The following article is the fourth in a series by L. Hugh Cooper (1920-2007). He was a Professor of Music (Bassoon) at the University of Michigan from 1945 to 1997, and a charter member of the International Double Reed Society.

Variable Damping: Window of Expressive Opportunity

L. Hugh Cooper with Mark Avery and Mark Clague
Decatur, Illinois

Damping is a term used to describe the resultant effect(s) that are produced by any element whose influence serves to reduce the vigor of oscillation of an oscillatory body. In short, damping is friction. Acoustic damping specifically reflects the various types and sources of any acoustic friction present during a sonic event. An acoustic oscillatory system's amplitude (acoustic power) varies indirectly with the level of damping introduced into the system: more damping = less amplitude (acoustic power); less damping = more amplitude (acoustic power). While a direct relationship exists between introduced damping and the oscillary system's "frequency response band width" (pitch, dynamic, and timbral flexibility): increased damping = increased flexibility; decreased damping = decreased flexibility.

The following two widely divergent hypothetical oscillatory systems would theoretically produce the following bizarre acoustic results.

1. Totally damped systems = infinitely broad "frequency response bandwidth," resulting in equal response amplitude at all frequencies. However, unfortunately the instrument's resonance response amplitude would be zero at all frequencies (sort of the ultimate in muting).
2. Totally un-damped systems = infinite response amplitude achieved only at an infinitely narrow, discrete frequency bandwidth (the sonic equivalent of a lethal laser beam).

Obviously neither extreme polarity of function is musically useful. Long before the un-damped system arrives at its maximum amplitude the enormous power potential of its acoustic standing wave will have reached a lethal level and destroyed the reed, instrument, player, and performance venue. Conversely, the totally damped version would refuse to sound at any frequency, regardless of the level of energerial input.

Somewhere between the two extremes lies a relatively narrow musically useful spectral range of acoustic damping, essential to the art of transforming notes into music. This narrow window of opportunity represents the realm of "musical damping" through which all refining musical expression must pass.

Viable musical instruments (including double reeds) must of necessity include an appropriate amount of acoustic damping within their basic design. Too little damping will result in a super efficient but dominating, inflexible, difficult to control acoustic monster. While too much creates an inefficient, resistant, non-projective acoustic "wimp," incapable of responding fully to the demands of expressive musical nuance. Musical instruments by design or fortuitous happenstance that target this narrow area of acceptability are eagerly sought out by experienced artist performers. The prime determinate of instrument quality is the proper proportionate mix of damping introduced within its design. Sources of instrumental damping built in by design are numerous and include, but are not limited to the following:

1. Bore damping (diameter and contour)
2. Tone-hole damping (diameter, chimney length, and contour)
3. Wall damping (smooth reflective surfaces versus rough)
4. Hermetic damping (porosity of surfaces/diffused leaks)
5. Pad clearance and reflectivity
6. Bocal choice (bore, material, wall thickness, and plating)
7. Choice of reed type (relatively damped or un-damped)

With the exception of the reed all of the above sources of damping are static in nature and not amenable to change or control by the performer during a performance. Individual musicians as creatures of their environment vary in their instrumental preference. Solo recording artists, studio musicians, and chamber players usually prefer a more damped, less vibrant instrument/reed combination, because the intimate nature of their venue (the proximity of the microphone or audience) requires less projection and the elimination of extraneous noise (dark sound).

It is often disappointing to hear a live performance by a virtuoso recording artist, whose unamplified, highly damped sound doesn't project beyond the footlights. Or whose beautiful homogeneous quality of tone, without benefit of a sound engineer, is limited to a 10–15 decibel dynamic excursion, barely enough to express two dynamic levels. Actually some players utilize reeds so linearly damped in nature that any embouchure set (even one up over the wires) produces the same severally limited pitch, timbral, and dynamic result. Surprisingly, these same individuals often extol the inflexibility of these limited spectrum reeds as a virtue.

In contrast to the above, an orchestral player performing principally in a large concert hall without benefit of amplification will probably choose a less damped instrument/reed combination. However, without some method of varying the amount of damping during a performance, the available dynamic range although generally louder will still be limited in its scope to a less than 10–15 decibel dynamic excursion, necessitating an assortment of dramatically different reeds individualized in size and trim to satisfy the varied, yet specific demands of dynamic, timbral, and pitch nuance.

