413     67    447     86
   278     59    312     77    346     76    380     60    414     66    448     90
   279     59    313     75    347     79    381     60    415     65    449     93
   280     59    314     73    348     82    382     61    416     64    450     95
   281     59    315     72    349     86    383     61    417     63    451     96
   282     59    316     71    350     89    384     61    418     63    452     95
   283     60    317     70    351     93    385     62    419     62    453     93
   284     61    318     69    352     95    386     62    420     61    454     91
   285     61    319     68    353     96    387     63    421     61    455     88
   286     62    320     67    354     96    388     63    422     60    456     84
   287     62    321     66    355     94    389     64    423     59    457     81
   288     63    322     65    356     92    390     65    424     59    458     79
   289     63    323     64    357     88    391     66    425     59    459     76
   290     64    324     64    358     85    392     67    426     59    460     75
```

Table 24-B

Stripchart for F4, Series II
26.0 cm H2O, 88 dBA, Page 02

```
STARTING ADDRESS = 513  ENDING ADDRESS = 713
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

    ---------      ---------      ---------      ---------      ---------      ---------
    513     84     547     67     581     55     615     76     649    107     683     54
    514     81     548     70     582     56     616     73     650    127     684     54
    515     79     549     75     583     56     617     71     651    143     685     56
    516     76     550     83     584     56     618     69     652    147     686     55
    517     74     551    103     585     57     619     67     653    144     687     56
    518     71     552    125     586     57     620     64     654    134     688     57
    519     69     553    143     587     57     621     61     655    120     689     59
    520     67     554    152     588     57     622     58     656    108     690     61
    521     65     555    151     589     58     623     55     657     96     691     63
    522     63     556    144     590     59     624     54     658     90     692     65
    523     60     557    130     591     61     625     54     659     85     693     67
    524     57     558    116     592     63     626     54     660     82     694     69
    525     55     559    105     593     64     627     54     661     79     695     73
    526     53     560     96     594     66     628     53     662     77     696     79
    527     53     561     90     595     68     629     53     663     74     697     95
    528     53     562     87     596     70     630     53     664     72     698    119
    529     53     563     85     597     73     631     53     665     70     699    139
    530     53     564     82     598     79     632     54     666     68     700    151
    531     53     565     80     599     91     633     54     667     66     701    152
    532     53     566     77     600    111     634     54     668     64     702    148
    533     53     567     74     601    135     635     54     669     61     703    138
    534     53     568     72     602    151     636     55     670     58     704    128
    535     53     569     71     603    158     637     55     671     55     705    112
    536     54     570     69     604    155     638     55     672     53     706    101
    537     54     571     66     605    144     639     56     673     53     707     93
    538     55     572     63     606    132     640     58     674     53     708     89
    539     55     573     60     607    116     641     59     675     53     709     86
    540     55     574     57     608    104     642     61     676     53     710     84
    541     55     575     56     609     96     643     63     677     53     711     82
    542     58     576     55     610     91     644     64     678     53     712     79
    543     60     577     55     611     87     645     67     679     53     713     76
    544     61     578     55     612     85     646     70     680     53     714     74
    545     63     579     55     613     82     647     75     681     53     715     72
    546     65     580     55     614     79     648     87     682     54     716     70
```

Table 25-B

Stripchart for F4, Series II
27.0 cm H2O, 92 dBA, Page 03

```
STARTING ADDRESS = 769  ENDING ADDRESS = 969
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

     ---------     ---------     ---------     ---------     ---------     ---------
     769    78     803    70     837    53     871    71     905   139     939    54
     770    76     804    75     838    53     872    70     906   144     940    54
     771    74     805    87     839    53     873    68     907   136     941    54
     772    73     806   103     840    53     874    64     908   120     942    54
     773    71     807   123     841    53     875    60     909   104     943    55
     774    70     808   135     842    52     876    57     910    93     944    55
     775    68     809   136     843    54     877    55     911    86     945    57
     776    65     810   122     844    54     878    55     912    83     946    59
     777    61     811   106     845    55     879    55     913    81     947    62
     778    58     812    92     846    56     880    55     914    80     948    65
     779    55     813    84     847    57     881    55     915    79     949    69
     780    54     814    80     848    59     882    55     916    78     950    73
     781    54     815    77     849    61     883    55     917    76     951    79
     782    54     816    76     850    65     884    55     918    74     952    95
     783    54     817    75     851    68     885    55     919    72     953   111
     784    54     818    74     852    71     886    56     920    71     954   127
     785    53     819    72     853    79     887    56     921    69     955   131
     786    53     820    71     854    91     888    56     922    66     956   122
     787    53     821    70     855   111     889    56     923    64     957   108
     788    54     822    68     856   127     890    56     924    59     958    96
     789    54     823    66     857   139     891    56     925    56     959    84
     790    54     824    64     858   136     892    57     926    54     960    80
     791    54     825    62     859   120     893    57     927    54     961    76
     792    53     826    58     860   104     894    58     928    54     962    75
     793    54     827    55     861    92     895    59     929    54     963    75
     794    54     828    53     862    86     896    59     930    54     964    74
     795    54     829    52     863    82     897    62     931    53     965    73
     796    55     830    52     864    80     898    65     932    53     966    71
     797    55     831    52     865    79     899    69     933    54     967    70
     798    57     832    52     866    78     900    71     934    54     968    69
     799    58     833    52     867    77     901    76     935    54     969    67
     800    60     834    52     868    76     902    83     936    54     970    65
     801    63     835    52     869    74     903    95     937    54     971    64
     802    67     836    52     870    73     904   119     938    54     972    60
```

Table 26-B

Stripchart for F4, Series II
28.0 cm H2O, 93 dBA, Page 04

```
STARTING ADDRESS = 1025  ENDING ADDRESS = 1225
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------      ---------      ---------      ---------      ---------      ---------
  1025    53     1059    71     1093    57     1127    53     1161    71     1195    77
  1026    53     1060    71     1094    61     1128    53     1162    70     1196    87
  1027    53     1061    70     1095    63     1129    53     1163    68     1197    99
  1028    52     1062    69     1096    69     1130    53     1164    67     1198   110
  1029    52     1063    68     1097    73     1131    53     1165    65     1199   111
  1030    52     1064    67     1098    79     1132    53     1166    62     1200   104
  1031    53     1065    66     1099    91     1133    54     1167    58     1201    90
  1032    53     1066    64     1100   103     1134    54     1168    55     1202    80
  1033    53     1067    63     1101   111     1135    54     1169    53     1203    75
  1034    53     1068    61     1102   108     1136    54     1170    53     1204    72
  1035    52     1069    58     1103    96     1137    54     1171    52     1205    71
  1036    52     1070    54     1104    86     1138    55     1172    53     1206    71
  1037    53     1071    51     1105    78     1139    55     1173    52     1207    70
  1038    53     1072    51     1106    75     1140    55     1174    52     1208    69
  1039    53     1073    50     1107    73     1141    57     1175    52     1209    68
  1040    53     1074    50     1108    72     1142    61     1176    52     1210    67
  1041    53     1075    50     1109    72     1143    65     1177    52     1211    66
  1042    53     1076    50     1110    72     1144    69     1178    52     1212    64
  1043    54     1077    50     1111    71     1145    73     1179    52     1213    63
  1044    57     1078    50     1112    70     1146    78     1180    52     1214    61
  1045    61     1079    50     1113    69     1147    87     1181    52     1215    58
  1046    63     1080    50     1114    67     1148   101     1182    52     1216    54
  1047    68     1081    51     1115    67     1149   111     1183    52     1217    52
  1048    71     1082    51     1116    65     1150   116     1184    52     1218    51
  1049    78     1083    51     1117    62     1151   112     1185    53     1219    50
  1050    87     1084    51     1118    59     1152    97     1186    53     1220    50
  1051   103     1085    51     1119    55     1153    86     1187    53     1221    50
  1052   111     1086    51     1120    53     1154    80     1188    53     1222    50
  1053   112     1087    51     1121    53     1155    76     1189    53     1223    50
  1054   100     1088    51     1122    53     1156    75     1190    55     1224    50
  1055    88     1089    52     1123    53     1157    75     1191    60     1225    50
  1056    80     1090    52     1124    53     1158    74     1192    63     1226    50
  1057    75     1091    52     1125    53     1159    73     1193    67     1227    51
  1058    72     1092    54     1126    52     1160    72     1194    71     1228    51
```

Table 27-B

Stripchart for F4, Series II
29.0 cm H2O, 93 dBA, Page 05

STARTING ADDRESS = 1281 ENDING ADDRESS = 1481
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

1281	55	1315	56	1349	83	1383	54	1417	55	1451	74
1282	55	1316	54	1350	77	1384	54	1418	55	1452	74
1283	56	1317	54	1351	74	1385	55	1419	55	1453	73
1284	56	1318	53	1352	71	1386	57	1420	55	1454	71
1285	56	1319	53	1353	72	1387	60	1421	55	1455	70
1286	56	1320	53	1354	71	1388	63	1422	55	1456	69
1287	56	1321	53	1355	71	1389	68	1423	55	1457	67
1288	57	1322	53	1356	70	1390	71	1424	55	1458	65
1289	59	1323	53	1357	69	1391	77	1425	55	1459	62
1290	63	1324	53	1358	67	1392	85	1426	55	1460	59
1291	67	1325	53	1359	66	1393	95	1427	55	1461	56
1292	71	1326	53	1360	64	1394	101	1428	55	1462	54
1293	75	1327	53	1361	62	1395	103	1429	55	1463	53
1294	79	1328	53	1362	60	1396	100	1430	55	1464	53
1295	87	1329	53	1363	56	1397	92	1431	56	1465	53
1296	99	1330	53	1364	54	1398	84	1432	56	1466	53
1297	103	1331	53	1365	53	1399	80	1433	56	1467	52
1298	104	1332	53	1366	52	1400	77	1434	57	1468	52
1299	99	1333	53	1367	52	1401	76	1435	59	1469	52
1300	90	1334	53	1368	52	1402	75	1436	63	1470	53
1301	83	1335	53	1369	52	1403	75	1437	67	1471	52
1302	78	1336	54	1370	52	1404	74	1438	71	1472	53
1303	76	1337	55	1371	52	1405	73	1439	75	1473	53
1304	75	1338	57	1372	52	1406	72	1440	79	1474	53
1305	75	1339	61	1373	52	1407	71	1441	87	1475	52
1306	74	1340	65	1374	53	1408	69	1442	99	1476	53
1307	73	1341	69	1375	53	1409	68	1443	103	1477	53
1308	72	1342	73	1376	53	1410	66	1444	104	1478	53
1309	70	1343	79	1377	53	1411	62	1445	98	1479	53
1310	69	1344	87	1378	53	1412	58	1446	90	1480	53
1311	68	1345	94	1379	53	1413	56	1447	83	1481	53
1312	66	1346	98	1380	54	1414	55	1448	78	1482	53
1313	63	1347	96	1381	54	1415	55	1449	76	1483	54
1314	60	1348	90	1382	54	1416	55	1450	75	1484	57

Table 28-B

Stripchart for F4, Series II
25.0 cm H2O, 72 dBA, Page 06

STARTING ADDRESS = 1537 ENDING ADDRESS = 1737
STEP = 1 DATA RATE = 17280

SIX COLUMNS: POINT NUMBER VALUE

1537	73	1571	90	1605	71	1639	68	1673	85	1707	79
1538	72	1572	88	1606	72	1640	68	1674	84	1708	82
1539	72	1573	87	1607	73	1641	68	1675	82	1709	83
1540	71	1574	85	1608	74	1642	68	1676	80	1710	85
1541	71	1575	83	1609	75	1643	68	1677	79	1711	87
1542	71	1576	81	1610	77	1644	68	1678	77	1712	89
1543	71	1577	80	1611	78	1645	69	1679	76	1713	90
1544	71	1578	78	1612	80	1646	69	1680	75	1714	91
1545	71	1579	77	1613	82	1647	69	1681	75	1715	91
1546	71	1580	75	1614	84	1648	70	1682	74	1716	92
1547	71	1581	74	1615	85	1649	70	1683	74	1717	91
1548	71	1582	73	1616	86	1650	71	1684	73	1718	90
1549	71	1583	72	1617	87	1651	71	1685	73	1719	88
1550	72	1584	71	1618	87	1652	72	1686	72	1720	87
1551	72	1585	71	1619	87	1653	73	1687	72	1721	85
1552	73	1586	70	1620	87	1654	74	1688	71	1722	83
1553	73	1587	69	1621	86	1655	75	1689	71	1723	81
1554	74	1588	69	1622	84	1656	76	1690	71	1724	79
1555	74	1589	68	1623	82	1657	77	1691	71	1725	77
1556	75	1590	68	1624	80	1658	79	1692	71	1726	76
1557	75	1591	69	1625	78	1659	81	1693	71	1727	75
1558	77	1592	67	1626	77	1660	83	1694	71	1728	73
1559	78	1593	68	1627	76	1661	85	1695	71	1729	72
1560	79	1594	67	1628	75	1662	87	1696	72	1730	72
1561	81	1595	67	1629	74	1663	89	1697	72	1731	71
1562	83	1596	68	1630	72	1664	91	1698	73	1732	71
1563	85	1597	68	1631	72	1665	92	1699	73	1733	70
1564	87	1598	68	1632	71	1666	93	1700	73	1734	69
1565	88	1599	68	1633	70	1667	93	1701	74	1735	69
1566	89	1600	69	1634	63	1668	93	1702	75	1736	68
1567	91	1601	69	1635	69	1669	92	1703	75	1737	68
1568	91	1602	69	1636	69	1670	91	1704	77	1738	68
1569	91	1603	70	1637	69	1671	89	1705	77	1739	68
1570	91	1604	71	1638	68	1672	87	1706	79	1740	68

Table 29-B

Stripchart for F4, Series II
26.0 cm H2O, 85 dBA, Page 07

STARTING ADDRESS = 1793 ENDING ADDRESS = 1993
STEP = 1 DATA RATE = 17280

SIX COLUMNS: POINT NUMBER VALUE

1793	88	1827	117	1861	55	1895	67	1929	244	1963	61
1794	82	1828	143	1862	55	1896	65	1930	240	1964	63
1795	77	1829	183	1863	57	1897	63	1931	224	1965	63
1796	74	1830	215	1864	57	1898	60	1932	196	1966	65
1797	72	1831	231	1865	58	1899	58	1933	176	1967	67
1798	70	1832	236	1866	59	1900	56	1934	152	1968	69
1799	67	1833	228	1867	60	1901	54	1935	132	1969	71
1800	65	1834	208	1868	61	1902	53	1936	120	1970	75
1801	62	1835	184	1869	63	1903	53	1937	108	1971	79
1802	60	1836	160	1870	65	1904	53	1938	98	1972	89
1803	57	1837	140	1871	67	1905	53	1939	90	1973	107
1804	56	1838	128	1872	69	1906	53	1940	84	1974	127
1805	55	1839	114	1873	72	1907	54	1941	78	1975	175
1806	55	1840	104	1874	79	1908	54	1942	75	1976	207
1807	55	1841	96	1875	93	1909	55	1943	72	1977	235
1808	56	1842	86	1876	115	1910	55	1944	70	1978	241
1809	56	1843	80	1877	143	1911	56	1945	68	1979	232
1810	57	1844	76	1878	183	1912	57	1946	66	1980	212
1811	57	1845	72	1879	213	1913	58	1947	63	1981	192
1812	57	1846	70	1880	227	1914	59	1948	60	1982	164
1813	58	1847	67	1881	226	1915	60	1949	58	1983	146
1814	59	1848	65	1882	212	1916	62	1950	56	1984	130
1815	60	1849	62	1883	192	1917	63	1951	55	1985	117
1816	61	1850	60	1884	168	1918	65	1952	55	1986	106
1817	62	1851	57	1885	146	1919	67	1953	55	1987	97
1818	63	1852	55	1886	128	1920	69	1954	55	1988	88
1819	65	1853	54	1887	116	1921	71	1955	56	1989	81
1820	66	1854	53	1888	106	1922	76	1956	56	1990	76
1821	68	1855	53	1889	96	1923	85	1957	57	1991	73
1822	70	1856	53	1890	88	1924	103	1958	57	1992	70
1823	71	1857	54	1891	81	1925	127	1959	58	1993	68
1824	75	1858	54	1892	77	1926	159	1960	59	1994	66
1825	81	1859	54	1893	72	1927	199	1961	59	1995	63
1826	95	1860	55	1894	69	1928	231	1962	60	1996	60

Table 30-B

Stripchart for F4, Series II
27.0 cm H2O, 90 dBA, Page 08

```
STARTING ADDRESS = 2049  ENDING ADDRESS = 2249
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

    ---------      ---------      ---------      ---------      ---------      ---------
    2049    61     2083    56     2117   144     2151    70     2185    58     2219   100
    2050    62     2084    55     2118   128     2152    71     2186    58     2220    93
    2051    65     2085    55     2119   118     2153    75     2187    58     2221    86
    2052    67     2086    55     2120   109     2154    78     2188    58     2222    81
    2053    69     2087    55     2121   102     2155    87     2189    58     2223    77
    2054    71     2088    55     2122    96     2156   111     2190    59     2224    74
    2055    73     2089    55     2123    88     2157   159     2191    60     2225    70
    2056    76     2090    55     2124    82     2158   223     2192    60     2226    68
    2057    83     2091    55     2125    78     2159   255     2193    61     2227    64
    2058    95     2092    55     2126    74     2160   255     2194    61     2228    60
    2059   127     2093    56     2127    72     2161   255     2195    61     2229    57
    2060   191     2094    57     2128    69     2162   240     2196    62     2230    55
    2061   247     2095    57     2129    65     2163   216     2197    63     2231    55
    2062   255     2096    57     2130    61     2164   192     2198    66     2232    55
    2063   255     2097    58     2131    58     2165   164     2199    69     2233    55
    2064   248     2098    59     2132    56     2166   146     2200    71     2234    55
    2065   224     2099    59     2133    55     2167   132     2201    73     2235    55
    2066   200     2100    62     2134    55     2168   122     2202    75     2236    55
    2067   176     2101    63     2135    55     2169   114     2203    79     2237    55
    2068   156     2102    67     2136    56     2170   108     2204    91     2238    55
    2069   138     2103    68     2137    56     2171   100     2205   119     2239    55
    2070   128     2104    70     2138    55     2172    92     2206   175     2240    57
    2071   117     2105    73     2139    56     2173    86     2207   223     2241    57
    2072   109     2106    79     2140    56     2174    81     2208   255     2242    57
    2073   102     2107    95     2141    57     2175    78     2209   255     2243    57
    2074    94     2108   143     2142    58     2176    75     2210   252     2244    58
    2075    86     2109   191     2143    59     2177    72     2211   232     2245    59
    2076    80     2110   239     2144    59     2178    68     2212   208     2246    61
    2077    76     2111   255     2145    59     2179    64     2213   180     2247    63
    2078    73     2112   252     2146    60     2180    60     2214   160     2248    66
    2079    70     2113   234     2147    61     2181    58     2215   140     2249    68
    2080    66     2114   212     2148    63     2182    58     2216   128     2250    70
    2081    64     2115   192     2149    65     2183    58     2217   115     2251    73
    2082    59     2116   164     2150    67     2184    58     2218   107     2252    77
```

Table 31-B

Stripcharts for F4, Series IV
Pages 02, 03

15.5 cm H20

