Refereed journal of the

國際圓號協會

International Horn Society

Internationale Horngesellschaft

Sociedad Internacional de Trompas

Société Internationale des Cornistes

THE HORN CALL

ANNUAL

No. 5, 1993

HORN CALL ANNUAL

Refereed Journal of the International Horn Society

No. 5, August 1993

Edited by Johnny L. Pherigo

ISSN 0046-7928

Kalamazoo, Michigan, USA

Designed by Graphic Communications

Printed by JB Printing

Cover art by Joel Barg, an IHS member and artist/designer from Montreal, Canada.

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The International Horn Society recommends that **Horn** be recognized as the correct name for our instrument in the English language. *[From the Minutes of the First General Meeting, June 15, 1971, Tallahassee, Florida, USA.]*

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The *Horn Call Annual* is a refereed journal issued annually in August as a publication of the International Horn Society. Opinions expressed by the authors are their own and are not necessarily those of the editorial staff or the International Horn Society.

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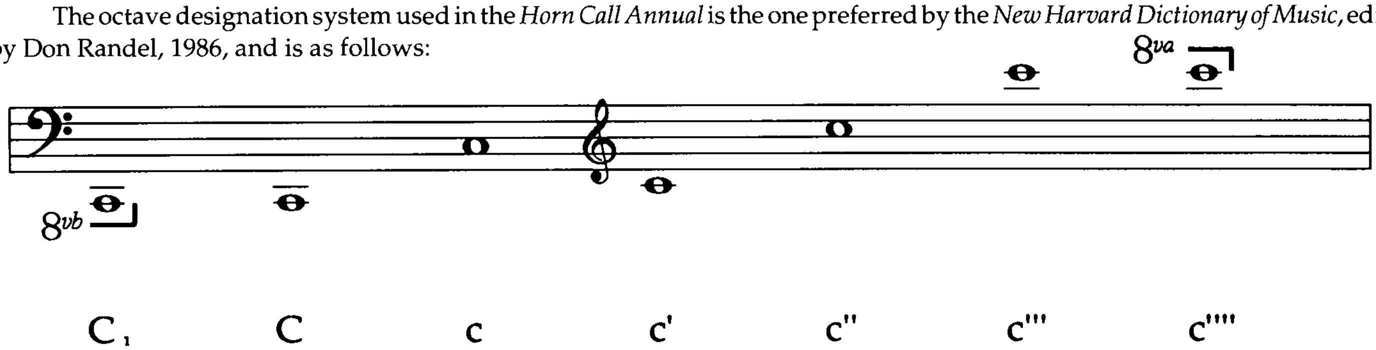


Who Composed "Haydn's Second Horn Concerto?"[1]

by John Jay Hilfiger

Musicians and public alike frequently value a musical work in proportion to the reputation of its composer. Hence, Fritz Kreisler's Vivaldi, Couperin, and other forgeries seemed lesser works after he was exposed. The same was true of the "Jena" symphony after it was shown not to be Beethoven's. The work commonly known as Haydn's *Concerto No. 2 for Horn in D, Hob. VIId:4*,[2] it seems, may be experiencing a similar fall from grace. Over the last two decades, one scholar after another has suggested that this composition may not be authentic Joseph Haydn.

Many works once attributed to Joseph Haydn have been shown to be spurious, while the authorship of other compositions bearing his name is doubtful. There are various reasons for this unfortunate state of affairs. Often the misattribution was the result of confusion with Joseph Haydn's younger brother, Michael. A number of late-eighteenth-century manuscripts identify the composer simply as "Sig. Haydn," without suggesting which one.[3] Similarly, many entries in the Breitkopf catalog[4] of (mostly) manuscripts appear with surname only and include works attributed to both Haydn's.[5] Even printed editions from this time frequently delete the composer's given name.[6] The Michael Haydn worklist in *The New Grove Dictionary of Music and Musicians* is a good indicator of the extent of this problem.[7] Many entries have "H," or Hoboken, numbers indicating that such works were once thought to have been composed by the more famous brother.