Neither of the aforementioned approaches proves adequate for effective musical expression. True articulative nuance (what many people call phrasing or musicality) requires a constant streaming of varied dynamics, timbral coloration, and micro pitch-leading to sustain the listener's interest. Change of any nature intrigues the human mind (essentially, an analytic scanning organ), but once a new phenomenon's impact is perceived as benign it becomes just another mundane status-quo happening. As a result, aspiring musicians must strive to develop and use the broadest possible flexibility in the areas of dynamics, timbral, and pitch nuance. Those individuals achieving the widest latitude in the above three areas possess the greatest potential for maximizing musical expression.

Certainly visual artists, regardless of their talent, would have difficulty portraying a varied landscape while using only one shade of brown as, no matter how appropriate for rocks and tree trunks, brown would fail miserably if called upon to depict green grass and blue sky. Yet many woodwind instrumentalists persist in using one limited tonal concept with its restricted dynamic range regardless of the musical nature of the passage being performed. For example, should the somber opening of Tchaikovsky's Sixth Symphony be expressed using the same dynamic/timbral approach used in Prokofiev's Peter and the Wolf? The author thinks not! To do so would represent a disservice to one or probably both compositions.

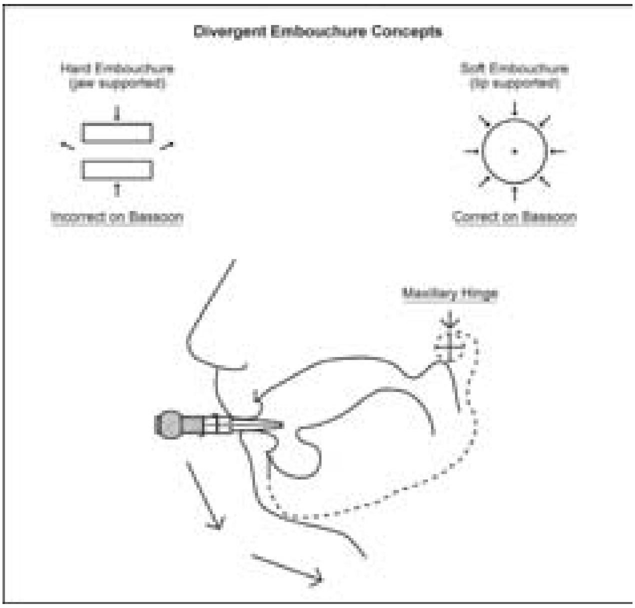
In actuality there is no such thing as a good sound, only dynamic/timbral statements appropriate for the passage involved, ideally consisting of variable sounds produced by an open-minded artist musician using a flexible reed in conjunction with a pro-active embouchure/breath relationship. It is only at this potentially creative juncture between an artist's embouchure and a malleable reed that the extent of damping and therefore musical nuance may be varied at will during performance. There is a growing contingent of players who are already reaping the benefits of variable damping. Hopefully, the following specific information regarding its benefits will serve to augment their ranks.

Variable Damping represents the terminology used by the author to collectively describe the four categories of embouchure control available for manipulating the extent of damping present at any point in time during an actual performance.

The embouchure's four controlling modes are: vertical cushioning, horizontal cushioning, horizontal torquing, and rotary torquing. Each of these four forms of embouchure control may be used individually (as is too often the case) or more efficiently combined in various admixtures to greater advantage. If used individually none of the four controlling embouchure modes will provide a sufficient change in variable damping to satisfy the expressive demands of musical nuance. Only when all four categories are combined in various configurations and then coordinated with a proactive breath-line can the necessary dynamic/timbral excursions of music be met. To believe otherwise is to perpetuate the long-standing prevailing myth that double reed instruments are incapable of effectively expressing dynamic nuance.

CUSHIONING

1. Vertical Cushioning is by far the most prevalent form of variable damping (albeit the least effective when applied alone), but sadly, is utilized discretely by many individuals to the exclusion of all other modes.