```
STARTING ADDRESS = 512  ENDING ADDRESS = 612
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------     ---------     ---------     ---------     ---------     ---------
    512    163    529    163    546    160    563    157    580    154    597    153
    513    163    530    163    547    160    564    157    581    154    598    153
    514    163    531    162    548    159    565    156    582    154    599    153
    515    164    532    162    549    159    566    156    583    154    600    153
    516    164    533    163    550    159    567    156    584    154    601    154
    517    164    534    162    551    159    568    155    585    154    602    154
    518    164    535    162    552    159    569    155    586    154    603    154
    519    164    536    162    553    159    570    154    587    154    604    154
    520    164    537    162    554    158    571    155    588    154    605    154
    521    164    538    162    555    158    572    155    589    154    606    154
    522    164    539    161    556    158    573    155    590    154    607    154
    523    164    540    161    557    158    574    155    591    154    608    154
    524    163    541    161    558    158    575    155    592    153    609    154
    525    163    542    161    559    158    576    155    593    153    610    154
    526    163    543    161    560    157    577    155    594    153    611    155
    527    163    544    160    561    157    578    154    595    153    612    155
    528    163    545    160    562    157    579    154    596    153    613    155
```

18.0 cm H20

```
STARTING ADDRESS = 769  ENDING ADDRESS = 869
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------     ---------     ---------     ---------     ---------     ---------
    769    135    786    133    803    132    820    133    837    136    854    140
    770    135    787    133    804    132    821    133    838    137    855    140
    771    135    788    132    805    132    822    133    839    137    856    140
    772    135    789    132    806    132    823    133    840    137    857    140
    773    135    790    132    807    132    824    133    841    137    858    140
    774    134    791    132    808    132    825    134    842    137    859    140
    775    134    792    132    809    133    826    134    843    138    860    140
    776    134    793    132    810    132    827    134    844    138    861    141
    777    134    794    132    811    133    828    135    845    138    862    141
    778    135    795    132    812    133    829    135    846    138    863    140
    779    134    796    132    813    133    830    135    847    139    864    141
    780    133    797    132    814    133    831    135    848    140    865    141
    781    133    798    132    815    132    832    135    849    139    866    141
    782    133    799    132    816    133    833    135    850    139    867    141
    783    133    800    132    817    133    834    135    851    139    868    141
    784    133    801    132    818    133    835    135    852    139    869    141
    785    133    802    132    819    133    836    136    853    140    870    141
```

Table 32-B

Stripcharts for F4, Series IV
Pages 04, 05

20.0 cm H20

STARTING ADDRESS = 1025 ENDING ADDRESS = 1125
STEP = 1 DATA RATE = 6983

SIX COLUMNS: POINT NUMBER VALUE

1025	115	1042	113	1059	112	1076	109	1093	108	1110	109
1026	116	1043	114	1060	112	1077	109	1094	108	1111	108
1027	115	1044	113	1061	111	1078	109	1095	108	1112	109
1028	115	1045	114	1062	111	1079	109	1096	109	1113	108
1029	115	1046	114	1063	111	1080	108	1097	109	1114	109
1030	115	1047	114	1064	111	1081	108	1098	109	1115	109
1031	115	1048	114	1065	110	1082	108	1099	109	1116	109
1032	115	1049	113	1066	110	1083	108	1100	109	1117	109
1033	115	1050	113	1067	110	1084	108	1101	108	1118	109
1034	114	1051	112	1068	110	1085	108	1102	108	1119	110
1035	114	1052	113	1069	110	1086	108	1103	109	1120	110
1036	115	1053	112	1070	110	1087	108	1104	108	1121	110
1037	115	1054	112	1071	110	1088	108	1105	108	1122	110
1038	114	1055	112	1072	110	1089	108	1106	108	1123	111
1039	114	1056	112	1073	110	1090	108	1107	109	1124	111
1040	114	1057	112	1074	110	1091	108	1108	109	1125	111
1041	114	1058	112	1075	110	1092	108	1109	109	1126	111

22.0 cm H20

STARTING ADDRESS = 1281 ENDING ADDRESS = 1381
STEP = 1 DATA RATE = 6983

SIX COLUMNS: POINT NUMBER VALUE

1281	101	1298	99	1315	97	1332	98	1349	99	1366	102
1282	101	1299	99	1316	97	1333	98	1350	99	1367	102
1283	101	1300	100	1317	97	1334	97	1351	99	1368	102
1284	101	1301	98	1318	97	1335	97	1352	99	1369	102
1285	101	1302	98	1319	97	1336	97	1353	99	1370	102
1286	101	1303	98	1320	97	1337	97	1354	99	1371	103
1287	101	1304	99	1321	97	1338	97	1355	100	1372	103
1288	100	1305	98	1322	97	1339	97	1356	99	1373	103
1289	100	1306	98	1323	98	1340	98	1357	100	1374	103
1290	100	1307	98	1324	97	1341	98	1358	100	1375	103
1291	100	1308	98	1325	97	1342	98	1359	101	1376	103
1292	100	1309	98	1326	97	1343	98	1360	101	1377	103
1293	99	1310	98	1327	97	1344	98	1361	101	1378	103
1294	100	1311	98	1328	97	1345	98	1362	101	1379	103
1295	100	1312	97	1329	97	1346	98	1363	101	1380	103
1296	100	1313	97	1330	98	1347	99	1364	102	1381	103
1297	100	1314	97	1331	98	1348	99	1365	112	1382	103

Table 33-B

Stripcharts for F4, Series IV
Pages 06, 07

24.5 cm H20

```
STARTING ADDRESS = 1537  ENDING ADDRESS = 1637
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

 ---------      ---------      ---------      ---------      ---------      ---------
 1537     77    1554     76    1571     75    1588     73    1605     72    1622     73
 1538     77    1555     76    1572     75    1589     73    1606     72    1623     73
 1539     77    1556     75    1573     74    1590     73    1607     72    1624     73
 1540     77    1557     76    1574     74    1591     73    1608     72    1625     73
 1541     77    1558     76    1575     74    1592     72    1609     72    1626     73
 1542     77    1559     76    1576     74    1593     72    1610     72    1627     73
 1543     77    1560     76    1577     74    1594     72    1611     72    1628     73
 1544     77    1561     76    1578     74    1595     71    1612     73    1629     74
 1545     77    1562     76    1579     74    1596     72    1613     73    1630     74
 1546     77    1563     76    1580     74    1597     72    1614     73    1631     74
 1547     77    1564     76    1581     74    1598     71    1615     73    1632     74
 1548     77    1565     75    1582     74    1599     71    1616     73    1633     74
 1549     76    1566     75    1583     74    1600     71    1617     73    1634     74
 1550     76    1567     75    1584     74    1601     71    1618     73    1635     74
 1551     76    1568     75    1585     74    1602     72    1619     73    1636     74
 1552     76    1569     75    1586     73    1603     72    1620     73    1637     74
 1553     75    1570     75    1587     73    1604     72    1621     73    1638     75
```

27.0 cm H20

```
STARTING ADDRESS = 1793  ENDING ADDRESS = 1893
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

 ---------      ---------      ---------      ---------      ---------      ---------
 1793     52    1810     52    1827     51    1844     50    1861     50    1878     49
 1794     52    1811     52    1828     51    1845     50    1862     50    1879     49
 1795     52    1812     52    1829     51    1846     50    1863     50    1880     49
 1796     52    1813     53    1830     50    1847     50    1864     50    1881     50
 1797     52    1814     52    1831     50    1848     50    1865     50    1882     49
 1798     52    1815     53    1832     51    1849     50    1866     50    1883     50
 1799     52    1816     53    1833     50    1850     50    1867     50    1884     50
 1800     53    1817     52    1834     50    1851     50    1868     49    1885     49
 1801     53    1818     52    1835     50    1852     50    1869     49    1886     49
 1802     53    1819     52    1836     50    1853     50    1870     49    1887     50
 1803     52    1820     52    1837     50    1854     50    1871     50    1888     49
 1804     52    1821     52    1838     50    1855     50    1872     50    1889     50
 1805     52    1822     51    1839     50    1856     49    1873     49    1890     50
 1806     52    1823     51    1840     50    1857     50    1874     49    1891     50
 1807     52    1824     51    1841     50    1858     49    1875     49    1892     49
 1808     53    1825     51    1842     49    1859     50    1876     49    1893     50
 1809     52    1826     51    1843     50    1860     50    1877     49    1894     50
```

Table 34-B

Stripcharts for F4, Series IV
Pages 08, 09

29.5 cm H20

```
STARTING ADDRESS = 2049  ENDING ADDRESS = 2149
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------      ---------      ---------      ---------      ---------      ---------
 2049     33    2066     33    2083     31    2100     31    2117     30    2134     31
 2050     34    2067     32    2084     31    2101     31    2118     30    2135     31
 2051     34    2068     33    2085     31    2102     31    2119     30    2136     31
 2052     34    2069     32    2086     31    2103     31    2120     30    2137     31
 2053     34    2070     32    2087     31    2104     31    2121     31    2138     31
 2054     33    2071     32    2088     31    2105     31    2122     31    2139     31
 2055     33    2072     32    2089     31    2106     31    2123     31    2140     31
 2056     33    2073     32    2090     31    2107     31    2124     30    2141     31
 2057     33    2074     32    2091     31    2108     31    2125     31    2142     31
 2058     33    2075     32    2092     31    2109     30    2126     31    2143     31
 2059     32    2076     32    2093     31    2110     30    2127     31    2144     31
 2060     32    2077     32    2094     31    2111     31    2128     31    2145     32
 2061     32    2078     31    2095     31    2112     31    2129     31    2146     32
 2062     32    2079     31    2096     31    2113     31    2130     31    2147     32
 2063     33    2080     31    2097     31    2114     31    2131     31    2148     32
 2064     33    2081     31    2098     31    2115     31    2132     31    2149     31
 2065     33    2082     31    2099     31    2116     30    2133     31    2150     32
```

32.0 cm H20

```
STARTING ADDRESS = 2305  ENDING ADDRESS = 2405
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------      ---------      ---------      ---------      ---------      ---------
 2305     19    2322     19    2339     19    2356     20    2373     19    2390     20
 2306     19    2323     18    2340     20    2357     19    2374     19    2391     20
 2307     18    2324     18    2341     20    2358     19    2375     19    2392     20
 2308     18    2325     18    2342     19    2359     19    2376     19    2393     20
 2309     18    2326     18    2343     19    2360     19    2377     19    2394     20
 2310     18    2327     18    2344     19    2361     19    2378     19    2395     20
 2311     18    2328     18    2345     20    2362     19    2379     19    2396     20
 2312     18    2329     18    2346     20    2363     19    2380     19    2397     20
 2313     18    2330     18    2347     20    2364     19    2381     19    2398     20
 2314     18    2331     19    2348     19    2365     19    2382     19    2399     19
 2315     18    2332     19    2349     19    2366     19    2383     19    2400     19
 2316     18    2333     19    2350     19    2367     19    2384     19    2401     19
 2317     18    2334     19    2351     19    2368     19    2385     19    2402     19
 2318     18    2335     19    2352     19    2369     19    2386     19    2403     20
 2319     18    2336     19    2353     19    2370     19    2387     20    2404     19
 2320     18    2337     19    2354     20    2371     19    2388     20    2405     19
 2321     18    2338     19    2355     20    2372     19    2389     20    2406     19
```

Table 35-B

Stripcharts for F4, Series IV
Pages 10, 11

32.5 cm H20

```
STARTING ADDRESS = 2561  ENDING ADDRESS = 2661
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------       ---------       ---------       ---------       ---------       ---------
   2561     29     2578     14     2595      5     2612     34     2629      9     2646      5
   2562     34     2579     11     2596      5     2613     37     2630      7     2647      5
   2563     38     2580      9     2597      5     2614     38     2631      6     2648      5
   2564     39     2581      7     2598      5     2615     38     2632      5     2649      5
   2565     40     2582      6     2599      5     2616     37     2633      5     2650      5
   2566     40     2583      5     2600      5     2617     36     2634      5     2651      5
   2567     38     2584      5     2601      5     2618     34     2635      5     2652      5
   2568     37     2585      5     2602      5     2619     32     2636      5     2653      6
   2569     35     2586      5     2603      6     2620     30     2637      5     2654      7
   2570     34     2587      5     2604      6     2621     28     2638      5     2655      8
   2571     32     2588      5     2605      7     2622     26     2639      5     2656     11
   2572     30     2589      5     2606      9     2623     24     2640      5     2657     15
   2573     28     2590      5     2607     11     2624     22     2641      5     2658     19
   2574     26     2591      5     2608     15     2625     20     2642      5     2659     25
   2575     24     2592      5     2609     21     2626     17     2643      5     2660     30
   2576     21     2593      5     2610     25     2627     14     2644      5     2661     35
   2577     18     2594      5     2611     30     2628     11     2645      5     2662     37
```

34.0 cm H20

```
STARTING ADDRESS = 2817  ENDING ADDRESS = 2917
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------       ---------       ---------       ---------       ---------       ---------
   2817     18     2834      4     2851     10     2868     15     2885      4     2902     13
   2818     17     2835      4     2852     11     2869     13     2886      4     2903     15
   2819     16     2836      4     2853     13     2870     12     2887      4     2904     16
   2820     14     2837      4     2854     15     2871     10     2888      4     2905     18
   2821     12     2838      4     2855     17     2872      9     2889      4     2906     19
   2822     11     2839      4     2856     18     2873      8     2890      4     2907     20
   2823     10     2840      4     2857     20     2874      7     2891      4     2908     21
   2824      8     2841      4     2858     21     2875      6     2892      4     2909     21
   2825      7     2842      4     2859     21     2876      5     2893      5     2910     22
   2826      6     2843      5     2860     21     2877      5     2894      5     2911     21
   2827      6     2844      5     2861     21     2878      5     2895      5     2912     21
   2828      5     2845      5     2862     21     2879      4     2896      6     2913     20
   2829      5     2846      6     2863     20     2880      4     2897      6     2914     19
   2830      4     2847      6     2864     19     2881      4     2898      7     2915     18
   2831      4     2848      7     2865     19     2882      4     2899      8     2916     17
   2832      4     2849      7     2866     17     2883      4     2900      9     2917     15
   2833      4     2850      9     2867     16     2884      4     2901     11     2918     14
```

Table 36-B

Stripcharts for F4, Series IV
Pages 00, 01

36.0 cm H20

```
STARTING ADDRESS = 0  ENDING ADDRESS = 100
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------    ---------    ---------    ---------    ---------    ---------
     0     3      17    43     34     3     51     5     68    41     85     3
     1     4      18    43     35     3     52     7     69    40     86     3
     2     5      19    42     36     3     53    14     70    37     87     3
     3     9      20    40     37     3     54    25     71    32     88     3
     4    19      21    36     38     3     55    35     72    26     89     3
     5    31      22    32     39     3     56    43     73    20     90     3
     6    41      23    24     40     3     57    49     74    12     91     3
     7    49      24    16     41     3     58    51     75     7     92     3
     8    53      25    10     42     3     59    50     76     4     93     3
     9    53      26     6     43     3     60    48     77     3     94     3
    10    51      27     4     44     3     61    45     78     3     95     3
    11    49      28     3     45     3     62    43     79     3     96     3
    12    46      29     3     46     3     63    42     80     3     97     3
    13    44      30     3     47     3     64    42     81     3     98     3
    14    44      31     3     48     3     65    42     82     3     99     3
    15    43      32     3     49     3     66    42     83     3    100     4
    16    43      33     3     50     3     67    42     84     3    101     5
```

34.5 cm H20

```
STARTING ADDRESS = 257  ENDING ADDRESS = 357
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------    ---------    ---------    ---------    ---------    ---------
   257    80     274     5    291    91    308    72    325     5    342   109
   258    72     275     5    292   106    309    56    326     5    343   109
   259    64     276     5    293   110    310    40    327     5    344   104
   260    48     277     5    294   108    311    20    328     5    345    97
   261    32     278     5    295   102    312     9    329     5    346    92
   262    13     279     5    296    96    313     6    330     5    347    87
   263     7     280     5    297    91    314     6    331     5    348    85
   264     5     281     5    298    88    315     5    332     5    349    85
   265     5     282     5    299    87    316     5    333     6    350    87
   266     5     283     5    300    87    317     5    334     6    351    89
   267     5     284     5    301    89    318     5    335     6    352    90
   268     5     285     5    302    91    319     5    336     7    353    91
   269     5     286     6    303    92    320     5    337    11    354    90
   270     5     287     7    304    93    321     5    338    27    355    88
   271     5     288    15    305    91    322     5    339    59    356    82
   272     5     289    39    306    88    323     5    340    83    357    74
   273     5     290    71    307    81    324     5    341    99    358    64
```

Table 37-B

Stripchart for F4, Series V
36.0 cm H2O, Gain = 100, Page 09
Transient Containing Reed´s Natural Frequency

```
STARTING ADDRESS = 2305  ENDING ADDRESS = 2560
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------     ---------     ---------     ---------     ---------     ---------
   2305   131    2348   137    2391   131    2434   131    2477   129    2520   126
   2306   130    2349   137    2392   131    2435   134    2478   131    2521   131
   2307   135    2350   133    2393   137    2436   132    2479   133    2522   131
   2308   136    2351   128    2394   130    2437   131    2480   130    2523   129
   2309   132    2352   127    2395   132    2438   132    2481   128    2524   127
   2310   131    2353   127    2396   135    2439   130    2482   127    2525   127
   2311   135    2354   131    2397   128    2440   131    2483   131    2526   136
   2312   133    2355   135    2398   126    2441   132    2484   135    2527   129
   2313   131    2356   139    2399   131    2442   135    2485   135    2528   122
   2314   133    2357   136    2400   135    2443   132    2486   132    2529   126
   2315   134    2358   134    2401   133    2444   125    2487   130    2530   131
   2316   133    2359   131    2402   130    2445   133    2488   129    2531   132
   2317   133    2360   125    2403   131    2446   135    2489   127    2532   129
   2318   133    2361   125    2404   130    2447   131    2490   131    2533   131
   2319   135    2362   131    2405   127    2448   133    2491   132    2534   131
   2320   136    2363   137    2406   131    2449   130    2492   132    2535   131
   2321   133    2364   136    2407   135    2450   125    2493   134    2536   128
   2322   129    2365   133    2408   131    2451   127    2494   133    2537   115
   2323   130    2366   131    2409   130    2452   133    2495   131    2538   126
   2324   133    2367   127    2410   131    2453   131    2496   129    2539   131
   2325   138    2368   133    2411   131    2454   133    2497   131    2540   131
   2326   134    2369   134    2412   135    2455   133    2498   129    2541   127
   2327   131    2370   135    2413   135    2456   133    2499   131    2542   127
   2328   131    2371   133    2414   128    2457   130    2500   135    2543   130
   2329   131    2372   131    2415   126    2458   126    2501   133    2544   128
   2330   133    2373   131    2416   133    2459   127    2502   129    2545   127
   2331   133    2374   133    2417   132    2460   128    2503   127    2546   134
   2332   132    2375   129    2418   131    2461   130    2504   131    2547   134
   2333   131    2376   127    2419   135    2462   132    2505   131    2548   130
   2334   134    2377   134    2420   132    2463   130    2506   131    2549   126
   2335   133    2378   139    2421   131    2464   129    2507   132    2550   125
   2336   135    2379   136    2422   131    2465   132    2508   128    2551   127
   2337   135    2380   128    2423   132    2466   129    2509   127    2552   129
   2338   128    2381   131    2424   129    2467   127    2510   129    2553   131
   2339   130    2382   131    2425   131    2468   127    2511   127    2554   135
   2340   135    2383   131    2426   134    2469   131    2512   131    2555   135
   2341   133    2384   134    2427   133    2470   131    2513   133    2556   131
   2342   130    2385   130    2428   132    2471   131    2514   125    2557   127
   2343   134    2386   131    2429   128    2472   127    2515   123    2558   126
   2344   132    2387   135    2430   127    2473   131    2516   127    2559   122
   2345   130    2388   132    2431   135    2474   133    2517   135    2560     0
   2346   131    2389   131    2432   135    2475   130    2518   129    2561     0
   2347   133    2390   135    2433   128    2476   130    2519   122    2562     0
```

Table 38-B

Stripchart for F4, Series V
37.0 cm H20, Gain = 1.0, Page 04
Reed's Natural Frequency