There is a less innocent cause of other misidentifications. Unscrupulous publishers would put Haydn's name on the works of lesser known composers in order to maximize profits. The autobiography of Czech composer Adalbert Gyrowetz, for example, relates his discovery of one of his own symphonies performed and published, in Paris, under Haydn's name.[8] Another case of possible fraud involves the "Opus 3" quartets, originally published, again in Paris, as Haydn's work. Careful investigation has revealed that plates for some of the quartets in this set originally bore the name of [Romanus] Hofstetter.[9]

Other reasons for mistaken authorship relate to the fact that a great deal of eighteenth-century music was published in manuscript form. Copyists sometimes forgot to write the composer's name, or copied it incorrectly, or wrote it illegibly, leaving musicians to draw their own conclusions. For whatever reason, the true authorship of many "Haydn" works, perhaps a thousand, is in doubt.[10]

Given the situation, one should hesitate to call any composition a work of Joseph Haydn without corroborating evidence. Virtual certainty is provided by such documentary evidence as an autograph manuscript or by an entry in one of the catalogs Joseph Haydn compiled or supervised: the *Entwurf Katalog* (EK) and the *Haydn Verzeichnis* (HV).[11] Other signed documents such as letters, musical manuscripts, or autographed printed editions are also convincing proof of Haydn's authorship.[12] Many other kinds of documentary evidence support varying degrees of certainty from high likelihood to remote possibility.

Although VIId:4 has been known as a Joseph Haydn work since his lifetime, the available documentation is insufficient to prove its authenticity, and several scholars have questioned its presumed authorship. There is no Haydn autograph of this concerto nor does it appear in EK or HV. This does not preclude Haydn authorship, however. The Joseph Haydn horn concerto of 1762 (VIId:3) is also absent from these two catalogs, yet the existence of the autograph proves its authenticity.[13]

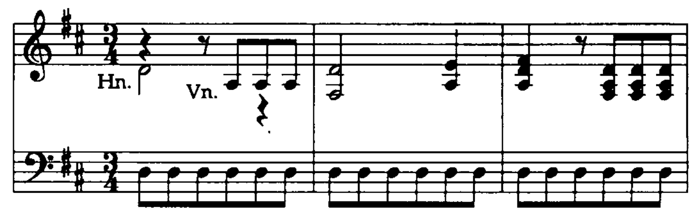
The earliest mention of VIId:4 is in the 1781 supplement to the Breitkopf catalog.[14] The entry includes an incipit and the heading, "Concerto da HAYDEN" [*sic*] "a Corno princ. 2 Viol. V. e B." According to Hoboken, this work is also mentioned in the 1783 catalog of Hamburg music publisher C. F. Westphal.[15] Early Haydn scholars accepted the work as authentic. It is included in the 1839 Haydn catalog of Fuchs[16] and was regarded as genuine by the first of the great Haydn scholars, C. F. Pohl.[17] Certain modern scholars have also regarded this work as authentic Haydn.[18]

In 1968, H. C. Robbins Landon published a discussion of the evidence supporting the authenticity of a number of concertos attributed to Joseph Haydn.[19] Concerning VIId:4, he remarked that "there is no strong stylistic evidence for or against Joseph Haydn, but the third movement has distinctly Michael Haydn touches." With this comment, he set off an explosion of arguments all attempting to show that for stylistic reasons alone VIId:4 was likely the work of Michael Haydn, or at least, not likely to be the work of Joseph Haydn. In a 1973 paper, Bryan pointed to the dissimilarity between the solo horn part in the concerto and horn parts in certain authentic Haydn works, mostly symphonies.[20] Landon later expressed stronger doubts about VIId:4, calling it "weak" and suggesting that "the leading note rhythm" (violin rhythm in the first measure of example la) of the last movement "could perfectly well be from the pen of Michael Haydn or a *Kleinmeister*."[21]