Vertical cushioning, when properly implemented, involves using a soft lip-supported embouchure to bring more or less inner-lip into contact with both upper and lower reed blade surfaces. Ideally, any increase (more damping) or decrease (less damping) in lip area contacting the reed blades should be accomplished with minimal fluctuation in the vertical pressure exerted on the reed.

Regardless of intent there is always some change in the vertical pressure exerted on the blades, which in turn directly affects the tip aperture opening and the reed's "static volume" (see Cooper, L. Hugh and Avery, Mark. "Reed Contribution," *The Double Reed*, Vol. 13, No. 3, Winter 1991, p. 59). These physical changes in the reed's inner capacity have a direct impact on its tuning characteristics: more vertical cushioning = higher frequency; less vertical cushioning = lower frequency.

As accuracy in tuning occupies a higher priority among teachers and/or conductors than dynamic/timbral considerations, the struggling neophyte student soon abandons any semblance of variable embouchure control and stays out of major trouble by using a single inflexible jaw-supported embouchure set under all circumstances—relying instead on stiff, heavy, linearly-damped reeds used in conjunction with a "skin of the teeth" jaw-supported embouchure. Unfortunately, this diminishing resultant approach drastically limits the extent of dynamic/timbral nuance, resulting in monotonous single dynamic level performances with their inevitable timbral limitation.

The author is convinced that such early negative experience with variable embouchure damping has resulted in several generations of otherwise extremely competent double reed artists with a severely limited dynamic/timbral range. These individuals have over time been successful in convincing conductors that restricted dynamic nuance (in some documented instances only 6 dB) is the norm for double reeds. The conductors in turn have reluctantly condoned this "sin of dynamic omission" within their double reed sections.

The author is equally convinced that, although never able to compete with the brass sections, double reeds are fully capable of producing a decibel range that will accommodate the minimum 30 dB excursion needed to express our basic six-tiered dynamic system (*pianissimo–fortissimo*), and in fact, are demonstrably capable of producing the "ideal" 50 dB dynamic excursion. (See Blake Patterson's article "Musical Dynamics" in *The Scientific American* magazine, November 1974, pages 78–95.)

The dynamic/timbral limitation isn't inherent in the instrument's design, but rather is attributed to a current mindset that chooses to sacrifice dynamic capability on the altar of homogeneous sound. Although pure conjecture, it is the author's suspicion that the beautiful subdued homogeneous American band sound has served to influence the damping down of American wind players. For certain, the many young woodwind students clinically tested with a decibel meter by the author, demonstrated on average, less than a 15 dB excursion between their softest and loudest efforts.

For those readers who would argue that they express dynamic nuance through timbral variance, rather than by decibel excursion, the author hastens to point out that controlled studies of the musical dynamic phenomenon have confirmed that individuals with the greatest decibel range also possess the greatest timbral variance, while those with the least timbral variance also have the least decibel excursion. No exception was found refuting the direct relationship existing between decibel level and timbral enhancement. To believe otherwise is a form of self-delusion. (See Lehman, Paul R. *The Harmonic Structure of the Tone of the Bassoon.* Ph.D. dissertation. University of Michigan, 1962. Published by Berdon Company, Seattle, Washington, 1965.)

Limiting oneself to using only the single embouchure mode of "vertical cushioning" precludes achieving a dynamic/timbral range sufficient to satisfy the requirements of musical expression. At the very least vertical cushioning *must* be accompanied by a compensatory amount of horizontal cushioning. You can't have one without the other, unless you are willing to accept severely limited dynamic/timbral expressions or worse, experiencing widely divergent tuning disparities.

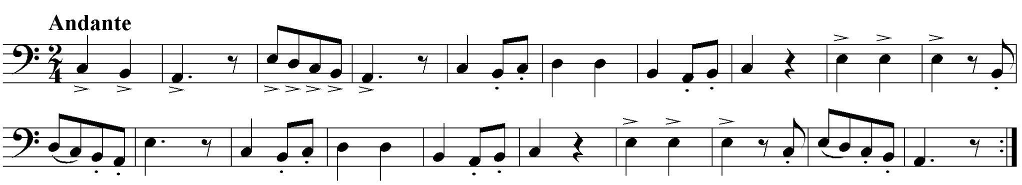
2. Horizontal Cushioning: This compensatory companion of vertical cushioning allows double the damping to be used without incurring commensurate shifts in tuning (the limiting factor when vertical cushioning is used alone).