```
STARTING ADDRESS = 1025  ENDING ADDRESS = 1280
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------      ---------      ---------      ---------      ---------      ---------
  1025   127     1068   132     1111   133     1154   136     1197   128     1240   127
  1026   135     1069   132     1112   133     1155   128     1198   124     1241   135
  1027   133     1070   134     1113   132     1156   119     1199   127     1242   134
  1028   133     1071   136     1114   128     1157   125     1200   131     1243   133
  1029   133     1072   130     1115   124     1158   134     1201   132     1244   133
  1030   132     1073   120     1116   126     1159   134     1202   133     1245   132
  1031   129     1074   123     1117   130     1160   133     1203   135     1246   130
  1032   125     1075   133     1118   132     1161   133     1204   134     1247   126
  1033   125     1076   135     1119   133     1162   133     1205   128     1248   125
  1034   129     1077   133     1120   135     1163   131     1206   119     1249   127
  1035   132     1078   133     1121   135     1164   128     1207   127     1250   131
  1036   132     1079   133     1122   128     1165   125     1208   135     1251   132
  1037   135     1080   131     1123   119     1166   127     1209   134     1252   133
  1038   135     1081   128     1124   127     1167   131     1210   133     1253   136
  1039   129     1082   124     1125   135     1168   132     1211   133     1254   132
  1040   119     1083   127     1126   134     1169   133     1212   132     1255   120
  1041   125     1084   131     1127   133     1170   135     1213   129     1256   122
  1042   133     1085   132     1128   133     1171   134     1214   125     1257   131
  1043   134     1086   133     1129   133     1172   122     1215   125     1258   135
  1044   133     1087   135     1130   130     1173   121     1216   127     1259   131
  1045   133     1088   135     1131   126     1174   127     1217   132     1260   133
  1046   133     1089   128     1132   125     1175   135     1218   132     1261   133
  1047   131     1090   119     1133   127     1176   133     1219   134     1262   132
  1048   128     1091   127     1134   131     1177   133     1220   136     1263   128
  1049   124     1092   135     1135   132     1178   133     1221   132     1264   125
  1050   127     1093   134     1136   133     1179   132     1222   120     1265   125
  1051   131     1094   133     1137   136     1180   129     1223   123     1266   130
  1052   132     1095   133     1138   133     1181   125     1224   133     1267   132
  1053   133     1096   132     1139   121     1182   125     1225   135     1268   133
  1054   135     1097   130     1140   121     1183   129     1226   133     1269   135
  1055   134     1098   126     1141   131     1184   132     1227   133     1270   135
  1056   128     1099   125     1142   135     1185   132     1228   133     1271   128
  1057   121     1100   127     1143   133     1186   135     1229   131     1272   119
  1058   127     1101   132     1144   133     1187   136     1230   128     1273   125
  1059   135     1102   132     1145   133     1188   130     1231   125     1274   134
  1060   133     1103   134     1146   132     1189   120     1232   126     1275   134
  1061   133     1104   136     1147   128     1190   123     1233   131     1276   133
  1062   133     1105   132     1148   125     1191   133     1234   132     1277   133
  1063   132     1106   120     1149   125     1192   135     1235   133     1278   133
  1064   129     1107   123     1150   130     1193   133     1236   135     1279   130
  1065   125     1108   131     1151   132     1194   133     1237   135     1280   125
  1066   125     1109   135     1152   132     1195   133     1238   128     1281   127
  1067   127     1110   133     1153   135     1196   131     1239   119     1282   126
```

Table 39-B

Stripchart for F4, Series V
37.0 cm H20, Gain = 100, Page 03
Transient Containing Steady State

STARTING ADDRESS = 769 ENDING ADDRESS = 1024
STEP = 1 DATA RATE = 6983

SIX COLUMNS: POINT NUMBER VALUE

769	129	812	129	855	135	898	135	941	130	984	133
770	131	813	127	856	134	899	135	942	125	985	133
771	130	814	133	857	130	900	135	943	127	986	132
772	129	815	133	858	130	901	132	944	135	987	129
773	129	816	130	859	131	902	129	945	136	988	129
774	129	817	127	860	133	903	131	946	135	989	126
775	131	818	126	861	133	904	131	947	137	990	127
776	130	819	127	862	132	905	133	948	129	991	143
777	126	820	132	863	135	906	135	949	127	992	136
778	125	821	129	864	132	907	134	950	130	993	125
779	133	822	127	865	129	908	132	951	131	994	131
780	132	823	127	866	131	909	135	952	133	995	133
781	127	824	127	867	132	910	134	953	135	996	131
782	131	825	129	868	129	911	133	954	137	997	133
783	135	826	127	869	127	912	132	955	136	998	135
784	132	827	131	870	129	913	129	956	132	999	132
785	129	828	129	871	125	914	133	957	128	1000	135
786	125	829	127	872	127	915	133	958	127	1001	133
787	127	830	129	873	131	916	131	959	133	1002	125
788	130	831	130	874	111	917	129	960	137	1003	131
789	130	832	127	875	131	918	127	961	136	1004	133
790	131	833	127	876	126	919	133	962	133	1005	135
791	134	834	131	877	125	920	133	963	130	1006	133
792	135	835	129	878	127	921	130	964	125	1007	132
793	133	836	131	879	130	922	128	965	127	1008	131
794	131	837	132	880	124	923	129	966	135	1009	131
795	130	838	131	881	127	924	129	967	137	1010	132
796	133	839	129	882	131	925	127	968	136	1011	132
797	130	840	127	883	129	926	129	969	133	1012	133
798	127	841	131	884	127	927	127	970	128	1013	134
799	134	842	132	885	131	928	127	971	127	1014	134
800	135	843	133	886	130	929	131	972	126	1015	131
801	135	844	133	887	127	930	132	973	127	1016	127
802	132	845	131	888	133	931	129	974	133	1017	130
803	131	846	130	889	132	932	127	975	135	1018	160
804	135	847	133	890	128	933	131	976	135	1019	127
805	136	848	135	891	127	934	131	977	135	1020	131
806	131	849	132	892	133	935	128	978	131	1021	133
807	131	850	129	893	132	936	127	979	127	1022	132
808	133	851	133	894	130	937	127	980	124	1023	130
809	125	852	137	895	130	938	133	981	127	1024	121
810	127	853	134	896	130	939	134	982	133	1025	127
811	138	854	132	897	134	940	132	983	130	1026	135

Table 40-B

Stripchart for F3 High-Intensity Closure
36.5 cm H20, 98 dBA, Gain = 3.3
F3 Tl 00

```
STARTING ADDRESS = 80  ENDING ADDRESS = 280
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

 ---------    ---------    ---------    ---------    ---------    ---------
  80  164     114    2     148  195     182  142     216    2     250  198
  81  162     115    2     149  200     183  130     217    2     251  196
  82  158     116    2     150  199     184  112     218    2     252  197
  83  153     117    2     151  194     185   88     219    2     253  198
  84  146     118    2     152  190     186   52     220    2     254  199
  85  132     119    2     153  189     187   16     221    2     255  200
  86  112     120    2     154  190     188    3     222    2     256   23
  87   84     121    2     155  191     189    2     223    2     257   43
  88   48     122    2     156  191     190    2     224    2     258   63
  89   12     123    2     157  193     191    2     225    3     259   91
  90    3     124    2     158  195     192    2     226    2     260  119
  91    2     125    2     159  194     193    2     227    2     261  151
  92    2     126    3     160  190     194    2     228    2     262  175
  93    2     127    2     161  186     195    2     229    2     263  191
  94    2     128    2     162  182     196    2     230    2     264  207
  95    2     129    2     163  180     197    2     231    2     265  212
  96    2     130    2     164  183     198    2     232    2     266  210
  97    2     131    2     165  189     199    2     233    2     267  208
  98    2     132    2     166  195     200    2     234    3     268  207
  99    2     133    2     167  198     201    2     235    4     269  209
 100    2     134    2     168  194     202    2     236   15     270  213
 101    2     135    2     169  184     203    2     237   55     271  215
 102    2     136    3     170  172     204    2     238  103     272  214
 103    2     137    5     171  161     205    2     239  151     273  211
 104    2     138   23     172  154     206    2     240  183     274  208
 105    2     139   63     173  149     207    2     241  203     275  207
 106    2     140  111     174  147     208    2     242  200     276  209
 107    2     141  155     175  149     209    2     243  188     277  212
 108    2     142  187     176  153     210    2     244  183     278  214
 109    2     143  201     177  157     211    2     245  191     279  214
 110    2     144  196     178  158     212    2     246  199     280  212
 111    2     145  184     179  157     213    2     247  206     281  210
 112    2     146  181     180  154     214    2     248  206     282  209
 113    2     147  187     181  148     215    2     249  202     283  208
```

Table 41-B

Stripchart for F3 High-Intensity Closure
27.5 cm H20, 90 dBA, Gain = 3.3
F3 Tl 09

```
STARTING ADDRESS = 2305  ENDING ADDRESS = 2505
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------     ---------     ---------     ---------     ---------     ---------
   2305   119    2339    11    2373    10    2407   114    2441    10    2475    11
   2306   119    2340    11    2374    10    2408   113    2442    10    2476    11
   2307   119    2341    11    2375    10    2409   114    2443    10    2477    11
   2308   119    2342    11    2376    10    2410   115    2444    10    2478    12
   2309   119    2343    10    2377    10    2411   116    2445    10    2479    12
   2310   119    2344    10    2378    11    2412   115    2446    10    2480    13
   2311   119    2345    10    2379    11    2413   112    2447    10    2481    18
   2312   121    2346    10    2380    11    2414   104    2448    10    2482    31
   2313   121    2347    10    2381    12    2415    96    2449    10    2483    47
   2314   121    2348    10    2382    13    2416    90    2450    10    2484    71
   2315   117    2349    10    2383    15    2417    84    2451    10    2485    87
   2316   112    2350    10    2384    27    2418    80    2452    10    2486    99
   2317   104    2351    10    2385    43    2419    79    2453    10    2487   105
   2318    96    2352    10    2386    63    2420    77    2454    10    2488   107
   2319    89    2353    10    2387    83    2421    79    2455    10    2489   108
   2320    85    2354    10    2388    94    2422    78    2456    10    2490   110
   2321    83    2355    10    2389    99    2423    77    2457    10    2491   113
   2322    82    2356    10    2390   102    2424    74    2458    10    2492   114
   2323    82    2357    10    2391   103    2425    67    2459    10    2493   114
   2324    82    2358    10    2392   105    2426    58    2460    10    2494   112
   2325    81    2359    10    2393   107    2427    48    2461    10    2495   111
   2326    78    2360    10    2394   109    2428    32    2462    10    2496   113
   2327    72    2361    10    2395   110    2429    20    2463    10    2497   115
   2328    64    2362    10    2396   108    2430    14    2464    10    2498   117
   2329    50    2363    10    2397   107    2431    12    2465    10    2499   119
   2330    36    2364    10    2398   107    2432    11    2466    10    2500   119
   2331    24    2365    10    2399   109    2433    11    2467    11    2501   119
   2332    16    2366    10    2400   111    2434    10    2468    11    2502   119
   2333    13    2367    10    2401   113    2435    10    2469    11    2503   119
   2334    12    2368    10    2402   114    2436    10    2470    11    2504   119
   2335    11    2369    10    2403   114    2437    10    2471    11    2505   119
   2336    11    2370    10    2404   114    2438    10    2472    11    2506   118
   2337    11    2371    10    2405   114    2439    10    2473    11    2507   119
   2338    11    2372    10    2406   114    2440    10    2474    11    2508   119
```

Table 42-B

Stripchart for F3 High-Intensity Closure
24.5 cm H20, 100 dBA, Gain = 1.0
F3 T2 00

STARTING ADDRESS = 0 ENDING ADDRESS = 200
STEP = 1 DATA RATE = 6983

SIX COLUMNS: POINT NUMBER VALUE

0	3	34	61	68	58	102	3	136	64	170	36
1	3	35	65	69	54	103	3	137	60	171	20
2	3	36	64	70	48	104	3	138	60	172	8
3	3	37	61	71	36	105	3	139	63	173	4
4	3	38	58	72	24	106	3	140	69	174	3
5	3	39	58	73	8	107	3	141	70	175	3
6	3	40	62	74	4	108	3	142	69	176	3
7	3	41	66	75	3	109	3	143	68	177	3
8	3	42	67	76	3	110	3	144	68	178	3
9	3	43	67	77	3	111	3	145	69	179	3
10	3	44	66	78	3	112	3	146	69	180	3
11	3	45	65	79	3	113	3	147	67	181	3
12	3	46	66	80	3	114	3	148	65	182	3
13	3	47	66	81	3	115	3	149	66	183	3
14	3	48	64	82	3	116	3	150	70	184	3
15	3	49	63	83	3	117	3	151	75	185	3
16	3	50	63	84	3	118	3	152	77	186	3
17	3	51	67	85	3	119	3	153	75	187	3
18	3	52	71	86	3	120	3	154	70	188	3
19	3	53	75	87	3	121	3	155	64	189	3
20	3	54	73	88	3	122	4	156	60	190	3
21	3	55	68	89	3	123	4	157	59	191	3
22	3	56	64	90	3	124	11	158	59	192	3
23	3	57	58	91	3	125	31	159	60	193	3
24	4	58	57	92	3	126	51	160	61	194	3
25	11	59	57	93	3	127	63	161	63	195	3
26	27	60	58	94	3	128	69	162	66	196	3
27	47	61	59	95	3	129	64	163	69	197	3
28	61	62	61	96	3	130	59	164	69	198	3
29	66	63	63	97	3	131	56	165	67	199	3
30	64	64	67	98	3	132	59	166	64	200	3
31	57	65	68	99	3	133	63	167	59	201	3
32	54	66	66	100	3	134	68	168	53	202	3
33	55	67	64	101	3	135	67	169	46	203	3

Table 43-B

Stripchart for F3 High-Intensity Closure
25.5 cm H20, 88 dBA, Gain = 3.3
F3 Tl 05

```
STARTING ADDRESS = 1281  ENDING ADDRESS = 1481
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------     ---------     ---------     ---------     ---------     ---------
  1281   155    1315    13    1349    12    1383   175    1417    11    1451    11
  1282   159    1316    12    1350    12    1384   179    1418    12    1452    12
  1283   165    1317    12    1351    12    1385   181    1419    12    1453    12
  1284   171    1318    12    1352    12    1386   182    1420    12    1454    12
  1285   175    1319    12    1353    12    1387   181    1421    12    1455    12
  1286   179    1320    12    1354    12    1388   181    1422    12    1456    13
  1287   180    1321    12    1355    12    1389   181    1423    12    1457    14
  1288   180    1322    12    1356    12    1390   182    1424    11    1458    18
  1289   180    1323    12    1357    13    1391   183    1425    11    1459    27
  1290   181    1324    12    1358    13    1392   182    1426    11    1460    45
  1291   182    1325    12    1359    15    1393   178    1427    11    1461    63
  1292   183    1326    12    1360    23    1394   172    1428    11    1462    87
  1293   183    1327    12    1361    37    1395   165    1429    11    1463   107
  1294   181    1328    12    1362    55    1396   160    1430    11    1464   125
  1295   176    1329    12    1363    79    1397   154    1431    11    1465   139
  1296   168    1330    12    1364    95    1398   153    1432    11    1466   149
  1297   161    1331    12    1365   118    1399   155    1433    11    1467   153
  1298   156    1332    12    1366   133    1400   159    1434    11    1468   153
  1299   154    1333    12    1367   143    1401   166    1435    11    1469   152
  1300   157    1334    12    1368   151    1402   168    1436    11    1470   149
  1301   163    1335    12    1369   154    1403   166    1437    11    1471   146
  1302   169    1336    12    1370   153    1404   160    1438    11    1472   146
  1303   172    1337    11    1371   149    1405   148    1439    11    1473   147
  1304   172    1338    11    1372   146    1406   134    1440    11    1474   150
  1305   166    1339    11    1373   144    1407   116    1441    11    1475   153
  1306   156    1340    11    1374   144    1408    96    1442    11    1476   156
  1307   144    1341    11    1375   146    1409    74    1443    11    1477   159
  1308   128    1342    11    1376   149    1410    52    1444    11    1478   162
  1309   106    1343    12    1377   151    1411    32    1445    11    1479   167
  1310    84    1344    12    1378   154    1412    17    1446    11    1480   173
  1311    64    1345    12    1379   157    1413    13    1447    11    1481   179
  1312    40    1346    12    1380   159    1414    12    1448    11    1482   184
  1313    24    1347    12    1381   165    1415    12    1449    11    1483   187
  1314    16    1348    12    1382   170    1416    12    1450    11    1484   189
```

Table 44-B

Stripchart for F4 High-Intensity Closure
38.5 cm H20, 100 dBA, Gain = 3.3
F4 Tl 04

```
STARTING ADDRESS = 1025  ENDING ADDRESS = 1225
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------        ---------        ---------        ---------        ---------        ---------
   1025     34      1059     74      1093      5      1127      6      1161     64      1195      5
   1026     20      1060     72      1094      5      1128      5      1162     60      1196      5
   1027     10      1061     69      1095      5      1129      5      1163     57      1197      5
   1028      6      1062     65      1096      5      1130      5      1164     57      1198      5
   1029      5      1063     61      1097      5      1131      5      1165     59      1199      6
   1030      5      1064     58      1098      5      1132      5      1166     61      1200      6
   1031      5      1065     56      1099      5      1133      5      1167     60      1201      9
   1032      5      1066     58      1100      5      1134      5      1168     57      1202     23
   1033      5      1067     61      1101      6      1135      5      1169     54      1203     47
   1034      5      1068     62      1102      7      1136      5      1170     52      1204     63
   1035      5      1069     60      1103     15      1137      5      1171     49      1205     75
   1036      5      1070     57      1104     39      1138      5      1172     42      1206     76
   1037      5      1071     54      1105     59      1139      5      1173     32      1207     74
   1038      5      1072     52      1106     74      1140      5      1174     17      1208     72
   1039      5      1073     48      1107     79      1141      5      1175      8      1209     69
   1040      5      1074     38      1108     77      1142      5      1176      6      1210     65
   1041      5      1075     24      1109     75      1143      5      1177      5      1211     62
   1042      5      1076     12      1110     73      1144      5      1178      5      1212     59
   1043      5      1077      7      1111     69      1145      5      1179      5      1213     57
   1044      5      1078      6      1112     65      1146      5      1180      5      1214     59
   1045      5      1079      5      1113     62      1147      5      1181      5      1215     62
   1046      5      1080      5      1114     59      1148      5      1182      5      1216     62
   1047      5      1081      5      1115     59      1149      5      1183      5      1217     59
   1048      5      1082      5      1116     63      1150      6      1184      5      1218     56
   1049      5      1083      5      1117     65      1151      7      1185      5      1219     54
   1050      5      1084      5      1118     63      1152     11      1186      5      1220     51
   1051      5      1085      5      1119     59      1153     31      1187      5      1221     46
   1052      6      1086      5      1120     56      1154     53      1188      5      1222     36
   1053      7      1087      5      1121     53      1155     69      1189      5      1223     20
   1054     15      1088      5      1122     50      1156     75      1190      5      1224     10
   1055     39      1089      5      1123     42      1157     75      1191      5      1225      6
   1056     61      1090      5      1124     32      1158     74      1192      5      1226      5
   1057     73      1091      5      1125     16      1159     71      1193      5      1227      5
   1058     76      1092      5      1126      8      1160     68      1194      5      1228      5
```

Table 45-B

Stripchart for F4 High-Intensity Closure
34.0 cm H20, 106 dBA, Gain = 3.3
F4 Tl 10