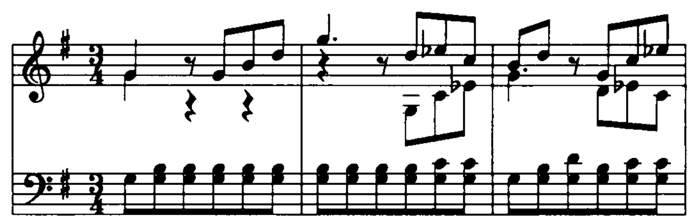
A later denial of Joseph Haydn's authorship is the Michael Haydn worklist in *The New Grove Dictionary of Music and Musicians*, which gives, without explanation, VIId:4 as a work of Michael Haydn.[22] The new edition of Karl Geiringer's Haydn biography reflected a new attitude about the work. While the 1946 edition had proclaimed of VIId:4 that "its close relationship to the first concerto makes Haydn's authorship almost certain,"[23] the 1982 edition allowed that VIId:4 was "probably the work of a follower of Haydn's."[24] Scott Fruehwald's quasi-statistical investigation of authenticity asserts that VIId:4 is spurious based upon rate of harmonic change, the rate of textural change in the opening tutti of the first movement, and a checklist of traits of the opening tutti of the second movement.[25] Ohmiya and Gerlach, in their 1985 critical notes accompanying the volume of wind concertos in the *Joseph Haydn Werke*,[26] offer the most detailed argument against Joseph Haydn's authorship of the disputed concerto. Their evaluation of sources questions the veracity of the Breitkopf and Westphal catalogs and repeats Landon's warning that the earliest manuscript, which is not an autograph, comes from the Zittau collection, from which certain other members have been proven to be spurious. They also enumerate the following stylistic features which they feel are uncharacteristic of Haydn's works: the second movement of VIId:4 is in a minor key, the first movement's development section is too elemental and the modulations too limited, the work is too lighthearted, and the third movement starts with the "leading note rhythm" to which Landon also pointed. More recently, in the preface to her 1991 edition of the concerto VIId:3, Gerlach asserts that VIId:4 has been "falsely attributed to Haydn."[27]

While much effort has been devoted to calling the authorship of VIId:4 into question, it is important to keep in mind that, although there is no documentary evidence to prove that Joseph Haydn composed this concerto, neither has documentary evidence been presented to prove that it was written by another composer. The arguments against Joseph Haydn's authorship have been based on finding some detail (or details) of the disputed work, VIId:4, unusual in works known to be authentic Joseph Haydn. The observer then declares that the evidence shows that VIId:4 is unlikely to be Haydn's. The problem with this approach is that music has so many possibilities that a creative composer such as Joseph Haydn could easily endow a given work with unusual or unique features. For example, the horn concerto VIId:3 requires an orchestra consisting of two oboes and strings, which is extremely rare among Haydn's authentic works (*Symphony No. 27* may be the only other authentic Haydn work to use this orchestration). To declare VIId:3 to be spurious for that reason alone would be simply incorrect, because the extant autograph of this composition attests to its authenticity.

Certain other unusual features of VIId:4 could well be part of a work by Joseph Haydn. It has been observed that the first movement of VIId:4 contains no true development section, only a sequence. This is indeed unusual for Joseph Haydn concertos and symphonies but not unusual for eighteenth-century horn concertos. The somewhat limited chromatic capabilities of the instrument led other composers, Mozart, for instance, sometimes to omit the development and put new themes in its place. That the second movement is in a minor key is hardly of great consequence. Although this may not occur in any other "demonstrably authentic" Joseph Haydn concerto, the number of such extant concertos is quite small, fewer than twenty works by the reckoning of Feder's worklist. If Haydn's symphonies are considered, as Ohmiya and Gerlach did when discussing development sections, the second movement is not infrequently in a minor key (e.g., in the early symphonies 12, 17, 33, and 37). The "leading note rhythm" of the beginning of the last movement, which concerned some scholars as being uncharacteristic for Haydn, may be unusual but is not unknown in his work. The *Terzetto* at the end of act 1 of *Lo speziale* contains such a figure (Ex. 1).



Example 1a. Horn Concerto, Hob. VIId:4, III, mm. 1-3 Manuscript Mus. 3356-0-503, Sächsische Landesbibliothek Dresden. Used by permission.



Example 1b. Haydn, *Lo speziale*, Act 1, Finale, mm. 72-74, from *Joseph Haydn Werke* xxv, 3. © 1959, G. Henle Verlag, Munich. Used by permission.

It has been shown, to this point, that scholarly opinion concerning VIId:4 has not been unanimous and that previously published evidence can be interpreted in new ways. What follows is new evidence derived from the disputed concerto itself and from demonstrably authentic works of both Joseph and Michael Haydn.