For every micro-ounce of variance in vertical pressure exerted on the reed blades, there ideally should be an equivalent fluctuation in the lateral pressure imposed along the rails by horizontal cushioning. Through this means the tip aperture along with its resultant pitch center remains relatively consistent even when using meaningful dynamic/timbral excursions.

In addition to maintaining a constant pitch level the available range of damping is effectively increased. Vertical cushioning continues to damp out unwanted vibration of the blade surfaces, while horizontal cushioning damps out the low frequency periodic noise factors generated along the rails.

A properly combined vertically/horizontally cushioned embouchure may be compared to a friendly, warm, but firm enveloping handshake, while a hard, lip-over the teeth, jaw-supported embouchure may be likened to the forceful but uninvolved impact of an exuberant "high five." Sharing one friendly handshake with a student will demonstrate the above analogy better than any written description, as also does cradling the blades of a reed in the crook of a curved index finger.

Ideally all four modes of variable damping should be demonstrated when introducing the low A-natural in the third lesson of Julius Weissenborn's *Method for the Bassoon.* This early lesson which introduces the typically harsh sounding low A-natural offers an ideal opportunity not only to demonstrate the effectiveness of variable damping, but more importantly, serves as an excellent vehicle in which to inculcate a student with a sense of personal responsibility for the quality of sound emanating from his or her instrument.



To this end students must be taught early on that they are individually accountable for whatever sounds emerge from the instrument, and, if necessary, be willing to stand on their head in the corner and wiggle their left ear to achieve acceptable musical results. Rather than figuratively wiggling ears the student is first introduced to "vertical and horizontal" cushioning, two lip induced forms of variable damping that are truly effective only when paired in a balanced coordinated manner.

As a paired controlling entity their functional usage may be demonstrated during the course of a single lesson. However, although these uncomplicated techniques are easily demonstrated, they prove difficult and wordy to describe. The following procedures reflect in detail the methodology used by the author when introducing the four modes of "variable damping."

At this early stage of development a basic "warm-up" exercise should always precede the introduction of new material. This first step involves having the student relax his or her embouchure sufficiently to produce a stable second space B-natural while fingering the adjacent upper neighbor C-natural. The student is then encouraged to increase his or her abdominal breath support until the sustained flatted pitch (B-natural) literally "jumps-up" the necessary half-step to produce a full resonant, stable, breath supported second-space C-natural. This warm-up process should be utilized by students prior to all other activity both during their lessons and individual practice. This process ensures the use of a proper relaxed lip-supported embouchure in conjunction with abdominal breath support even prior to adequate development of the student's potentially strong orbicularis ring musculature**.** Students, if left to chance, will invariably opt to use their already strong, well developed jaw muscles to "bite" on the reed with a jaw-supported hard embouchure to maintain the pitch center as opposed to utilizing a relaxed embouchure with abdominal breath support.

Following the above preliminary "warm-up" approach to C-natural, the student is introduced to combined vertical/horizontal cushioning by having to play the first two measures of Weissenborn's third lesson (see above), slurring slowly down from a prepared second space C-natural, through B-natural, to a sustained low A-natural. As this sequence is repeated several times the student is asked to observe the marked timbral difference that exists between the normally harsh sounding A-natural and the more refined C and B.

Then while the student is again sustaining the rather raucous low A, the instructor surreptitiously depresses the low C♯/D♭ key (located on the long joint). The timbral results are both immediate and positive in nature. By simply opening the closed low C♯/D♭ key (hole) the harsh sound quality of low A has been mechanically damped, and is now more subdued, covered, and less strident. Having the student alternately open (more damped sound) and close (less damped sound) the low C♯/D♭ key helps to orient the student to the aural effect of timbral difference when the degree of damping is either increased or decreased.