```
STARTING ADDRESS = 2561  ENDING ADDRESS = 2761
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------    ---------    ---------    ---------    ---------    ---------
  2561     6   2595     6   2629    60   2663    13   2697     6   2731    45
  2562     6   2596     6   2630    61   2664    19   2698     6   2732    40
  2563     6   2597     6   2631    58   2665    31   2699     6   2733    36
  2564     7   2598     6   2632    52   2666    46   2700     6   2734    32
  2565    14   2599     6   2633    44   2667    57   2701     6   2735    22
  2566    21   2600     6   2634    39   2668    69   2702     6   2736    16
  2567    31   2601     6   2635    35   2669    79   2703     6   2737     9
  2568    47   2602     6   2636    29   2670    80   2704     6   2738     7
  2569    61   2603     6   2637    21   2671    76   2705     6   2739     6
  2570    73   2604     6   2638    13   2672    68   2706     6   2740     6
  2571    82   2605     6   2639     8   2673    58   2707     6   2741     6
  2572    82   2606     6   2640     6   2674    52   2708     6   2742     6
  2573    78   2607     6   2641     6   2675    50   2709     6   2743     6
  2574    69   2608     6   2642     6   2676    51   2710     6   2744     6
  2575    58   2609     6   2643     6   2677    53   2711     7   2745     6
  2576    53   2610     6   2644     6   2678    57   2712    12   2746     6
  2577    52   2611     6   2645     6   2679    59   2713    19   2747     6
  2578    53   2612     7   2646     6   2680    56   2714    30   2748     6
  2579    55   2613     7   2647     6   2681    49   2715    45   2749     6
  2580    59   2614    14   2648     6   2682    42   2716    59   2750     6
  2581    61   2615    21   2649     6   2683    37   2717    71   2751     6
  2582    58   2616    31   2650     6   2684    34   2718    79   2752     6
  2583    52   2617    47   2651     6   2685    29   2719    82   2753     6
  2584    44   2618    61   2652     6   2686    21   2720    78   2754     6
  2585    40   2619    74   2653     6   2687    13   2721    70   2755     6
  2586    36   2620    83   2654     6   2688     8   2722    60   2756     6
  2587    30   2621    84   2655     6   2689     7   2723    54   2757     6
  2588    21   2622    80   2656     6   2690     6   2724    53   2758     6
  2589    13   2623    72   2657     6   2691     6   2725    53   2759     7
  2590     8   2624    60   2658     6   2692     6   2726    56   2760     7
  2591     6   2625    54   2659     6   2693     6   2727    61   2761    12
  2592     6   2626    53   2660     6   2694     6   2728    62   2762    19
  2593     6   2627    53   2661     6   2695     6   2729    59   2763    29
  2594     6   2628    55   2662     7   2696     6   2730    52   2764    45
```

Table 46-B

Stripchart for F4 High-Intensity Closure
28.0 cm H20, 93 dBA, Gain = 33
F4 T2 04

```
STARTING ADDRESS = 1025  ENDING ADDRESS = 1225
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

     ---------       ---------       ---------       ---------       ---------       ---------
     1025     53     1059     71     1093     57     1127     53     1161     71     1195     77
     1026     53     1060     71     1094     61     1128     53     1162     70     1196     87
     1027     53     1061     70     1095     63     1129     53     1163     68     1197     99
     1028     52     1062     69     1096     69     1130     53     1164     67     1198    110
     1029     52     1063     68     1097     73     1131     53     1165     65     1199    111
     1030     52     1064     67     1098     79     1132     53     1166     62     1200    104
     1031     53     1065     66     1099     91     1133     54     1167     58     1201     90
     1032     53     1066     64     1100    103     1134     54     1168     55     1202     80
     1033     53     1067     63     1101    111     1135     54     1169     53     1203     75
     1034     53     1068     61     1102    108     1136     54     1170     53     1204     72
     1035     52     1069     58     1103     96     1137     54     1171     52     1205     71
     1036     52     1070     54     1104     86     1138     55     1172     53     1206     71
     1037     53     1071     51     1105     78     1139     55     1173     52     1207     70
     1038     53     1072     51     1106     75     1140     55     1174     52     1208     69
     1039     53     1073     50     1107     73     1141     57     1175     52     1209     68
     1040     53     1074     50     1108     72     1142     61     1176     52     1210     67
     1041     53     1075     50     1109     72     1143     65     1177     52     1211     66
     1042     53     1076     50     1110     72     1144     69     1178     52     1212     64
     1043     54     1077     50     1111     71     1145     73     1179     52     1213     63
     1044     57     1078     50     1112     70     1146     78     1180     52     1214     61
     1045     61     1079     50     1113     69     1147     87     1181     52     1215     58
     1046     63     1080     50     1114     67     1148    101     1182     52     1216     54
     1047     68     1081     51     1115     67     1149    111     1183     52     1217     52
     1048     71     1082     51     1116     65     1150    116     1184     52     1218     51
     1049     78     1083     51     1117     62     1151    112     1185     53     1219     50
     1050     87     1084     51     1118     59     1152     97     1186     53     1220     50
     1051    103     1085     51     1119     55     1153     86     1187     53     1221     50
     1052    111     1086     51     1120     53     1154     80     1188     53     1222     50
     1053    112     1087     51     1121     53     1155     76     1189     53     1223     50
     1054    100     1088     51     1122     53     1156     75     1190     55     1224     50
     1055     88     1089     52     1123     53     1157     75     1191     60     1225     50
     1056     80     1090     52     1124     53     1158     74     1192     63     1226     50
     1057     75     1091     52     1125     53     1159     73     1193     67     1227     51
     1058     72     1092     54     1126     52     1160     72     1194     71     1228     51
```

Table 47-B

Stripchart for F4 High-Intensity Closure
29.0 cm H20, 93 dBA, Gain = 33
F4 T2 05

```
STARTING ADDRESS = 1281  ENDING ADDRESS = 1481
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------       ---------       ---------       ---------       ---------       ---------
    1281     55     1315     56     1349     83     1383     54     1417     55     1451     74
    1282     55     1316     54     1350     77     1384     54     1418     55     1452     74
    1283     56     1317     54     1351     74     1385     55     1419     55     1453     73
    1284     56     1318     53     1352     71     1386     57     1420     55     1454     71
    1285     56     1319     53     1353     72     1387     60     1421     55     1455     70
    1286     56     1320     53     1354     71     1388     63     1422     55     1456     69
    1287     56     1321     53     1355     71     1389     68     1423     55     1457     67
    1288     57     1322     53     1356     70     1390     71     1424     55     1458     65
    1289     59     1323     53     1357     69     1391     77     1425     55     1459     62
    1290     63     1324     53     1358     67     1392     85     1426     55     1460     59
    1291     67     1325     53     1359     66     1393     95     1427     55     1461     56
    1292     71     1326     53     1360     64     1394    101     1428     55     1462     54
    1293     75     1327     53     1361     62     1395    103     1429     55     1463     53
    1294     79     1328     53     1362     60     1396    100     1430     55     1464     53
    1295     87     1329     53     1363     56     1397     92     1431     56     1465     53
    1296     99     1330     53     1364     54     1398     84     1432     56     1466     53
    1297    103     1331     53     1365     53     1399     80     1433     56     1467     52
    1298    104     1332     53     1366     52     1400     77     1434     57     1468     52
    1299     99     1333     53     1367     52     1401     76     1435     59     1469     52
    1300     90     1334     53     1368     52     1402     75     1436     63     1470     53
    1301     83     1335     53     1369     52     1403     75     1437     67     1471     52
    1302     78     1336     54     1370     52     1404     74     1438     71     1472     53
    1303     76     1337     55     1371     52     1405     73     1439     75     1473     53
    1304     75     1338     57     1372     52     1406     72     1440     79     1474     53
    1305     75     1339     61     1373     52     1407     71     1441     87     1475     52
    1306     74     1340     65     1374     53     1408     69     1442     99     1476     53
    1307     73     1341     69     1375     53     1409     68     1443    103     1477     53
    1308     72     1342     73     1376     53     1410     66     1444    104     1478     53
    1309     70     1343     79     1377     53     1411     62     1445     98     1479     53
    1310     69     1344     87     1378     53     1412     58     1446     90     1480     53
    1311     68     1345     94     1379     53     1413     56     1447     83     1481     53
    1312     66     1346     98     1380     54     1414     55     1448     78     1482     53
    1313     63     1347     96     1381     54     1415     55     1449     76     1483     54
    1314     60     1348     90     1382     54     1416     55     1450     75     1484     57
```

Table 48-B

Stripchart for F5 High-Intensity Closure
36.5 cm H20, 100 dBA, Gain = 3.3
F5 T1 03

```
STARTING ADDRESS = 769  ENDING ADDRESS = 969
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

     ---------      ---------      ---------      ---------      ---------      ---------
     769     6      803     6      837    95      871     7      905     6      939    92
     770     6      804     6      838    98      872     6      906     6      940    95
     771     6      805     7      839    96      873     6      907     7      941    96
     772     6      806     9      840    86      874     6      908     7      942    88
     773     6      807    21      841    72      875     6      909    15      943    74
     774     6      808    43      842    48      876     6      910    39      944    56
     775     6      809    63      843    28      877     6      911    63      945    32
     776     6      810    79      844    12      878     6      912    79      946    16
     777     6      811    91      845     7      879     6      913    91      947     8
     778     6      812    95      846     6      880     6      914    99      948     6
     779     6      813    96      847     6      881     6      915   100      949     6
     780     7      814    89      848     6      882     7      916    96      950     6
     781    13      815    76      849     6      883    11      917    84      951     6
     782    31      816    56      850     6      884    27      918    64      952     6
     783    59      817    36      851     6      885    55      919    42      953     6
     784    77      818    18      852     6      886    75      920    22      954     6
     785    89      819     8      853     6      887    89      921    10      955     6
     786    95      820     6      854     6      888    97      922     7      956     6
     787    98      821     6      855     6      889   102      923     6      957     6
     788    94      822     6      856     7      890   100      924     6      958     6
     789    84      823     6      857     7      891    90      925     6      959     7
     790    66      824     6      858    15      892    76      926     6      960    13
     791    48      825     6      859    39      893    52      927     6      961    31
     792    24      826     6      860    63      894    32      928     6      962    55
     793    11      827     6      861    83      895    16      929     6      963    75
     794     7      828     6      862    94      896     8      930     6      964    87
     795     6      829     6      863   100      897     7      931     6      965    95
     796     6      830     6      864   101      898     6      932     6      966    97
     797     6      831     7      865    96      899     6      933     7      967    94
     798     6      832    11      866    82      900     6      934     9      968    84
     799     6      833    31      867    64      901     6      935    23      969    66
     800     6      834    55      868    40      902     6      936    47      970    48
     801     6      835    75      869    20      903     6      937    69      971    24
     802     6      836    87      870    10      904     6      938    83      972    11
```

Table 49-B

Stripchart for Bb5 High-Intensity Closure
34.0 cm H20, 100 dBA, Gain = 3.3
Bb5 Tl 03

```
STARTING ADDRESS = 769  ENDING ADDRESS = 969
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

---------      ---------      ---------      ---------      ---------      ---------
769     5      803     5      837     7      871    64      905    79      939    39
770     5      804     5      838     5      872    32      906    80      940    63
771     5      805     5      839     5      873    10      907    68      941    75
772     6      806     5      840     5      874     6      908    40      942    79
773     7      807     5      841     5      875     5      909    16      943    72
774    15      808     5      842     5      876     5      910     7      944    52
775    39      809     6      843     5      877     5      911     5      945    24
776    63      810     9      844     5      878     5      912     5      946     8
777    75      811    27      845     6      879     5      913     5      947     5
778    80      812    55      846     7      880     5      914     5      948     5
779    74      813    70      847    15      881     6      915     5      949     5
780    56      814    77      848    43      882     6      916     5      950     5
781    24      815    76      849    63      883    11      917     5      951     5
782     9      816    64      850    77      884    31      918     6      952     5
783     5      817    36      851    80      885    59      919     7      953     5
784     5      818    12      852    72      886    75      920    19      954     5
785     5      819     6      853    50      887    82      921    47      955     6
786     5      820     5      854    24      888    80      922    63      956    11
787     5      821     5      855     8      889    64      923    78      957    31
788     5      822     5      856     5      890    34      924    80      958    55
789     5      823     5      857     5      891    12      925    72      959    71
790     5      824     5      858     5      892     6      926    48      960    78
791     6      825     5      859     5      893     5      927    20      961    74
792    11      826     5      860     5      894     5      928     8      962    56
793    31      827     6      861     5      895     5      929     5      963    32
794    59      828     7      862     5      896     5      930     5      964    10
795    73      829    23      863     6      897     5      931     5      965     6
796    79      830    47      864     7      898     5      932     5      966     5
797    76      831    63      865    15      899     6      933     5      967     5
798    64      832    76      866    31      900     6      934     5      968     5
799    32      833    77      867    63      901     9      935     5      969     5
800    10      834    66      868    77      902    23      936     5      970     5
801     6      835    42      869    82      903    55      937     7      971     5
802     5      836    16      870    76      904    71      938    15      972     5
```

Table 50-B

Stripchart for F3, Series I
31.0 cm H2O, 70 dBA, Gain 33
F3 Tl 07

```
STARTING ADDRESS = 1793  ENDING ADDRESS = 1993
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------       ---------       ---------       ---------       ---------       ---------
  1793     85    1827     85    1861    110    1895     87    1929     85    1963    103
  1794     85    1828     85    1862    110    1896     87    1930     86    1964    102
  1795     84    1829     86    1863    109    1897     87    1931     86    1965    102
  1796     84    1830     86    1864    109    1898     87    1932     87    1966    101
  1797     84    1831     86    1865    109    1899     87    1933     87    1967    101
  1798     83    1832     87    1866    109    1900     86    1934     89    1968    100
  1799     83    1833     87    1867    108    1901     86    1935     90    1969    100
  1800     83    1834     87    1868    108    1902     86    1936     91    1970     99
  1801     83    1835     88    1869    107    1903     86    1937     93    1971     98
  1802     83    1836     90    1870    106    1904     86    1938     94    1972     98
  1803     83    1837     91    1871    106    1905     86    1939     95    1973     97
  1804     83    1838     93    1872    105    1906     86    1940     96    1974     96
  1805     83    1839     94    1873    104    1907     86    1941     97    1975     95
  1806     83    1840     95    1874    103    1908     85    1942     98    1976     94
  1807     83    1841     97    1875    103    1909     85    1943     99    1977     93
  1808     83    1842     99    1876    102    1910     85    1944    100    1978     93
  1809     83    1843    100    1877    101    1911     85    1945    101    1979     92
  1810     83    1844    101    1878    100    1912     85    1946    101    1980     91
  1811     83    1845    102    1879     99    1913     85    1947    102    1981     90
  1812     83    1846    103    1880     98    1914     85    1948    102    1982     89
  1813     83    1847    104    1881     96    1915     85    1949    103    1983     88
  1814     83    1848    105    1882     95    1916     85    1950    103    1984     88
  1815     84    1849    106    1883     94    1917     85    1951    104    1985     87
  1816     83    1850    106    1884     93    1918     85    1952    104    1986     87
  1817     83    1851    107    1885     92    1919     85    1953    104    1987     87
  1818     83    1852    108    1886     91    1920     85    1954    104    1988     87
  1819     83    1853    109    1887     90    1921     85    1955    104    1989     87
  1820     84    1854    109    1888     90    1922     85    1956    104    1990     87
  1821     84    1855    110    1889     89    1923     85    1957    104    1991     87
  1822     84    1856    110    1890     89    1924     84    1958    104    1992     87
  1823     84    1857    110    1891     89    1925     86    1959    102    1993     87
  1824     85    1858    110    1892     88    1926     85    1960    103    1994     87
  1825     85    1859    110    1893     88    1927     85    1961    103    1995     87
  1826     85    1860    110    1894     87    1928     86    1962    103    1996     87
```

Table 51-B

Stripchart for F3, Series I
29.0 cm H2O, 80 dBA, Gain 33
F3 Tl 08

STARTING ADDRESS = 2049 ENDING ADDRESS = 2249
STEP = 1 DATA RATE = 6983

SIX COLUMNS: POINT NUMBER VALUE

2049	85	2083	158	2117	89	2151	90	2185	150	2219	85
2050	85	2084	155	2118	89	2152	90	2186	145	2220	85
2051	85	2085	154	2119	89	2153	91	2187	137	2221	85
2052	85	2086	154	2120	89	2154	92	2188	129	2222	85
2053	86	2087	155	2121	89	2155	94	2189	122	2223	85
2054	86	2088	153	2122	89	2156	95	2190	117	2224	85
2055	86	2089	148	2123	89	2157	98	2191	113	2225	86
2056	87	2090	140	2124	89	2158	100	2192	110	2226	86
2057	88	2091	133	2125	89	2159	102	2193	108	2227	86
2058	90	2092	128	2126	89	2160	104	2194	106	2228	86
2059	92	2093	120	2127	89	2161	107	2195	104	2229	86
2060	95	2094	117	2128	89	2162	111	2196	103	2230	86
2061	97	2095	114	2129	89	2163	115	2197	102	2231	86
2062	99	2096	112	2130	89	2164	119	2198	101	2232	86
2063	101	2097	110	2131	89	2165	126	2199	100	2233	87
2064	103	2098	109	2132	89	2166	135	2200	99	2234	87
2065	108	2099	108	2133	89	2167	143	2201	98	2235	87
2066	113	2100	107	2134	89	2168	151	2202	96	2236	87
2067	119	2101	106	2135	89	2169	154	2203	94	2237	87
2068	125	2102	105	2136	89	2170	155	2204	92	2238	87
2069	134	2103	104	2137	89	2171	158	2205	90	2239	87
2070	143	2104	103	2138	89	2172	163	2206	88	2240	88
2071	150	2105	101	2139	89	2173	165	2207	87	2241	88
2072	154	2106	99	2140	89	2174	165	2208	88	2242	88
2073	156	2107	96	2141	89	2175	166	2209	86	2243	89
2074	159	2108	94	2142	89	2176	164	2210	86	2244	89
2075	161	2109	92	2143	89	2177	164	2211	86	2245	89
2076	164	2110	91	2144	89	2178	162	2212	85	2246	89
2077	166	2111	91	2145	89	2179	160	2213	85	2247	90
2078	165	2112	91	2146	89	2180	157	2214	85	2248	90
2079	164	2113	91	2147	89	2181	153	2215	85	2249	91
2080	163	2114	90	2148	89	2182	152	2216	85	2250	91
2081	162	2115	90	2149	89	2183	152	2217	85	2251	93
2082	160	2116	90	2150	89	2184	152	2218	85	2252	95

Table 52-B

Stripchart for F3, Series I
27.5 cm H2O, 90 dBA, Gain 3.3
F3 T1 09