Once again an undamped low A is sustained by the student, only this time the instructor's right index finger is lightly pressed inward and up against the student's lower lip, causing more of the lower lip's inner surface to contact the reed's lower blade. The timbral shift is similar in nature to that produced by adding the low C♯/D♭ key; however, even this slight increase in vertical pressure results in a drastic rise in the pitch. The slightest increase or decrease in finger pressure will cause the pitch to vary. This pronounced pitch distortion vividly demonstrates to the student why vertical cushioning (especially jaw supported) can't be used alone to modify dynamic/timbral nuance without incurring an unacceptable fluctuation in pitch or having to severely limit musical expression.

Finally, with the undamped low A once more being sustained by the student, the instructor's right index finger is again lightly pressed inward and up against the student's lower lip, only this time the lower lip is also slightly pinched in horizontally between the instructor's right thumb and middle finger. This inward focusing compensatory lateral thrust not only increases the amount of available damping, but also serves to maintain a more consistent vertical tip aperture opening. This aperture stability helps maintain a more stable pitch center coupled with increased expressive latitude.

The participating student is now experiencing for the first time the advantages of using coordinated vertical/horizontal cushioning to control and modify the dynamic/timbral characteristics of their sound, without incurring an unwanted secondary impact on intonation (albeit accomplished through the expert guidance of an instructor's helping hand used in lieu of their own yet to be developed orbicularis ring musculature). See Larry Teal's *The Art of Saxophone Playing*, published by Summy Birchard, for specific exercises designed to hasten development of the orbicularis.

Eureka! Simply using lip-imposed horizontal cushioning (impossible when the lips are tightly stretched over the teeth) in conjunction with vertical cushioning potentially doubles the available decibel excursion. Presto! The instrument is no longer the expressively impaired "wimp" of the woodwind family, but is now at least capable of expressing the "minimum" 30 dB range dictated by our six tier musical dynamic system. When the potential effects of the two remaining variable damping modes are further factored into the damping mix even the "ideal" 50 dB excursion is demonstrably feasible. (See Blake Patterson's article "Musical Dynamics" in *The Scientific American* magazine, November 1974, pages 78–95.)

TORQUING

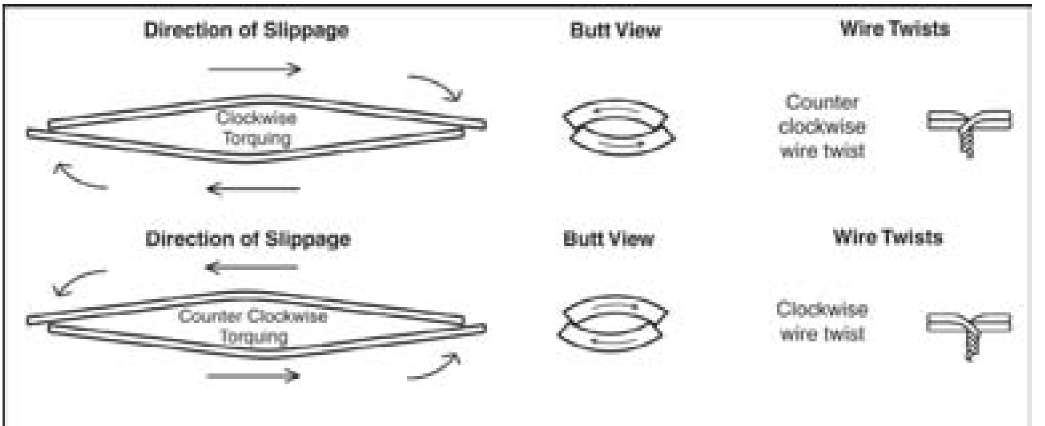
The following two exotic sounding forms of variable damping are to some degree an integral aspect of the vast majority (if not all) of embouchure sets. Strangely, most players whose embouchure already incorporates torquing elements are completely oblivious not only to its practical usage but to torquing's very existence and meaning. "Torquing" represents terminology used to identify a turning force that causes an object to twist.

The very physical nature of this ungainly elongated bass of the woodwind family requires a torquing relationship between performers and their instrument. Holding the instrument also demands that it be canted diagonally across the vertical axis of the performer's torso while the bocal (crook) must meander back across at some appropriate angle to place the reed within grasp of the individual's embouchure. Unless the player is sighting directly down the bocal's longitudinal axis the reed must of necessity enter the mouth at an angle protracted on a horizontal plane that lies somewhere between the impossible extremes of zero and ninety degrees.