```
STARTING ADDRESS = 2305  ENDING ADDRESS = 2505
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------        ---------        ---------        ---------        ---------        ---------
   2305   119       2339    11       2373    10       2407   114       2441    10       2475    11
   2306   119       2340    11       2374    10       2408   113       2442    10       2476    11
   2307   119       2341    11       2375    10       2409   114       2443    10       2477    11
   2308   119       2342    11       2376    10       2410   115       2444    10       2478    12
   2309   119       2343    10       2377    10       2411   116       2445    10       2479    12
   2310   119       2344    10       2378    11       2412   115       2446    10       2480    13
   2311   119       2345    10       2379    11       2413   112       2447    10       2481    18
   2312   121       2346    10       2380    11       2414   104       2448    10       2482    31
   2313   121       2347    10       2381    12       2415    96       2449    10       2483    47
   2314   121       2348    10       2382    13       2416    90       2450    10       2484    71
   2315   117       2349    10       2383    15       2417    84       2451    10       2485    87
   2316   112       2350    10       2384    27       2418    80       2452    10       2486    99
   2317   104       2351    10       2385    43       2419    79       2453    10       2487   105
   2318    96       2352    10       2386    63       2420    77       2454    10       2488   107
   2319    89       2353    10       2387    83       2421    79       2455    10       2489   108
   2320    85       2354    10       2388    94       2422    78       2456    10       2490   110
   2321    83       2355    10       2389    99       2423    77       2457    10       2491   113
   2322    82       2356    10       2390   102       2424    74       2458    10       2492   114
   2323    82       2357    10       2391   103       2425    67       2459    10       2493   114
   2324    82       2358    10       2392   105       2426    58       2460    10       2494   112
   2325    81       2359    10       2393   107       2427    48       2461    10       2495   111
   2326    78       2360    10       2394   109       2428    32       2462    10       2496   113
   2327    72       2361    10       2395   110       2429    20       2463    10       2497   115
   2328    64       2362    10       2396   108       2430    14       2464    10       2498   117
   2329    50       2363    10       2397   107       2431    12       2465    10       2499   119
   2330    36       2364    10       2398   107       2432    11       2466    10       2500   119
   2331    24       2365    10       2399   109       2433    11       2467    11       2501   119
   2332    16       2366    10       2400   111       2434    10       2468    11       2502   119
   2333    13       2367    10       2401   113       2435    10       2469    11       2503   119
   2334    12       2368    10       2402   114       2436    10       2470    11       2504   119
   2335    11       2369    10       2403   114       2437    10       2471    11       2505   119
   2336    11       2370    10       2404   114       2438    10       2472    11       2506   118
   2337    11       2371    10       2405   114       2439    10       2473    11       2507   119
   2338    11       2372    10       2406   114       2440    10       2474    11       2508   119
```

Table 53-B

Stripchart for F3, Series I
27.5 cm H2O, 90 dBA, Gain 3.3
F3 Tl 10

```
STARTING ADDRESS = 2561  ENDING ADDRESS = 2761
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------     ---------     ---------     ---------     ---------     ---------
   2561     14   2595    191   2629     93   2663     13   2697    175   2731     35
   2562     16   2596    219   2630    119   2664     13   2698    207   2732     47
   2563     14   2597    230   2631    151   2665     13   2699    227   2733     79
   2564     13   2598    224   2632    182   2666     12   2700    229   2734    107
   2565     12   2599    204   2633    184   2667     12   2701    216   2735    108
   2566     11   2600    180   2634    160   2668     12   2702    192   2736     80
   2567     11   2601    160   2635     96   2669     11   2703    172   2737     32
   2568     11   2602    149   2636     32   2670     11   2704    162   2738     13
   2569     11   2603    151   2637     12   2671     11   2705    167   2739     11
   2570     12   2604    159   2638     11   2672     11   2706    181   2740     11
   2571     13   2605    175   2639     10   2673     12   2707    199   2741     11
   2572     15   2606    191   2640     11   2674     13   2708    215   2742     11
   2573     17   2607    213   2641     11   2675     15   2709    222   2743     12
   2574     16   2608    221   2642     14   2676     17   2710    222   2744     19
   2575     13   2609    220   2643     31   2677     17   2711    218   2745     38
   2576     13   2610    212   2644     50   2678     14   2712    215   2746     38
   2577     12   2611    204   2645     32   2679     13   2713    219   2747     18
   2578     12   2612    201   2646     13   2680     13   2714    227   2748     12
   2579     12   2613    203   2647     11   2681     12   2715    231   2749     11
   2580     12   2614    204   2648     10   2682     13   2716    226   2750     11
   2581     13   2615    202   2649     10   2683     15   2717    208   2751     10
   2582     14   2616    196   2650     10   2684     31   2718    180   2752     11
   2583     23   2617    187   2651     11   2685     63   2719    148   2753     11
   2584     47   2618    180   2652     13   2686    119   2720    128   2754     12
   2585     75   2619    179   2653     27   2687    159   2721    127   2755     15
   2586     95   2620    186   2654     32   2688    187   2722    155   2756     18
   2587    103   2621    197   2655     16   2689    203   2723    191   2757     14
   2588    108   2622    207   2656     12   2690    200   2724    231   2758     12
   2589    107   2623    208   2657     11   2691    192   2725    245   2759     11
   2590    104   2624    196   2658     10   2692    172   2726    228   2760     11
   2591    109   2625    176   2659     10   2693    152   2727    192   2761     10
   2592    123   2626    144   2660     10   2694    140   2728    128   2762     11
   2593    143   2627    112   2661     11   2695    143   2729     72   2763     11
   2594    167   2628     90   2662     11   2696    155   2730     40   2764     11
```

Table 54-B

Stripchart for F3, Series III
27.5 cm H2O, 90 dBA, Gain 10
High Lip Pressure
F3 T3 08

```
STARTING ADDRESS = 2049  ENDING ADDRESS = 2249
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------     ---------     ---------     ---------     ---------     ---------
   2049    62    2083    27    2117     4    2151    32    2185    63    2219     4
   2050    53    2084    39    2118     4    2152    25    2186    75    2220     4
   2051    45    2085    51    2119     4    2153    19    2187    83    2221     4
   2052    38    2086    62    2120     4    2154    14    2188    87    2222     5
   2053    32    2087    73    2121     4    2155    10    2189    89    2223     5
   2054    24    2088    83    2122     4    2156     8    2190    89    2224     6
   2055    18    2089    89    2123     4    2157     6    2191    86    2225     7
   2056    13    2090    92    2124     5    2158     5    2192    82    2226     7
   2057    10    2091    93    2125     5    2159     4    2193    78    2227    10
   2058     7    2092    92    2126     6    2160     4    2194    74    2228    13
   2059     6    2093    89    2127     7    2161     4    2195    68    2229    18
   2060     5    2094    85    2128     8    2162     4    2196    64    2230    23
   2061     4    2095    80    2129    11    2163     4    2197    56    2231    31
   2062     4    2096    76    2130    13    2164     4    2198    49    2232    43
   2063     4    2097    70    2131    19    2165     4    2199    42    2233    55
   2064     4    2098    64    2132    25    2166     4    2200    34    2234    69
   2065     4    2099    56    2133    35    2167     4    2201    26    2235    79
   2066     4    2100    48    2134    46    2168     4    2202    20    2236    87
   2067     4    2101    40    2135    57    2169     4    2203    16    2237    91
   2068     4    2102    32    2136    69    2170     4    2204    11    2238    94
   2069     4    2103    25    2137    78    2171     4    2205     8    2239    93
   2070     4    2104    19    2138    85    2172     4    2206     6    2240    90
   2071     4    2105    14    2139    88    2173     4    2207     5    2241    87
   2072     4    2106    10    2140    89    2174     5    2208     4    2242    82
   2073     4    2107     8    2141    88    2175     5    2209     4    2243    77
   2074     4    2108     6    2142    86    2176     6    2210     4    2244    71
   2075     5    2109     5    2143    82    2177     7    2211     4    2245    64
   2076     5    2110     4    2144    77    2178    10    2212     4    2246    58
   2077     6    2111     4    2145    72    2179    13    2213     4    2247    50
   2078     7    2112     4    2146    66    2180    17    2214     4    2248    43
   2079     9    2113     4    2147    60    2181    23    2215     4    2249    36
   2080    11    2114     4    2148    54    2182    31    2216     4    2250    28
   2081    15    2115     4    2149    48    2183    43    2217     4    2251    21
   2082    21    2116     4    2150    40    2184    55    2218     4    2252    16
```

Table 55-B

Stripchart for F3, Series III
26.0 cm H2O, 90 dBA, Gain 10
Low Lip Pressure
F3 T3 09

STARTING ADDRESS = 2305 ENDING ADDRESS = 2505
STEP = 1 DATA RATE = 17280

SIX COLUMNS: POINT NUMBER VALUE

2305	136	2339	111	2373	6	2407	92	2441	183	2475	7
2306	128	2340	127	2374	6	2408	74	2442	201	2476	8
2307	112	2341	157	2375	6	2409	56	2443	211	2477	9
2308	96	2342	175	2376	7	2410	40	2444	212	2478	11
2309	80	2343	197	2377	8	2411	28	2445	208	2479	13
2310	64	2344	211	2378	9	2412	18	2446	200	2480	15
2311	48	2345	216	2379	11	2413	12	2447	186	2481	19
2312	33	2346	215	2380	12	2414	8	2448	176	2482	23
2313	22	2347	208	2381	14	2415	6	2449	164	2483	35
2314	14	2348	197	2382	17	2416	5	2450	155	2484	51
2315	9	2349	184	2383	21	2417	5	2451	148	2485	71
2316	7	2350	176	2384	30	2418	5	2452	140	2486	95
2317	5	2351	166	2385	43	2419	5	2453	130	2487	118
2318	5	2352	160	2386	63	2420	5	2454	120	2488	141
2319	5	2353	150	2387	87	2421	5	2455	104	2489	159
2320	5	2354	142	2388	109	2422	6	2456	90	2490	183
2321	5	2355	132	2389	127	2423	6	2457	74	2491	203
2322	5	2356	118	2390	157	2424	6	2458	58	2492	215
2323	5	2357	104	2391	179	2425	7	2459	42	2493	219
2324	6	2358	86	2392	199	2426	7	2460	32	2494	216
2325	6	2359	70	2393	215	2427	9	2461	19	2495	208
2326	6	2360	52	2394	223	2428	10	2462	12	2496	197
2327	7	2361	38	2395	223	2429	11	2463	8	2497	185
2328	7	2362	25	2396	216	2430	13	2464	6	2498	176
2329	9	2363	16	2397	205	2431	15	2465	5	2499	166
2330	10	2364	11	2398	193	2432	19	2466	5	2500	160
2331	12	2365	8	2399	182	2433	26	2467	5	2501	150
2332	14	2366	6	2400	172	2434	38	2468	5	2502	141
2333	17	2367	5	2401	164	2435	55	2469	5	2503	130
2334	22	2368	5	2402	156	2436	75	2470	5	2504	116
2335	31	2369	5	2403	148	2437	95	2471	5	2505	100
2336	47	2370	5	2404	137	2438	119	2472	6	2506	84
2337	63	2371	5	2405	128	2439	143	2473	6	2507	68
2338	87	2372	6	2406	108	2440	167	2474	6	2508	50

Table 56-B

Stripchart for F3, Series III
33.5 cm H2O, 100 dBA, Gain 10
High Lip Pressure
F3 T3 10

```
STARTING ADDRESS = 2561  ENDING ADDRESS = 2761
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------     ---------     ---------     ---------     ---------     ---------
  2561     4    2595     4    2629    50    2663     5    2697     4    2731    32
  2562     4    2596     4    2630    48    2664     7    2698     4    2732    24
  2563     4    2597     4    2631    43    2665    19    2699     4    2733    18
  2564     4    2598     4    2632    36    2666    43    2700     4    2734    12
  2565     6    2599     4    2633    28    2667    63    2701     4    2735     8
  2566    11    2600     4    2634    21    2668    87    2702     4    2736     5
  2567    27    2601     4    2635    16    2669    95    2703     4    2737     4
  2568    55    2602     4    2636    10    2670    99    2704     4    2738     4
  2569    79    2603     4    2637     7    2671    92    2705     4    2739     4
  2570    95    2604     4    2638     5    2672    80    2706     4    2740     4
  2571   103    2605     4    2639     4    2673    66    2707     4    2741     4
  2572   102    2606     4    2640     4    2674    56    2708     4    2742     4
  2573    90    2607     4    2641     4    2675    49    2709     4    2743     4
  2574    76    2608     4    2642     4    2676    46    2710     4    2744     4
  2575    65    2609     4    2643     4    2677    47    2711     4    2745     4
  2576    56    2610     4    2644     4    2678    51    2712     5    2746     4
  2577    50    2611     4    2645     4    2679    50    2713     7    2747     4
  2578    49    2612     4    2646     4    2680    45    2714    15    2748     4
  2579    52    2613     4    2647     4    2681    38    2715    39    2749     4
  2580    53    2614     5    2648     4    2682    30    2716    63    2750     4
  2581    51    2615     9    2649     3    2683    22    2717    87    2751     4
  2582    45    2616    23    2650     4    2684    16    2718    99    2752     4
  2583    37    2617    47    2651     4    2685    12    2719   102    2753     4
  2584    28    2618    71    2652     4    2686     8    2720    96    2754     4
  2585    21    2619    87    2653     4    2687     5    2721    82    2755     4
  2586    16    2620    95    2654     4    2688     4    2722    69    2756     4
  2587    10    2621    96    2655     4    2689     4    2723    58    2757     4
  2588     6    2622    86    2656     4    2690     4    2724    50    2758     4
  2589     5    2623    72    2657     4    2691     4    2725    47    2759     4
  2590     4    2624    60    2658     4    2692     4    2726    49    2760     4
  2591     4    2625    52    2659     4    2693     4    2727    52    2761     4
  2592     4    2626    46    2660     4    2694     4    2728    52    2762     7
  2593     4    2627    45    2661     4    2695     4    2729    48    2763    15
  2594     4    2628    47    2662     4    2696     4    2730    40    2764    31
```

Table 57-B

Stripchart for F3, Series III
29.5 cm H2O, 100 dBA, Gain 10
Low Lip Pressure
F3 T3 11

```
STARTING ADDRESS = 2817  ENDING ADDRESS = 3017
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------     ---------     ---------     ---------     ---------     ---------
  2817   19     2851    4     2885  218     2919  231     2953    4     2987  128
  2818   63     2852    4     2886  202     2920  255     2954    4     2988   80
  2819  127     2853    4     2887  176     2921  255     2955    4     2989   32
  2820  215     2854    4     2888  136     2922  255     2956    4     2990   10
  2821  255     2855    4     2889   96     2923  255     2957    4     2991    5
  2822  255     2856    4     2890   40     2924  255     2958    4     2992    4
  2823  255     2857    4     2891   12     2925  248     2959    4     2993    4
  2824  255     2858    4     2892    5     2926  240     2960    4     2994    4
  2825  255     2859    4     2893    4     2927  236     2961    4     2995    4
  2826  244     2860    4     2894    4     2928  233     2962    5     2996    4
  2827  234     2861    4     2895    4     2929  230     2963    6     2997    4
  2828  229     2862    4     2896    4     2930  229     2964    7     2998    4
  2829  226     2863    5     2897    4     2931  228     2965   15     2999    4
  2830  222     2864    6     2898    4     2932  227     2966   39     3000    4
  2831  221     2865    7     2899    4     2933  224     2967  111     3001    4
  2832  221     2866   13     2900    4     2934  218     2968  191     3002    4
  2833  221     2867   31     2901    4     2935  208     2969  255     3003    4
  2834  220     2868   95     2902    4     2936  184     2970  255     3004    4
  2835  216     2869  191     2903    4     2937  152     2971  255     3005    4
  2836  204     2870  255     2904    4     2938  112     2972  255     3006    4
  2837  184     2871  255     2905    4     2939   64     2973  255     3007    4
  2838  160     2872  255     2906    4     2940   20     2974  244     3008    4
  2839  112     2873  255     2907    4     2941    7     2975  234     3009    4
  2840   64     2874  255     2908    4     2942    4     2976  230     3010    4
  2841   24     2875  255     2909    4     2943    4     2977  228     3011    5
  2842    8     2876  246     2910    4     2944    4     2978  226     3012    5
  2843    4     2877  240     2911    4     2945    4     2979  224     3013    7
  2844    4     2878  236     2912    5     2946    4     2980  222     3014   11
  2845    4     2879  234     2913    5     2947    4     2981  220     3015   23
  2846    4     2880  233     2914    7     2948    4     2982  218     3016   79
  2847    4     2881  232     2915   11     2949    4     2983  216     3017  159
  2848    4     2882  232     2916   23     2950    4     2984  206     3018  239
  2849    4     2883  231     2917   63     2951    4     2985  192     3019  255
  2850    4     2884  228     2918  159     2952    4     2986  164     3020  255
```

Table 58-B

Stripchart for F3, Series II
36.0 cm H2O, 98 dBA, Page 01

```
STARTING ADDRESS = 257  ENDING ADDRESS = 457
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------    ---------    ---------    ---------    ---------    ---------
   257   185    291   231    325     8    359   203    393   180    427     9
   258   177    292   226    326     8    360   206    394   160    428     9
   259   187    293   212    327     8    361   200    395   128    429     9
   260   203    294   194    328     8    362   188    396    96    430     9
   261   213    295   176    329     9    363   184    397    48    431     9
   262   210    296   144    330     8    364   191    398    12    432     9
   263   200    297   112    331     8    365   206    399    10    433     9
   264   190    298    64    332     8    366   215    400     9    434     9
   265   191    299    16    333     8    367   218    401     9    435     9
   266   207    300    10    334     8    368   215    402     9    436     9
   267   221    301     9    335     8    369   213    403     9    437     9
   268   227    302     9    336     8    370   214    404     9    438     9
   269   224    303     9    337     8    371   215    405     9    439     9
   270   220    304     9    338     8    372   213    406     9    440     9
   271   220    305     9    339     8    373   208    407     8    441     9
   272   222    306     9    340     8    374   206    408     9    442     9
   273   221    307     9    341     8    375   211    409     9    443     9
   274   218    308     9    342     8    376   223    410     9    444     9
   275   215    309     9    343     8    377   239    411     9    445    10
   276   219    310     9    344     8    378   242    412     9    446    11
   277   231    311     9    345     9    379   232    413     9    447    13
   278   247    312     9    346     9    380   212    414     9    448    31
   279   254    313     9    347    10    381   193    415     9    449    87
   280   248    314     9    348    11    382   184    416     9    450   143
   281   228    315     9    349    23    383   185    417     9    451   191
   282   210    316     9    350    63    384   189    418     9    452   217
   283   197    317     9    351   127    385   193    419     9    453   212
   284   195    318     9    352   175    386   199    420     9    454   196
   285   198    319     9    353   206    387   206    421     9    455   182
   286   201    320     9    354   208    388   215    422     9    456   183
   287   205    321     9    355   192    389   223    423     9    457   199
   288   211    322     9    356   178    390   222    424     9    458   213
   289   221    323     9    357   174    391   214    425     9    459   213
   290   229    324     9    358   187    392   200    426     9    460   204
```

Table 59-B

Stripchart for F3, Series II
34.0 cm H2O, 97.5 dBA, Page 02

```
STARTING ADDRESS = 513  ENDING ADDRESS = 713
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------      ---------      ---------      ---------      ---------      ---------
   513   207      547     9      581   196      615   219      649     9      683   205
   514   213      548     9      582   181      616   219      650     9      684   215
   515   219      549     9      583   179      617   210      651     9      685   216
   516   226      550     9      584   189      618   196      652     9      686   208
   517   228      551     9      585   199      619   176      653     9      687   196
   518   221      552     9      586   205      620   152      654     9      688   195
   519   208      553     9      587   200      621   128      655     9      689   207
   520   192      554     9      588   189      622    80      656     9      690   219
   521   164      555     9      589   185      623    36      657     9      691   227
   522   136      556     9      590   191      624    12      658     9      692   226
   523    96      557     9      591   205      625    10      659     9      693   221
   524    52      558     9      592   215      626     9      660     9      694   218
   525    16      559     9      593   218      627     9      661     9      695   218
   526    11      560     9      594   215      628     9      662     9      696   219
   527     9      561     9      595   212      629     9      663     9      697   217
   528     9      562     9      596   211      630     9      664     9      698   214
   529     9      563     9      597   212      631     9      665     9      699   214
   530     9      564     8      598   212      632     9      666     9      700   222
   531     9      565     9      599   210      633     9      667     9      701   235
   532     9      566     9      600   209      634     9      668     9      702   243
   533     9      567     9      601   215      635     9      669     9      703   240
   534     9      568     9      602   227      636     9      670    10      704   224
   535     9      569     9      603   238      637     9      671    10      705   204
   536     9      570     9      604   240      638     9      672    11      706   192
   537     9      571     9      605   228      639     9      673    23      707   184
   538     9      572    10      606   210      640     9      674    55      708   187
   539     9      573    11      607   192      641     9      675   103      709   191
   540     9      574    15      608   185      642     9      676   159      710   198
   541     9      575    39      609   186      643     9      677   191      711   203
   542     9      576    87      610   191      644     9      678   215      712   207
   543     9      577   127      611   195      645     9      679   212      713   215
   544     9      578   175      612   199      646     9      680   200      714   218
   545     9      579   203      613   206      647     9      681   188      715   216
   546     9      580   206      614   213      648     9      682   191      716   204
```

Table 60-B

Stripchart for F3, Series II
32.5 cm H2O, 98 dBA, Page 03

```
STARTING ADDRESS = 769  ENDING ADDRESS = 969
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

     ---------      ---------      ---------      ---------      ---------      ---------
     769       9    803       9    837     224    871       9    905       9    939     230
     770       9    804       9    838     225    872       9    906       9    940     237
     771       9    805       9    839     227    873       9    907       9    941     245
     772       9    806       9    840     229    874       9    908       9    942     249
     773       9    807       9    841     233    875       9    909      10    943     246
     774       9    808       9    842     239    876       9    910      10    944     234
     775       9    809      10    843     247    877       9    911      11    945     216
     776       9    810      10    844     246    878       9    912      19    946     202
     777       9    811      11    845     237    879       9    913      47    947     197
     778       9    812      11    846     224    880       9    914      87    948     201
     779       9    813      15    847     208    881       9    915     127    949     207
     780       9    814      31    848     198    882       9    916     175    950     218
     781       9    815      71    849     197    883       9    917     205    951     223
     782       9    816     119    850     203    884       9    918     214    952     228
     783       9    817     167    851     211    885       9    919     208    953     231
     784       9    818     203    852     218    886       9    920     196    954     230
     785       9    819     221    853     223    887       9    921     189    955     224
     786       9    820     220    854     226    888       9    922     191    956     212
     787       9    821     209    855     226    889       9    923     203    957     192
     788       9    822     200    856     222    890       9    924     213    958     164
     789       9    823     199    857     212    891       9    925     213    959     128
     790       9    824     207    858     194    892       9    926     208    960      88
     791       9    825     215    859     168    893       9    927     201    961      40
     792       9    826     219    860     144    894       9    928     203    962      16
     793       9    827     216    861     104    895       9    929     211    963      11
     794       9    828     208    862      64    896       9    930     223    964      10
     795       9    829     206    863      20    897       9    931     231    965       9
     796       9    830     211    864      11    898       9    932     232    966       9
     797       9    831     223    865      10    899       9    933     227    967       9
     798       9    832     231    866       9    900       9    934     222    968      10
     799       9    833     235    867       9    901       9    935     221    969      10
     800       9    834     233    868       9    902       9    936     223    970      10
     801       9    835     228    869       9    903       9    937     225    971       9
     802       9    836     225    870       9    904       9    938     227    972       9
```

Table 61-B

Stripchart for F3, Series II
30.5 cm H2O, 94 dBA, Page 04

```
STARTING ADDRESS = 1025  ENDING ADDRESS = 1225
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------    ---------    ---------    ---------    ---------    ---------
  1025     9   1059   207   1093   148   1127     9   1161   215   1195    20
  1026    10   1060   214   1094   112   1128     9   1162   215   1196    12
  1027    10   1061   215   1095    72   1129     9   1163   219   1197    11
  1028    10   1062   214   1096    32   1130     9   1164   226   1198    10
  1029    10   1063   213   1097    12   1131     9   1165   233   1199    10
  1030    10   1064   214   1098    11   1132     9   1166   237   1200    10
  1031    10   1065   219   1099    10   1133     9   1167   236   1201    10
  1032    10   1066   227   1100     9   1134     9   1168   232   1202    10
  1033    10   1067   231   1101     9   1135     9   1169   228   1203    10
  1034    10   1068   233   1102     9   1136     9   1170   227   1204    10
  1035    10   1069   230   1103     9   1137     9   1171   231   1205    10
  1036    10   1070   224   1104     9   1138     9   1172   235   1206    10
  1037    10   1071   221   1105     9   1139     9   1173   241   1207     9
  1038    10   1072   221   1106     9   1140    10   1174   245   1208     9
  1039    10   1073   225   1107     9   1141    10   1175   247   1209     9
  1040    10   1074   230   1108     9   1142    11   1176   245   1210     9
  1041    10   1075   235   1109     9   1143    11   1177   240   1211     9
  1042    10   1076   237   1110     9   1144    13   1178   232   1212     9
  1043    11   1077   237   1111     9   1145    23   1179   224   1213     9
  1044    11   1078   233   1112     9   1146    47   1180   212   1214     9
  1045    12   1079   226   1113     9   1147    79   1181   206   1215     9
  1046    15   1080   216   1114     9   1148   123   1182   207   1216     9
  1047    31   1081   206   1115     9   1149   159   1183   215   1217     9
  1048    63   1082   199   1116     9   1150   191   1184   223   1218     9
  1049   107   1083   197   1117     9   1151   211   1185   235   1219     9
  1050   151   1084   203   1118     9   1152   217   1186   239   1220     9
  1051   183   1085   213   1119     9   1153   213   1187   236   1221     9
  1052   207   1086   223   1120     9   1154   206   1188   226   1222     9
  1053   215   1087   229   1121     9   1155   201   1189   212   1223     9
  1054   214   1088   228   1122     9   1156   202   1190   194   1224     9
  1055   208   1089   221   1123     9   1157   207   1191   172   1225     9
  1056   200   1090   210   1124     9   1158   213   1192   144   1226     9
  1057   198   1091   196   1125     9   1159   217   1193   104   1227     9
  1058   202   1092   176   1126     9   1160   217   1194    64   1228     9
```

Table 62-B

Stripchart for F3, Series II
29.0 cm H2O, 88 dBA, Page 05

```
STARTING ADDRESS = 1281  ENDING ADDRESS = 1481
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------     ---------     ---------     ---------     ---------     ---------
  1281    10    1315    10    1349   145    1383     9    1417     9    1451   143
  1282     9    1316    10    1350   145    1384     9    1418     9    1452   147
  1283     9    1317    10    1351   146    1385     9    1419    10    1453   148
  1284     9    1318    10    1352   146    1386     9    1420    10    1454   148
  1285     9    1319    10    1353   147    1387     9    1421    10    1455   145
  1286     9    1320    10    1354   148    1388     9    1422    11    1456   140
  1287     9    1321    10    1355   148    1389     9    1423    12    1457   132
  1288     9    1322    11    1356   146    1390     9    1424    15    1458   128
  1289     9    1323    11    1357   142    1391     9    1425    23    1459   121
  1290     9    1324    11    1358   138    1392     9    1426    39    1460   119
  1291     9    1325    13    1359   132    1393     9    1427    55    1461   119
  1292     9    1326    19    1360   124    1394     9    1428    75    1462   121
  1293     9    1327    31    1361   120    1395     9    1429    94    1463   123
  1294     9    1328    47    1362   118    1396     9    1430   107    1464   124
  1295     9    1329    69    1363   117    1397     9    1431   114    1465   122
  1296     9    1330    87    1364   119    1398     9    1432   117    1466   119
  1297     9    1331   103    1365   121    1399     9    1433   117    1467   113
  1298     9    1332   115    1366   121    1400     9    1434   116    1468   104
  1299     9    1333   121    1367   120    1401     9    1435   117    1469    96
  1300     9    1334   122    1368   116    1402     9    1436   118    1470    80
  1301     9    1335   123    1369   108    1403     9    1437   120    1471    64
  1302     9    1336   123    1370    98    1404     9    1438   122    1472    40
  1303     9    1337   123    1371    85    1405     9    1439   122    1473    24
  1304     9    1338   123    1372    68    1406     9    1440   123    1474    13
  1305     9    1339   124    1373    52    1407     9    1441   123    1475    11
  1306     9    1340   125    1374    32    1408     9    1442   125    1476    11
  1307     9    1341   126    1375    18    1409     9    1443   129    1477    10
  1308     9    1342   127    1376    12    1410     9    1444   135    1478    10
  1309     9    1343   129    1377    11    1411     9    1445   139    1479    10
  1310    10    1344   131    1378    10    1412     9    1446   142    1480    10
  1311    10    1345   135    1379    10    1413     9    1447   143    1481    10
  1312    10    1346   139    1380     9    1414     9    1448   142    1482    10
  1313    10    1347   143    1381     9    1415     9    1449   142    1483    10
  1314    10    1348   145    1382     9    1416     9    1450   142    1484    10
```

Table 63-B

Stripchart for F3, Series II
27.0 cm H2O, 84 dBA, Page 06

```
STARTING ADDRESS = 1537  ENDING ADDRESS = 1737
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

     ---------      ---------      ---------      ---------      ---------      ---------
     1537   109     1571    97     1605    56     1639   115     1673    82     1707    59
     1538   111     1572    94     1606    57     1640   116     1674    79     1708    61
     1539   113     1573    92     1607    58     1641   117     1675    77     1709    62
     1540   114     1574    90     1608    59     1642   118     1676    75     1710    63
     1541   116     1575    87     1609    60     1643   118     1677    73     1711    66
     1542   117     1576    85     1610    61     1644   119     1678    71     1712    67
     1543   117     1577    83     1611    63     1645   119     1679    70     1713    69
     1544   118     1578    82     1612    63     1646   119     1680    68     1714    71
     1545   119     1579    80     1613    66     1647   119     1681    66     1715    73
     1546   119     1580    78     1614    67     1648   119     1682    64     1716    75
     1547   120     1581    76     1615    68     1649   118     1683    63     1717    78
     1548   121     1582    73     1616    70     1650   118     1684    61     1718    79
     1549   121     1583    70     1617    72     1651   118     1685    59     1719    83
     1550   122     1584    68     1618    73     1652   117     1686    57     1720    85
     1551   122     1585    65     1619    76     1653   116     1687    56     1721    87
     1552   122     1586    64     1620    78     1654   116     1688    55     1722    90
     1553   121     1587    61     1621    80     1655   114     1689    54     1723    92
     1554   121     1588    60     1622    83     1656   113     1690    54     1724    94
     1555   121     1589    59     1623    85     1657   112     1691    53     1725    97
     1556   120     1590    58     1624    87     1658   110     1692    53     1726    99
     1557   119     1591    58     1625    89     1659   109     1693    53     1727   101
     1558   119     1592    57     1626    91     1660   108     1694    53     1728   103
     1559   118     1593    57     1627    93     1661   106     1695    52     1729   106
     1560   116     1594    56     1628    95     1662   105     1696    52     1730   107
     1561   114     1595    56     1629    97     1663   104     1697    53     1731   109
     1562   113     1596    55     1630    98     1664   102     1698    52     1732   111
     1563   112     1597    55     1631   101     1665   100     1699    53     1733   113
     1564   110     1598    55     1632   103     1666    98     1700    53     1734   115
     1565   109     1599    55     1633   105     1667    95     1701    54     1735   118
     1566   108     1600    55     1634   108     1668    93     1702    55     1736   119
     1567   106     1601    55     1635   110     1669    91     1703    55     1737   121
     1568   104     1602    55     1636   111     1670    88     1704    56     1738   122
     1569   102     1603    55     1637   113     1671    86     1705    57     1739   123
     1570   100     1604    55     1638   115     1672    84     1706    58     1740   123
```

Table 64-B

Stripchart for F3, Series II
25.0 cm H2O, 78 dBA, Page 07

STARTING ADDRESS = 1793 ENDING ADDRESS = 1993
STEP = 1 DATA RATE = 17280

SIX COLUMNS: POINT NUMBER VALUE

1793	58	1827	11	1861	107	1895	24	1929	11	1963	111
1794	48	1828	11	1862	109	1896	18	1930	11	1964	113
1795	37	1829	11	1863	111	1897	14	1931	11	1965	115
1796	27	1830	11	1864	115	1898	13	1932	11	1966	117
1797	20	1831	11	1865	117	1899	12	1933	11	1967	119
1798	16	1832	11	1866	119	1900	12	1934	11	1968	120
1799	13	1833	11	1867	122	1901	12	1935	11	1969	121
1800	12	1834	11	1868	123	1902	11	1936	11	1970	122
1801	11	1835	11	1869	125	1903	11	1937	11	1971	122
1802	11	1836	11	1870	126	1904	11	1938	11	1972	122
1803	11	1837	11	1871	127	1905	11	1939	12	1973	122
1804	11	1838	11	1872	127	1906	11	1940	12	1974	120
1805	11	1839	11	1873	128	1907	11	1941	13	1975	119
1806	11	1840	11	1874	128	1908	11	1942	15	1976	116
1807	11	1841	12	1875	127	1909	11	1943	19	1977	114
1808	11	1842	13	1876	125	1910	11	1944	25	1978	111
1809	11	1843	11	1877	123	1911	11	1945	34	1979	108
1810	11	1844	17	1878	120	1912	11	1946	43	1980	106
1811	11	1845	22	1879	118	1913	11	1947	55	1981	104
1812	11	1846	29	1880	115	1914	11	1948	63	1982	102
1813	11	1847	39	1881	113	1915	11	1949	73	1983	100
1814	11	1848	47	1882	110	1916	11	1950	79	1984	97
1815	11	1849	59	1883	108	1917	11	1951	87	1985	94
1816	11	1850	70	1884	106	1918	11	1952	91	1986	89
1817	11	1851	79	1885	102	1919	11	1953	94	1987	86
1818	11	1852	85	1886	99	1920	11	1954	96	1988	76
1819	10	1853	91	1887	96	1921	11	1955	99	1989	68
1820	10	1854	95	1888	90	1922	11	1956	100	1990	57
1821	10	1855	98	1889	84	1923	11	1957	101	1991	48
1822	10	1856	100	1890	76	1924	11	1958	102	1992	36
1823	10	1857	102	1891	66	1925	11	1959	103	1993	27
1824	10	1858	103	1892	56	1926	11	1960	105	1994	20
1825	10	1859	105	1893	44	1927	11	1961	107	1995	16
1826	10	1860	106	1894	32	1928	11	1962	109	1996	13

Table 65-B

Stripchart for F3, Series II
23.5 cm H2O, 71 dBA, Page 08

```
STARTING ADDRESS = 2049  ENDING ADDRESS = 2249
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

  ---------      ---------      ---------      ---------      ---------      ---------
  2049    19     2083    13     2117   109     2151    14     2185    16     2219   113
  2050    17     2084    13     2118   109     2152    13     2186    18     2220   113
  2051    16     2085    14     2119   110     2153    13     2187    19     2221   112
  2052    14     2086    15     2120   111     2154    13     2188    22     2222   111
  2053    14     2087    15     2121   111     2155    13     2189    25     2223   110
  2054    13     2088    17     2122   110     2156    13     2190    28     2224   109
  2055    13     2089    19     2123   110     2157    13     2191    31     2225   107
  2056    13     2090    22     2124   109     2158    12     2192    39     2226   105
  2057    13     2091    25     2125   108     2159    13     2193    43     2227   102
  2058    13     2092    28     2126   106     2160    12     2194    50     2228    99
  2059    12     2093    31     2127   105     2161    12     2195    55     2229    96
  2060    12     2094    37     2128   103     2162    12     2196    62     2230    92
  2061    12     2095    43     2129   100     2163    12     2197    67     2231    88
  2062    12     2096    47     2130    97     2164    12     2198    74     2232    84
  2063    12     2097    55     2131    94     2165    12     2199    79     2233    80
  2064    12     2098    61     2132    90     2166    12     2200    85     2234    76
  2065    12     2099    67     2133    87     2167    12     2201    89     2235    72
  2066    12     2100    73     2134    83     2168    12     2202    93     2236    66
  2067    12     2101    77     2135    79     2169    12     2203    95     2237    60
  2068    12     2102    82     2136    75     2170    12     2204    97     2238    54
  2069    12     2103    86     2137    70     2171    12     2205    99     2239    48
  2070    12     2104    89     2138    65     2172    12     2206   101     2240    42
  2071    12     2105    91     2139    60     2173    12     2207   103     2241    37
  2072    12     2106    94     2140    53     2174    12     2208   105     2242    32
  2073    12     2107    95     2141    48     2175    12     2209   106     2243    27
  2074    12     2108    97     2142    41     2176    12     2210   107     2244    23
  2075    12     2109    99     2143    36     2177    13     2211   108     2245    20
  2076    12     2110   101     2144    32     2178    13     2212   109     2246    17
  2077    12     2111   102     2145    26     2179    13     2213   110     2247    16
  2078    12     2112   103     2146    23     2180    13     2214   111     2248    14
  2079    12     2113   105     2147    20     2181    13     2215   111     2249    14
  2080    12     2114   106     2148    18     2182    14     2216   113     2250    13
  2081    12     2115   107     2149    16     2183    15     2217   113     2251    13
  2082    13     2116   108     2150    15     2184    15     2218   113     2252    13
```

Table 66-B

Stripchart for F3, Series II
22.5 cm H2O, 68 dBA, Page 09

```
STARTING ADDRESS = 2305  ENDING ADDRESS = 2505
STEP = 1   DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------      ---------      ---------      ---------      ---------      ---------
   2305     49    2339     86    2373     23    2407     59    2441     74    2475     23
   2306     52    2340     85    2374     23    2408     61    2442     72    2476     23
   2307     54    2341     83    2375     23    2409     63    2443     70    2477     23
   2308     57    2342     81    2376     23    2410     66    2444     68    2478     23
   2309     59    2343     79    2377     23    2411     69    2445     66    2479     23
   2310     62    2344     77    2378     23    2412     71    2446     64    2480     24
   2311     63    2345     75    2379     23    2413     73    2447     61    2481     24
   2312     67    2346     72    2380     23    2414     75    2448     58    2482     25
   2313     69    2347     70    2381     23    2415     77    2449     56    2483     25
   2314     71    2348     68    2382     23    2416     79    2450     54    2484     26
   2315     74    2349     65    2383     23    2417     80    2451     52    2485     27
   2316     76    2350     63    2384     23    2418     82    2452     49    2486     27
   2317     78    2351     60    2385     24    2419     83    2453     47    2487     28
   2318     80    2352     58    2386     25    2420     85    2454     45    2488     29
   2319     82    2353     55    2387     25    2421     86    2455     42    2489     30
   2320     84    2354     53    2388     26    2422     86    2456     40    2490     31
   2321     86    2355     50    2389     27    2423     87    2457     39    2491     33
   2322     87    2356     47    2390     28    2424     87    2458     37    2492     35
   2323     89    2357     45    2391     29    2425     87    2459     35    2493     36
   2324     90    2358     43    2392     29    2426     87    2460     34    2494     39
   2325     91    2359     41    2393     31    2427     87    2461     32    2495     40
   2326     91    2360     39    2394     33    2428     87    2462     30    2496     43
   2327     91    2361     37    2395     35    2429     87    2463     29    2497     45
   2328     91    2362     35    2396     36    2430     87    2464     28    2498     47
   2329     92    2363     33    2397     38    2431     87    2465     27    2499     49
   2330     92    2364     32    2398     39    2432     86    2466     26    2500     51
   2331     91    2365     30    2399     42    2433     85    2467     25    2501     53
   2332     91    2366     29    2400     43    2434     84    2468     25    2502     56
   2333     91    2367     28    2401     46    2435     83    2469     25    2503     59
   2334     90    2368     27    2402     47    2436     82    2470     24    2504     61
   2335     90    2369     26    2403     50    2437     81    2471     23    2505     63
   2336     89    2370     25    2404     53    2438     80    2472     23    2506     66
   2337     88    2371     25    2405     55    2439     78    2473     23    2507     69
   2338     87    2372     24    2406     58    2440     76    2474     23    2508     71
```

Table 67-B

Stripchart for F5, Series I
31.5 cm H2O, 96 dBA, Page 06