The actual angle of entry will vary dramatically among individuals but seldom has it been determined by any valid pedagogic insight. Instead the angle used is (usually) predetermined by a variety of early environmental experiences while a beginning student, such as placement of the music stand, length and type of seat strap, type of chair, bocal nib angle, or pure happenstance. Regardless of its derivation or musical relevance, the evolved angle quickly becomes a habitual fixture of the student's performance stance. This passive, static form of torquing is useless as a source of variable damping, for only through embouchure mobility can the expressive dynamic/timbral resources be enhanced by means of horizontal and/or rotary torquing.

3. Horizontal torquing and its induced damping may be varied in extent by small omnidirectional "no-no" motions of the head as it is pivoted laterally on its vertical axis, while simultaneously the wrists and hands are used to turn the instrument's body in an opposite direction on its longitudinal axis.

Horizontal (and rotary) torquing directionality can be either clockwise (top of the head rotated to the right—most common) or counter-clockwise (top of the head rotated to the left—least common). The torquing directionality in the following discussion is presented clockwise. See Cooper, L. Hugh. "Slippage: Reed Making's Most Benevolent Fault," *The Double Reed*, Vol. 32, No. 2, 2009, p. 85 for a discussion of rotary torquing's reed slippage compatibility, and the graphic below.



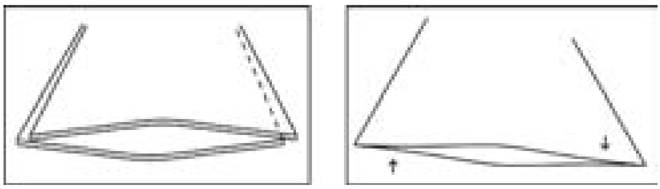
Direction of slippage must be compatible to rotational direction of embouchure torquing.
Also, direction of wire twist should correctly reinforce blade slippage.

These coordinated movements of the head and wrist/hands are utilized as follows. To increase horizontal torquing and its inherent level of damping, the performer's head is turned as if to "look" clockwise to the player's right (most common), as the instrument body is turned counter-clockwise by wrist/hand action. To decrease horizontal torquing and its attendant level of damping, the head is turned counter-clockwise to the left (back to center) while the instrument body is torqued in a clockwise direction.

The relative amount of variable damping produced is directly related to the degree of horizontal torquing being utilized to bring more or less of the reed blades' left (from the performer's perspective) rail area gently into contact with the soft, enveloping, inner surface of the performer's lower lip. For example, assuming a normally torqued embouchure set as being neutral: increasing horizontal torquing = more lip contact = more damping; while decreasing horizontal torquing = less lip contact = less damping.

4. Rotary torquing is imposed as the performer's head is "cocked" slightly in a vertical plane as it is rotated omnidirectionally on its horizontal axis. These small "quizzical" head movements serve to control the extent of contact area existing between the inner-lip surfaces and rail areas on both blades of the reed. Rotary torquing is normally used in conjunction with horizontal torquing as another paired embouchure mechanism.

A clockwise rotary movement of the head to the performer's right (most common—illustrated below) will increase the amount of lateral damping imposed along both the lower left and upper right rails, while a reverse counter-clockwise rotation to the performer's left (back to center) will decrease the damping imposed by rotary torquing within the same above blade areas. Obviously, simultaneous use of wrist/hand action to rotate the instrument's body longitudinally will effectively enhance the shift in variable damping attributed to the rotary torquing movement of the head. [Note: counter-clockwise torquing reflects the reed cant in the opposite direction as illustrated below.]



As would be expected, a direct relationship exists between the amount of rotary torquing used and its imposed variable damping. This direct relationship may be expressed as follows. Assuming a normally torqued embouchure set as being neutral: increasing rotary torquing = more lip contact = more damping; decreasing rotary torquing = less lip contact = less damping. [Note: horizontal torquing combined with rotary torquing functions superbly well when tapering the sustained *morendo* on an open F that closes the second movement of Tchaikovsky's 4th Symphony.]