```
STARTING ADDRESS = 1792  ENDING ADDRESS = 1992
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------      ---------      ---------      ---------      ---------      ---------
   1792    62     1826    10     1860    25     1894    61     1928    10     1962    23
   1793    56     1827     9     1861    31     1895    56     1929     9     1963    29
   1794    48     1828     9     1862    39     1896    48     1930     8     1964    38
   1795    40     1829     9     1863    50     1897    40     1931     9     1965    47
   1796    32     1830    10     1864    58     1898    32     1932     9     1966    55
   1797    24     1831    11     1865    63     1899    24     1933    10     1967    63
   1798    18     1832    13     1866    68     1900    17     1934    12     1968    67
   1799    13     1833    17     1867    69     1901    13     1935    15     1969    68
   1800    11     1834    21     1868    67     1902    10     1936    19     1970    67
   1801     9     1835    27     1869    62     1903     9     1937    25     1971    64
   1802     9     1836    35     1870    54     1904     9     1938    31     1972    56
   1803     9     1837    45     1871    46     1905     9     1939    41     1973    48
   1804     9     1838    55     1872    37     1906     9     1940    51     1974    38
   1805    10     1839    61     1873    28     1907     9     1941    57     1975    29
   1806    12     1840    67     1874    21     1908    11     1942    63     1976    21
   1807    15     1841    69     1875    16     1909    13     1943    66     1977    16
   1808    19     1842    69     1876    12     1910    15     1944    66     1978    12
   1809    23     1843    65     1877    10     1911    22     1945    62     1979    10
   1810    31     1844    60     1878     9     1912    29     1946    57     1980     9
   1811    39     1845    52     1879     9     1913    37     1947    50     1981     9
   1812    47     1846    42     1880     9     1914    45     1948    41     1982     9
   1813    58     1847    32     1881     9     1915    53     1949    32     1983    10
   1814    63     1848    24     1882    10     1916    59     1950    24     1984    11
   1815    68     1849    18     1883    12     1917    63     1951    18     1985    13
   1816    68     1850    14     1884    15     1918    65     1952    14     1986    15
   1817    66     1851    11     1885    19     1919    64     1953    11     1987    20
   1818    62     1852    10     1886    26     1920    59     1954     9     1988    27
   1819    54     1853     9     1887    31     1921    53     1955     9     1989    35
   1820    46     1854     9     1888    43     1922    45     1956     9     1990    43
   1821    37     1855     9     1889    51     1923    36     1957     9     1991    53
   1822    28     1856    10     1890    59     1924    28     1958    10     1992    60
   1823    21     1857    12     1891    63     1925    20     1959    11     1993    66
   1824    16     1858    15     1892    66     1926    16     1960    13     1994    69
   1825    12     1859    19     1893    65     1927    12     1961    17     1995    69
```

Table 68-B

Stripchart for F5, Series I
29.0 cm H2O, 86 dBA, Page 07

```
STARTING ADDRESS = 2048  ENDING ADDRESS = 2248
STEP = 1    DATA RATE = 17280

SIX COLUMNS: POINT NUMBER   VALUE

   ---------      ---------      ---------      ---------      ---------      ---------
   2048     0     2082     0     2116     0     2150     0     2184     0     2218     0
   2049     0     2083     0     2117     0     2151     0     2185     0     2219     0
   2050     0     2084     0     2118     0     2152     0     2186     0     2220     0
   2051     0     2085     0     2119     0     2153     0     2187     0     2221     0
   2052     0     2086     0     2120     0     2154     0     2188     0     2222     0
   2053     0     2087     0     2121     0     2155     0     2189     0     2223     0
   2054     0     2088     0     2122     0     2156     0     2190     0     2224     0
   2055     0     2089     0     2123     0     2157     0     2191     0     2225     0
   2056     0     2090     0     2124     0     2158     0     2192     0     2226     0
   2057     0     2091     0     2125     0     2159     0     2193     0     2227     0
   2058     0     2092     0     2126     0     2160     0     2194     0     2228     0
   2059     0     2093     0     2127     0     2161     0     2195     0     2229     0
   2060     0     2094     0     2128     0     2162     0     2196     0     2230     0
   2061     0     2095     0     2129     0     2163     0     2197     0     2231     0
   2062     0     2096     0     2130     0     2164     0     2198     0     2232     0
   2063     0     2097     0     2131     0     2165     0     2199     0     2233     0
   2064     0     2098     0     2132     0     2166     0     2200     0     2234     0
   2065     0     2099     0     2133     0     2167     0     2201     0     2235     0
   2066     0     2100     0     2134     0     2168     0     2202     0     2236     0
   2067     0     2101     0     2135     0     2169     0     2203     0     2237     0
   2068     0     2102     0     2136     0     2170     0     2204     0     2238     0
   2069     0     2103     0     2137     0     2171     0     2205     0     2239     0
   2070     0     2104     0     2138     0     2172     0     2206     0     2240     0
   2071     0     2105     0     2139     0     2173     0     2207     0     2241     0
   2072     0     2106     0     2140     0     2174     0     2208     0     2242     0
   2073     0     2107     0     2141     0     2175     0     2209     0     2243     0
   2074     0     2108     0     2142     0     2176     0     2210     0     2244     0
   2075     0     2109     0     2143     0     2177     0     2211     0     2245     0
   2076     0     2110     0     2144     0     2178     0     2212     0     2246     0
   2077     0     2111     0     2145     0     2179     0     2213     0     2247     0
   2078     0     2112     0     2146     0     2180     0     2214     0     2248     0
   2079     0     2113     0     2147     0     2181     0     2215     0     2249     0
   2080     0     2114     0     2148     0     2182     0     2216     0     2250     0
   2081     0     2115     0     2149     0     2183     0     2217     0     2251     0
```

Table 69-B

Stripchart for Bb5, Series I
24.0 cm H2O, 90 dBA, Page 09

```
STARTING ADDRESS = 2305  ENDING ADDRESS = 2505
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------      ---------      ---------      ---------      ---------      ---------
   2305     16    2339     26    2373     32    2407     31    2441     25    2475     15
   2306     12    2340     22    2374     31    2408     32    2442     27    2476     19
   2307     11    2341     17    2375     28    2409     33    2443     30    2477     23
   2308     11    2342     13    2376     24    2410     32    2444     33    2478     26
   2309     12    2343     11    2377     19    2411     30    2445     34    2479     29
   2310     15    2344     10    2378     15    2412     26    2446     34    2480     31
   2311     18    2345     11    2379     12    2413     22    2447     32    2481     33
   2312     21    2346     13    2380     10    2414     18    2448     30    2482     34
   2313     25    2347     15    2381     10    2415     14    2449     26    2483     33
   2314     28    2348     19    2382     11    2416     11    2450     21    2484     31
   2315     31    2349     23    2383     13    2417     10    2451     16    2485     28
   2316     33    2350     26    2384     16    2418     10    2452     13    2486     24
   2317     34    2351     29    2385     19    2419     12    2453     11    2487     19
   2318     34    2352     31    2386     23    2420     15    2454     10    2488     14
   2319     32    2353     33    2387     26    2421     19    2455     11    2489     12
   2320     29    2354     33    2388     29    2422     22    2456     14    2490     10
   2321     25    2355     33    2389     31    2423     25    2457     17    2491     10
   2322     21    2356     30    2390     32    2424     28    2458     20    2492     12
   2323     16    2357     27    2391     32    2425     30    2459     23    2493     14
   2324     13    2358     23    2392     31    2426     32    2460     27    2494     18
   2325     11    2359     18    2393     28    2427     33    2461     30    2495     21
   2326     10    2360     14    2394     25    2428     33    2462     31    2496     25
   2327     11    2361     11    2395     20    2429     31    2463     34    2497     27
   2328     14    2362     10    2396     16    2430     28    2464     34    2498     30
   2329     17    2363     10    2397     13    2431     24    2465     33    2499     31
   2330     20    2364     12    2398     10    2432     19    2466     30    2500     33
   2331     23    2365     15    2399     10    2433     15    2467     26    2501     33
   2332     27    2366     18    2400     11    2434     12    2468     22    2502     32
   2333     30    2367     21    2401     13    2435     10    2469     18    2503     28
   2334     31    2368     24    2402     15    2436     11    2470     14    2504     24
   2335     33    2369     27    2403     19    2437     12    2471     11    2505     20
   2336     34    2370     30    2404     23    2438     14    2472     10    2506     16
   2337     33    2371     31    2405     25    2439     17    2473     11    2507     12
   2338     30    2372     32    2406     28    2440     21    2474     13    2508     10
```

Table 70-B

Stripchart for Bb5, Series I
25.0 cm H2O, 100 dBA, Page 10

```
STARTING ADDRESS = 2561  ENDING ADDRESS = 2761
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

    ---------     ---------     ---------     ---------     ---------     ---------
    2561   40     2595   37     2629   25     2663   13     2697    4     2731    3
    2562   34     2596   39     2630   29     2664   19     2698    6     2732    3
    2563   26     2597   39     2631   35     2665   23     2699   11     2733    3
    2564   18     2598   36     2632   39     2666   28     2700   15     2734    5
    2565    9     2599   30     2633   40     2667   33     2701   21     2735    7
    2566    4     2600   22     2634   38     2668   39     2702   26     2736   13
    2567    3     2601   13     2635   34     2669   41     2703   31     2737   18
    2568    3     2602    6     2636   26     2670   41     2704   35     2738   23
    2569    3     2603    3     2637   18     2671   38     2705   39     2739   27
    2570    6     2604    3     2638    9     2672   32     2706   41     2740   31
    2571   10     2605    3     2639    4     2673   24     2707   40     2741   37
    2572   15     2606    4     2640    3     2674   14     2708   36     2742   39
    2573   19     2607    7     2641    3     2675    6     2709   28     2743   39
    2574   25     2608   11     2642    3     2676    4     2710   18     2744   36
    2575   30     2609   17     2643    5     2677    3     2711   10     2745   32
    2576   35     2610   22     2644    9     2678    3     2712    5     2746   22
    2577   39     2611   26     2645   14     2679    4     2713    3     2747   13
    2578   41     2612   31     2646   19     2680    7     2714    3     2748    6
    2579   40     2613   35     2647   23     2681   12     2715    3     2749    4
    2580   36     2614   39     2648   29     2682   17     2716    6     2750    3
    2581   28     2615   39     2649   34     2683   23     2717    9     2751    3
    2582   20     2616   37     2650   39     2684   27     2718   15     2752    4
    2583   11     2617   32     2651   40     2685   31     2719   19     2753    7
    2584    5     2618   24     2652   39     2686   37     2720   25     2754   11
    2585    3     2619   16     2653   36     2687   41     2721   29     2755   15
    2586    3     2620    8     2654   28     2688   42     2722   35     2756   21
    2587    3     2621    4     2655   20     2689   39     2723   39     2757   26
    2588    5     2622    3     2656   12     2690   33     2724   41     2758   31
    2589    7     2623    3     2657    5     2691   26     2725   40     2759   35
    2590   13     2624    4     2658    3     2692   16     2726   36     2760   39
    2591   18     2625    7     2659    3     2693    8     2727   29     2761   39
    2592   23     2626   11     2660    3     2694    4     2728   20     2762   37
    2593   27     2627   15     2661    5     2695    3     2729   12     2763   32
    2594   31     2628   21     2662    7     2696    3     2730    5     2764   24
```

Table 71-B

Stripchart for Bb5, Series I
31.0 cm H2O, 100 dBA, Page 11

```
STARTING ADDRESS = 2817  ENDING ADDRESS = 3017
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------        ---------        ---------        ---------        ---------        ---------
   2817     16      2851     32      2885     27      2919      6      2953      3      2987      2
   2818      6      2852     27      2886     31      2920     13      2954      3      2988      3
   2819      3      2853     18      2887     32      2921     23      2955      4      2989      3
   2820      3      2854      9      2888     28      2922     29      2956     11      2990      3
   2821      2      2855      4      2889     22      2923     31      2957     19      2991      3
   2822      2      2856      3      2890     12      2924     29      2958     27      2992      7
   2823      2      2857      3      2891      5      2925     24      2959     31      2993     15
   2824      3      2858      2      2892      3      2926     16      2960     31      2994     26
   2825      3      2859      2      2893      3      2927      8      2961     27      2995     31
   2826      3      2860      2      2894      2      2928      3      2962     20      2996     33
   2827      3      2861      3      2895      2      2929      2      2963     10      2997     30
   2828      6      2862      3      2896      2      2930      2      2964      4      2998     24
   2829     13      2863      3      2897      3      2931      2      2965      3      2999     14
   2830     23      2864      4      2898      3      2932      2      2966      3      3000      6
   2831     29      2865     11      2899      3      2933      2      2967      2      3001      3
   2832     32      2866     21      2900      3      2934      2      2968      2      3002      3
   2833     30      2867     28      2901      7      2935      3      2969      2      3003      2
   2834     25      2868     31      2902     15      2936      3      2970      3      3004      2
   2835     16      2869     32      2903     23      2937      5      2971      3      3005      2
   2836      8      2870     28      2904     29      2938     11      2972      3      3006      3
   2837      3      2871     20      2905     31      2939     21      2973      3      3007      3
   2838      3      2872     10      2906     29      2940     28      2974      9      3008      3
   2839      3      2873      4      2907     22      2941     31      2975     19      3009      3
   2840      2      2874      3      2908     13      2942     30      2976     27      3010      7
   2841      2      2875      3      2909      6      2943     25      2977     31      3011     15
   2842      2      2876      2      2910      3      2944     17      2978     32      3012     23
   2843      3      2877      2      2911      3      2945      8      2979     28      3013     31
   2844      3      2878      2      2912      2      2946      4      2980     21      3014     33
   2845      3      2879      3      2913      2      2947      2      2981     12      3015     30
   2846      5      2880      3      2914      2      2948      3      2982      5      3016     24
   2847     11      2881      3      2915      2      2949      2      2983      3      3017     16
   2848     21      2882      3      2916      2      2950      2      2984      3      3018      8
   2849     29      2883      7      2917      3      2951      2      2985      2      3019      3
   2850     32      2884     18      2918      3      2952      3      2986      2      3020      3
```

Table 72-B

Stripchart for Bb5, Series II
25.0 cm H2O, 90 dBA, Page 02

```
STARTING ADDRESS = 513  ENDING ADDRESS = 713
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

     ---------      ---------      ---------      ---------      ---------      ---------
     513     0      547     0      581     0      615     0      649     0      683     0
     514     0      548     0      582     0      616     0      650     0      684     0
     515     0      549     0      583     0      617     0      651     0      685     0
     516     0      550     0      584     0      618     0      652     0      686     0
     517     0      551     0      585     0      619     0      653     0      687     0
     518     0      552     0      586     0      620     0      654     0      688     0
     519     0      553     0      587     0      621     0      655     0      689     0
     520     0      554     0      588     0      622     0      656     0      690     0
     521     0      555     0      589     0      623     0      657     0      691     0
     522     0      556     0      590     0      624     0      658     0      692     0
     523     0      557     0      591     0      625     0      659     0      693     0
     524     0      558     0      592     0      626     0      660     0      694     0
     525     0      559     0      593     0      627     0      661     0      695     0
     526     0      560     0      594     0      628     0      662     0      696     0
     527     0      561     0      595     0      629     0      663     0      697     0
     528     0      562     0      596     0      630     0      664     0      698     0
     529     0      563     0      597     0      631     0      665     0      699     0
     530     0      564     0      598     0      632     0      666     0      700     0
     531     0      565     0      599     0      633     0      667     0      701     0
     532     0      566     0      600     0      634     0      668     0      702     0
     533     0      567     0      601     0      635     0      669     0      703     0
     534     0      568     0      602     0      636     0      670     0      704     0
     535     0      569     0      603     0      637     0      671     0      705     0
     536     0      570     0      604     0      638     0      672     0      706     0
     537     0      571     0      605     0      639     0      673     0      707     0
     538     0      572     0      606     0      640     0      674     0      708     0
     539     0      573     0      607     0      641     0      675     0      709     0
     540     0      574     0      608     0      642     0      676     0      710     0
     541     0      575     0      609     0      643     0      677     0      711     0
     542     0      576     0      610     0      644     0      678     0      712     0
     543     0      577     0      611     0      645     0      679     0      713     0
     544     0      578     0      612     0      646     0      680     0      714     0
     545     0      579     0      613     0      647     0      681     0      715     0
     546     0      580     0      614     0      648     0      682     0      716     0
```

Table 73-B

Stripchart for Bb5, Series II
25.6 cm H2O, 96 dBA, Page 04

```
STARTING ADDRESS = 1025  ENDING ADDRESS = 1225
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------        ---------        ---------        ---------        ---------        ---------
   1025      0      1059      0      1093      0      1127      0      1161      0      1195      0
   1026      0      1060      0      1094      0      1128      0      1162      0      1196      0
   1027      0      1061      0      1095      0      1129      0      1163      0      1197      0
   1028      0      1062      0      1096      0      1130      0      1164      0      1198      0
   1029      0      1063      0      1097      0      1131      0      1165      0      1199      0
   1030      0      1064      0      1098      0      1132      0      1166      0      1200      0
   1031      0      1065      0      1099      0      1133      0      1167      0      1201      0
   1032      0      1066      0      1100      0      1134      0      1168      0      1202      0
   1033      0      1067      0      1101      0      1135      0      1169      0      1203      0
   1034      0      1068      0      1102      0      1136      0      1170      0      1204      0
   1035      0      1069      0      1103      0      1137      0      1171      0      1205      0
   1036      0      1070      0      1104      0      1138      0      1172      0      1206      0
   1037      0      1071      0      1105      0      1139      0      1173      0      1207      0
   1038      0      1072      0      1106      0      1140      0      1174      0      1208      0
   1039      0      1073      0      1107      0      1141      0      1175      0      1209      0
   1040      0      1074      0      1108      0      1142      0      1176      0      1210      0
   1041      0      1075      0      1109      0      1143      0      1177      0      1211      0
   1042      0      1076      0      1110      0      1144      0      1178      0      1212      0
   1043      0      1077      0      1111      0      1145      0      1179      0      1213      0
   1044      0      1078      0      1112      0      1146      0      1180      0      1214      0
   1045      0      1079      0      1113      0      1147      0      1181      0      1215      0
   1046      0      1080      0      1114      0      1148      0      1182      0      1216      0
   1047      0      1081      0      1115      0      1149      0      1183      0      1217      0
   1048      0      1082      0      1116      0      1150      0      1184      0      1218      0
   1049      0      1083      0      1117      0      1151      0      1185      0      1219      0
   1050      0      1084      0      1118      0      1152      0      1186      0      1220      0
   1051      0      1085      0      1119      0      1153      0      1187      0      1221      0
   1052      0      1086      0      1120      0      1154      0      1188      0      1222      0
   1053      0      1087      0      1121      0      1155      0      1189      0      1223      0
   1054      0      1088      0      1122      0      1156      0      1190      0      1224      0
   1055      0      1089      0      1123      0      1157      0      1191      0      1225      0
   1056      0      1090      0      1124      0      1158      0      1192      0      1226      0
   1057      0      1091      0      1125      0      1159      0      1193      0      1227      0
   1058      0      1092      0      1126      0      1160      0      1194      0      1228      0
```

Table 74-B

Stripchart for Bb5, Series II
26.0 cm H2O, 100 dBA, Page 06

```
STARTING ADDRESS = 1537  ENDING ADDRESS = 1737
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------    ---------    ---------    ---------    ---------    ---------
 1537     0   1571     0   1605     0   1639     0   1673     0   1707     0
 1538     0   1572     0   1606     0   1640     0   1674     0   1708     0
 1539     0   1573     0   1607     0   1641     0   1675     0   1709     0
 1540     0   1574     0   1608     0   1642     0   1676     0   1710     0
 1541     0   1575     0   1609     0   1643     0   1677     0   1711     0
 1542     0   1576     0   1610     0   1644     0   1678     0   1712     0
 1543     0   1577     0   1611     0   1645     0   1679     0   1713     0
 1544     0   1578     0   1612     0   1646     0   1680     0   1714     0
 1545     0   1579     0   1613     0   1647     0   1681     0   1715     0
 1546     0   1580     0   1614     0   1648     0   1682     0   1716     0
 1547     0   1581     0   1615     0   1649     0   1683     0   1717     0
 1548     0   1582     0   1616     0   1650     0   1684     0   1718     0
 1549     0   1583     0   1617     0   1651     0   1685     0   1719     0
 1550     0   1584     0   1618     0   1652     0   1686     0   1720     0
 1551     0   1585     0   1619     0   1653     0   1687     0   1721     0
 1552     0   1586     0   1620     0   1654     0   1688     0   1722     0
 1553     0   1587     0   1621     0   1655     0   1689     0   1723     0
 1554     0   1588     0   1622     0   1656     0   1690     0   1724     0
 1555     0   1589     0   1623     0   1657     0   1691     0   1725     0
 1556     0   1590     0   1624     0   1658     0   1692     0   1726     0
 1557     0   1591     0   1625     0   1659     0   1693     0   1727     0
 1558     0   1592     0   1626     0   1660     0   1694     0   1728     0
 1559     0   1593     0   1627     0   1661     0   1695     0   1729     0
 1560     0   1594     0   1628     0   1662     0   1696     0   1730     0
 1561     0   1595     0   1629     0   1663     0   1697     0   1731     0
 1562     0   1596     0   1630     0   1664     0   1698     0   1732     0
 1563     0   1597     0   1631     0   1665     0   1699     0   1733     0
 1564     0   1598     0   1632     0   1666     0   1700     0   1734     0
 1565     0   1599     0   1633     0   1667     0   1701     0   1735     0
 1566     0   1600     0   1634     0   1668     0   1702     0   1736     0
 1567     0   1601     0   1635     0   1669     0   1703     0   1737     0
 1568     0   1602     0   1636     0   1670     0   1704     0   1738     0
 1569     0   1603     0   1637     0   1671     0   1705     0   1739     0
 1570     0   1604     0   1638     0   1672     0   1706     0   1740     0
```

Table 75-B

Stripchart for Bb5, Series II
39.0 cm H2O, 105 dBA, Page 08

```
STARTING ADDRESS = 2049  ENDING ADDRESS = 2249
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------       ---------       ---------       ---------       ---------       ---------
   2049     0      2083     0      2117     0      2151     0      2185     0      2219     0
   2050     0      2084     0      2118     0      2152     0      2186     0      2220     0
   2051     0      2085     0      2119     0      2153     0      2187     0      2221     0
   2052     0      2086     0      2120     0      2154     0      2188     0      2222     0
   2053     0      2087     0      2121     0      2155     0      2189     0      2223     0
   2054     0      2088     0      2122     0      2156     0      2190     0      2224     0
   2055     0      2089     0      2123     0      2157     0      2191     0      2225     0
   2056     0      2090     0      2124     0      2158     0      2192     0      2226     0
   2057     0      2091     0      2125     0      2159     0      2193     0      2227     0
   2058     0      2092     0      2126     0      2160     0      2194     0      2228     0
   2059     0      2093     0      2127     0      2161     0      2195     0      2229     0
   2060     0      2094     0      2128     0      2162     0      2196     0      2230     0
   2061     0      2095     0      2129     0      2163     0      2197     0      2231     0
   2062     0      2096     0      2130     0      2164     0      2198     0      2232     0
   2063     0      2097     0      2131     0      2165     0      2199     0      2233     0
   2064     0      2098     0      2132     0      2166     0      2200     0      2234     0
   2065     0      2099     0      2133     0      2167     0      2201     0      2235     0
   2066     0      2100     0      2134     0      2168     0      2202     0      2236     0
   2067     0      2101     0      2135     0      2169     0      2203     0      2237     0
   2068     0      2102     0      2136     0      2170     0      2204     0      2238     0
   2069     0      2103     0      2137     0      2171     0      2205     0      2239     0
   2070     0      2104     0      2138     0      2172     0      2206     0      2240     0
   2071     0      2105     0      2139     0      2173     0      2207     0      2241     0
   2072     0      2106     0      2140     0      2174     0      2208     0      2242     0
   2073     0      2107     0      2141     0      2175     0      2209     0      2243     0
   2074     0      2108     0      2142     0      2176     0      2210     0      2244     0
   2075     0      2109     0      2143     0      2177     0      2211     0      2245     0
   2076     0      2110     0      2144     0      2178     0      2212     0      2246     0
   2077     0      2111     0      2145     0      2179     0      2213     0      2247     0
   2078     0      2112     0      2146     0      2180     0      2214     0      2248     0
   2079     0      2113     0      2147     0      2181     0      2215     0      2249     0
   2080     0      2114     0      2148     0      2182     0      2216     0      2250     0
   2081     0      2115     0      2149     0      2183     0      2217     0      2251     0
   2082     0      2116     0      2150     0      2184     0      2218     0      2252     0
```

Table 76-B

Stripchart for F6, Series I
29.5 cm H2O, 100 dBA, Page 00

STARTING ADDRESS = 0 ENDING ADDRESS = 200
STEP = 1 DATA RATE = 17280

SIX COLUMNS: POINT NUMBER VALUE

0	82	34	83	68	84	102	85	136	81	170	85
1	82	35	85	69	82	103	83	137	81	171	86
2	82	36	87	70	82	104	83	138	82	172	85
3	83	37	86	71	83	105	80	139	83	173	84
4	84	38	85	72	86	106	78	140	84	174	85
5	85	39	85	73	87	107	79	141	82	175	86
6	83	40	87	74	85	108	79	142	81	176	87
7	80	41	88	75	85	109	83	143	78	177	87
8	79	42	88	76	85	110	83	144	79	178	85
9	79	43	86	77	86	111	82	145	80	179	83
10	81	44	83	78	87	112	81	146	83	180	82
11	84	45	82	79	86	113	82	147	83	181	83
12	84	46	83	80	84	114	83	148	82	182	85
13	83	47	85	81	82	115	84	149	82	183	87
14	83	48	87	82	80	116	83	150	83	184	86
15	83	49	87	83	81	117	80	151	84	185	85
16	85	50	86	84	84	118	78	152	85	186	86
17	86	51	86	85	86	119	78	153	84	187	87
18	85	52	87	86	84	120	79	154	81	188	88
19	82	53	88	87	83	121	81	155	79	189	89
20	80	54	89	88	83	122	83	156	79	190	86
21	80	55	87	89	84	123	81	157	81	191	84
22	82	56	84	90	86	124	81	158	84	192	83
23	85	57	82	91	86	125	81	159	85	193	83
24	86	58	83	92	83	126	82	160	83	194	85
25	84	59	84	93	81	127	83	161	83	195	87
26	84	60	87	94	79	128	83	162	83	196	87
27	85	61	87	95	79	129	80	163	85	197	86
28	86	62	86	96	82	130	78	164	86	198	86
29	87	63	85	97	84	131	77	165	85	199	87
30	86	64	86	98	84	132	78	166	83	200	88
31	84	65	87	99	82	133	81	167	81	201	89
32	82	66	88	100	82	134	83	168	80	202	87
33	81	67	87	101	83	135	82	169	82	203	85

Table 77-B

Stripchart for F6, Series I
23.5 cm H2O, 96 dBA, Page 01

```
STARTING ADDRESS = 257  ENDING ADDRESS = 457
STEP = 1    DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

 ---------      ---------      ---------      ---------      ---------      ---------
 257      0     291      0     325      0     359      0     393      0     427      0
 258      0     292      0     326      0     360      0     394      0     428      0
 259      0     293      0     327      0     361      0     395      0     429      0
 260      0     294      0     328      0     362      0     396      0     430      0
 261      0     295      0     329      0     363      0     397      0     431      0
 262      0     296      0     330      0     364      0     398      0     432      0
 263      0     297      0     331      0     365      0     399      0     433      0
 264      0     298      0     332      0     366      0     400      0     434      0
 265      0     299      0     333      0     367      0     401      0     435      0
 266      0     300      0     334      0     368      0     402      0     436      0
 267      0     301      0     335      0     369      0     403      0     437      0
 268      0     302      0     336      0     370      0     404      0     438      0
 269      0     303      0     337      0     371      0     405      0     439      0
 270      0     304      0     338      0     372      0     406      0     440      0
 271      0     305      0     339      0     373      0     407      0     441      0
 272      0     306      0     340      0     374      0     408      0     442      0
 273      0     307      0     341      0     375      0     409      0     443      0
 274      0     308      0     342      0     376      0     410      0     444      0
 275      0     309      0     343      0     377      0     411      0     445      0
 276      0     310      0     344      0     378      0     412      0     446      0
 277      0     311      0     345      0     379      0     413      0     447      0
 278      0     312      0     346      0     380      0     414      0     448      0
 279      0     313      0     347      0     381      0     415      0     449      0
 280      0     314      0     348      0     382      0     416      0     450      0
 281      0     315      0     349      0     383      0     417      0     451      0
 282      0     316      0     350      0     384      0     418      0     452      0
 283      0     317      0     351      0     385      0     419      0     453      0
 284      0     318      0     352      0     386      0     420      0     454      0
 285      0     319      0     353      0     387      0     421      0     455      0
 286      0     320      0     354      0     388      0     422      0     456      0
 287      0     321      0     355      0     389      0     423      0     457      0
 288      0     322      0     356      0     390      0     424      0     458      0
 289      0     323      0     357      0     391      0     425      0     459      0
 290      0     324      0     358      0     392      0     426      0     460      0
```

Table 78-B

Stripchart for F3, Series III
Threshold Sound at High Lip Pressure
26.0 cm H20, Gain 10
F3, T3, 06

```
STARTING ADDRESS = 1537  ENDING ADDRESS = 1737
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

   ---------      ---------      ---------      ---------      ---------      ---------
   1537   16     1571   49     1605   17     1639   12     1673   47     1707   25
   1538   14     1572   48     1606   19     1640   11     1674   45     1708   27
   1539   13     1573   47     1607   21     1641   11     1675   42     1709   31
   1540   12     1574   46     1608   23     1642   11     1676   39     1710   34
   1541   11     1575   44     1609   26     1643   10     1677   36     1711   37
   1542   11     1576   41     1610   29     1644   10     1678   32     1712   40
   1543   10     1577   39     1611   33     1645   10     1679   29     1713   43
   1544   10     1578   36     1612   37     1646   11     1680   26     1714   45
   1545   10     1579   32     1613   39     1647   11     1681   23     1715   47
   1546   10     1580   29     1614   43     1648   11     1682   21     1716   49
   1547   10     1581   27     1615   46     1649   12     1683   19     1717   50
   1548   10     1582   24     1616   49     1650   12     1684   17     1718   50
   1549   11     1583   22     1617   50     1651   13     1685   15     1719   50
   1550   11     1584   19     1618   51     1652   14     1686   14     1720   48
   1551   11     1585   17     1619   52     1653   15     1687   12     1721   47
   1552   12     1586   16     1620   52     1654   17     1688   12     1722   45
   1553   13     1587   14     1621   52     1655   19     1689   11     1723   43
   1554   14     1588   13     1622   51     1656   21     1690   10     1724   40
   1555   15     1589   12     1623   50     1657   23     1691   10     1725   38
   1556   17     1590   11     1624   48     1658   26     1692   10     1726   35
   1557   19     1591   11     1625   45     1659   29     1693   10     1727   32
   1558   21     1592   10     1626   42     1660   31     1694   10     1728   29
   1559   23     1593   10     1627   39     1661   36     1695   10     1729   26
   1560   26     1594   10     1628   36     1662   39     1696   10     1730   23
   1561   29     1595   10     1629   32     1663   43     1697   11     1731   21
   1562   31     1596   10     1630   29     1664   45     1698   11     1732   18
   1563   35     1597   10     1631   26     1665   47     1699   11     1733   16
   1564   38     1598   10     1632   24     1666   50     1700   13     1734   15
   1565   41     1599   11     1633   21     1667   51     1701   13     1735   14
   1566   43     1600   11     1634   19     1668   52     1702   15     1736   13
   1567   45     1601   12     1635   17     1669   52     1703   16     1737   12
   1568   47     1602   13     1636   15     1670   52     1704   18     1738   11
   1569   48     1603   14     1637   14     1671   51     1705   20     1739   10
   1570   49     1604   12     1638   13     1672   49     1706   23     1740   10
```

Table 79-B

Stripchart for F3, Series III
Threshold Sound at Low Lip Pressure
24.5 cm H20, Gain 10
F3, T3, 07

```
STARTING ADDRESS = 1793  ENDING ADDRESS = 1993
STEP = 1   DATA RATE = 6983

SIX COLUMNS: POINT NUMBER   VALUE

  ---------      ---------      ---------      ---------      ---------      ---------
  1793    62     1827    53     1861    90     1895    69     1929    46     1963    83
  1794    65     1828    51     1862    88     1896    72     1930    45     1964    80
  1795    68     1829    49     1863    85     1897    75     1931    45     1965    77
  1796    69     1830    48     1864    82     1898    78     1932    46     1966    74
  1797    71     1831    48     1865    80     1899    79     1933    46     1967    70
  1798    75     1832    48     1866    77     1900    82     1934    47     1968    68
  1799    77     1833    48     1867    74     1901    83     1935    49     1969    65
  1800    79     1834    49     1868    70     1902    86     1936    50     1970    62
  1801    83     1835    50     1869    68     1903    87     1937    52     1971    60
  1802    87     1836    50     1870    64     1904    89     1938    55     1972    58
  1803    89     1837    51     1871    62     1905    91     1939    56     1973    56
  1804    90     1838    53     1872    60     1906    91     1940    59     1974    54
  1805    92     1839    55     1873    57     1907    92     1941    63     1975    53
  1806    94     1840    58     1874    55     1908    92     1942    67     1976    51
  1807    95     1841    61     1875    53     1909    90     1943    70     1977    49
  1808    96     1842    63     1876    51     1910    89     1944    72     1978    49
  1809    96     1843    66     1877    49     1911    87     1945    75     1979    49
  1810    94     1844    69     1878    47     1912    84     1946    79     1980    48
  1811    93     1845    71     1879    45     1913    81     1947    81     1981    48
  1812    91     1846    75     1880    45     1914    78     1948    83     1982    49
  1813    88     1847    77     1881    45     1915    75     1949    86     1983    49
  1814    86     1848    79     1882    44     1916    72     1950    87     1984    50
  1815    84     1849    83     1883    45     1917    69     1951    89     1985    51
  1816    81     1850    85     1884    45     1918    66     1952    91     1986    53
  1817    78     1851    87     1885    46     1919    63     1953    91     1987    56
  1818    75     1852    89     1886    48     1920    60     1954    93     1988    59
  1819    72     1853    90     1887    50     1921    58     1955    94     1989    62
  1820    69     1854    92     1888    52     1922    57     1956    95     1990    65
  1821    66     1855    94     1889    55     1923    55     1957    95     1991    67
  1822    64     1856    95     1890    57     1924    53     1958    95     1992    70
  1823    62     1857    95     1891    60     1925    51     1959    93     1993    73
  1824    60     1858    95     1892    63     1926    50     1960    91     1994    75
  1825    58     1859    94     1893    65     1927    48     1961    88     1995    79
  1826    56     1860    92     1894    67     1928    47     1962    85     1996    81
```

APPENDIX C

NATURAL BLOWING PRESSURES

Analyses of Natural Blowing Pressure Tests

It was observed that with the A-weighted scale in operation, the fortissimo of 100 DbA measured by the sound-level meter was not always in accordance with the subjective dynamic sensitivity of the ear of the performer. A chromatic scale was played slowly (quarter note = mm40) (by human means) and tape recorded while maintaining a constant 100 DbA. Upon playback, it was very noticeable that the scale did not sound dynamically consistent to the writer, although most of the pitches sounded within the mf to ff range. The blowing pressures observed are listed in Table C-1. The pitches listed are transposed (i.e. E3 would sound D3).

Table C-1

Mouth Pressures for Various Pitches of High Intensity

Pitch	cm H20	Pitch	cm H20
E3	53.0	C5	42.0
F3	51.0	C#5	44.0
F#3	51.0	D5	51.0
G3	44.0	D#5	37.0
G#3	48.0	E5	37.0
A3	51.0	F5	37.0
A#3	42.0	F#5	39.0
B3	44.0	G5	35.0
C4	48.0	G#5	35.0
C#4	62.0	A5	33.0
D4	48.0	A#5	33.0
D#4	48.0	B5	28.0
E4	42.0	C6	30.5
F4	46.0	C#6	30.5
F#4	51.0	D6	28.0
G4	46.0	D#6	28.0
G#4	46.0	E6	28.0
A4	46.0	F6	30.5
A#4	60.0	F#6	30.5
B4	42.0	G6	33.0

There was a noticeable decrease in the amount of air pressure required to maintain the same intensity level in the low and high registers. It was noted that specific pitches required more air pressure to maintain an equal intensity level with neighboring pitches. These pitches (C#4, F#4, A#4, D5) are notorious among clarinetists as being "bad" tones on the Boehm system clarinet in terms of tone quality. An example is C#4, which required 62 cm H20, as compared to pitches in close proximity to it, C4 and D4, each of which required 48 cm H20. Similar cases may be found for F#4, A#4, and D5.

Pressures used by McGinnis and Gallagher (1940) ranged from 1.6 cm to 3.6 cm of mercury. Converted into centimeters of water, this would be equivalent to a range of 22 cm to 49 cm:

Density of H20 = 1.000 g/cm3
Density of Hg = 13.55 g/cm3

1.6 cm Hg x 13.55 = 21.68 cm H20
3.6 cm Hg x 13.55 = 48.78 cm H20

Backus (1961) found that blowing pressure for a clarinet as sounded by an artificial embouchure was between 5 and 20 inches of water (10-40 mm Hg). Converted to cm H20, this would represent a range of 13 cm H20 to 52 cm H20.

5 inches H20 x 2.6 cm/inch = 13 cm H20
20 inches H20 x 2.6 cm/inch = 52 cm H20
or:
10 mm Hg (1 cm Hg) x 13.55 = 13.55 cm H20
40 mm Hg (4 cm Hg) x 13.55 = 54.20 cm H20

Backus noted that "the same range of pressures is required for blowing the clarinet by mouth" (p. 806).

An average range of blowing pressure for the clarinet was reported by Broadhouse (1892) as being "15 to 18 inches of water" (p. 229). Mooney (1968) concluded that "clarinetists use slightly different air pressures in the mouth to produce tones at the same "volume" and pitch. Air pressure decreases as the high register is approached" (p. 2742). Bouhuys (1964) noted that "measurements of mouth pressures and air-flow rates during play on various wind instruments have shown a wide range of variability. In most instruments, mouth pressures increase with both frequency and sound output" (p. 453). This would seem to be in disagreement with findings of Bouhuys as well as with the findings above. In summary, it was observed that air-pressure requirements for sounding a clarinet via an aritificial-embouchure device were consistent with air-pressure requirements for a clarinet as blown by a human.

APPENDIX D

U.S.A. STANDARDS ASSOCIATION OCTAVE NOTATION

U.S.A. Standards Association Octave Notation