Due to the inherent verbal complexity involved in describing horizontal and rotary torquing, both are best introduced by means of hands-on guided movements imposed by an informed instructor. These directed motions are introduced as the students are once again asked to slur slowly down to the now ubiquitous sustained low A-natural.

Horizontal torquing is introduced as the instructor sitting to the right places his or her left hand on top of the student's head and slowly turns the head clockwise on its vertical axis toward the student's right shoulder. While at the same time the instructor's right hand grasps the instrument at the juncture between the "boot/butt" and "wing/tenor" joints and slowly but firmly turns the body of the instrument counter-clockwise on its longitudinal axis. [Note: any change in directionality of either or both of the above guided movements will reverse the effect on damping.] After cycling the above guided motions several times the instructor allows the student to gradually assume full responsibility for the motions.

Rotary torquing, may be readily paired with horizontal torquing and both added to the existing damping mix. The composite damping mix is then further enhanced by rotary torquing as the instructor's guiding left hand deftly "cocks" the students head quizzically clockwise to the right on its horizontal axis. This small clockwise rotary motion results in additional contact area between the inner-lip surfaces and both upper and lower reed blades without causing appreciable change in the reed's "static volume" and related pitch center. Reversing directionality of the torque will decrease the amount of variable damping.

The use of instructor-guided motion enables an experienced teacher to conceptually introduce all four variable damping modes during the course of a single, early stage lesson. Subsequent assimilation and ultimate mastery of variable damping techniques requires much diligent practice by the involved student, not only to refine and implement the coordinated movements, but also to physiologically develop the orbicularis ring musculature. Maintaining maximum mobility of embouchure function is paramount during this early period of development.

Above all, avoid premature assignments of steady-state sustained long tones and extended length musical phrases. For imposing such unachievable demands on undeveloped lip musculature is certain to mandate the use of a jaw-supported hard embouchure. Besides the seemingly unfettered gyrations of dynamic, timbral, and pitch nuance that are encompassed within a student's early variable damping attempts are worthy of preservation, for they largely represent the parameters of nuance required to adequately fulfill the expressive demands of our music system. The only element missing from the equation is sensitive control.

Take Care: Don't throw the baby out with the wash water for at this critical point misguided haste to achieve control will only result in pseudo-refinement through the means of ridged jaw imposed tonal confinement. Broad expressive mobility remains the ultimate goal. Allow such embouchure mobility at this early stage or lose it!

Efficient utilization of variable damping's considerably expressive potential requires the following actions to implement, with a coordinated composite use of all four controlling embouchure modes. Single mode embouchure control dictates limited dynamic/timbral expression.

Even the productive pairing of vertical and horizontal cushioning fails to provide a sufficient excursion in acoustic power to produce a full spectrum dynamic/timbral range. Only when all four variable damping modes are combined in a complementary fashion can even the 30 dB minimum demands of music's six tiered dynamic system be satisfied.

The four available damping modes may be combined at the performer's discretion in various ad-mixtures that will satisfy the total damping requirements of the involved passage. (Damping is damping.) Assuming an expressive shift requiring a 40% change in variable damping, the expressive statement might be implemented in a variety of ways. See Example X.

Example X. Admixtures of the four types of variable damping that could be used to achieve a 40% variance of damping.

Damping Mode	% of Damping Contribution			
	Example A	Example B	Example C	Other
1. Vertical Cushioning	10	5	15	x
2. Horizontal Cushioning	10	5	15	x
3. Horizontal Torquing	10	15	5	y
4. Rotary Torquing	10	15	5	y
Total Damping Requirement:	40	40	40	2x + 2y

Note: Example B might prove more appropriate at the end of a long day of a lip-tiring rehearsal and/or the final few years of a long performance career.

Productive implementation of the four variable damping modes requires the commitment of an informed player who is convinced that effective dynamic change is directly associated with a commensurate variance in timbral complexity. Increasing the level of acoustic power will enhance timbral complexity, while decreasing acoustic power will reduce timbral complexity. Effective dynamic excursion always elicits a change in timbre and opens the window of expressive opportunity. ◆

ARTICLES