Since the disputed work is a horn concerto, it would be prudent to consider the nature of the instrument. VIId:4 was certainly composed in the years preceding its appearance in the 1781 Breitkopf catalog. The horn had long been limited to tones in the harmonic series, but experiments with hand-stopping about this time had made a wider choice of pitches available. Some of these new pitches were easy to produce while others were more difficult. The timbres of the pitches outside the harmonic series and those of the traditional horn tones did not quite match. For these and other reasons, composers dealt with the instrument in different ways. Some composers readily incorporated the chromatic tones into their works while others were more conservative. Figure 1 gives the pitches used by Joseph and Michael Haydn in the solo horn parts of several works. The white notes are those in the harmonic series, produced only by varying lip tension. The white notes in parentheses are flat and need to be "lipped up" or played with the right hand drawn out from its normal position in the bell. The black notes can be produced by "stopping" or closing the bell with the right hand to various degrees, or in the case of the lowest black notes ("factitious notes"), by bending or "lipping down" tones in the harmonic series.

The figure also includes an inventory of pitches used in a group of solo horn works by Joseph Haydn and another group by Michael Haydn. The Joseph Haydn works are similar to each other in that none uses many tones outside the harmonic series, and they all make use of the second partial, the written note c. The Michael Haydn works are

Figure 1. Pitches used by Joseph Haydn and Michael Haydn in solo horn writing. o = note in harmonic series; (o) = note in harmonic series needing to be "lipped up"; • = stopped or factitious note.

Works by JOSEPH HAYDN:

a. Horn Concerto, Hob. VIId:3. (1762)

b. Divertimento a tre, Hob. IV:5. (1767)

c. Symphony No. 31. (1765)

Horn Concerto, Hob. VIId:4.

Works by MICHAEL HAYDN

a. Concertino in D, for Horn and Orchestra. (ca. 1767)

b. Adagio and Allegro Molto, for Horn, Trombone, and Orchestra (1767?)

similar to each other in their use of many chromatic tones, most notably c#" and e-flat", and also in their avoidance of the low register. Each composer's works, then, form a homogeneous group quite distinct from the other composer's. The pitch inventory of the disputed work is clearly more similar to the Joseph Haydn works, casting some doubt on modern assessments of the work's authorship. This analysis is admittedly based on a limited amount of information, but so are the arguments against Joseph Haydn's authorship.

There are other resemblances with authentic works of Joseph Haydn, some of them striking. The opening of the third movement of Joseph Haydn's *Symphony No. 17* is virtually identical to a fragment of the last movement of VIId:4 but transposed to a different key (Ex. 2). A phrase (Ex. 3) from the solo part of VIId:4 appears as a horn motive and in the same key several times in authentic Joseph Haydn works. It is used at least twice in *Symphony No. 31*, the so-called "Hornsignal" symphony, and several times in the horn concerto VIId:3. Nothing resembling this motive appears in any of the Michael Haydn horn works discussed above. The connection between VIId:4 and VIId:3 is even more apparent in the remarkable passage from *Symphony No. 24*, which incorporates phrases from both horn concertos (Ex. 4) in a single period.

Horn in D

Example 2a. Horn Concerto, Hob. VIId:4, mm. 81-85. Manuscript Mus. 3356-0-503, Sächsische Landesbibliothek Dresden. Used by permission.

Violin I

Example 2b. Haydn, Symphony No. 17, III, mm. 1-4

Horn in D

Example 3a. Horn Concerto, Hob. VIId:4, III, mm. 58-61 Manuscript Mus. 3356-0-503, Sächsische Landesbibliothek Dresden. Used by permission.

Horn in D

Example 3b. Haydn *Symphony No. 31*, IV (var. 6), mm. 6-8.

Horn in D

Example 3c. Haydn *Symphony No. 31*, IV (var. 4), mm.7-8.

Horn in D

Example 3d. Haydn, Horn Concerto, Hob. VIId:3, III, mm. 65-68.

Horn in D

Example 3e. Haydn, Horn Concerto, Hob. VIId:3, II, mm. 97-99.

While these thematic and pitch relationships do not prove the concerto to be authentic Joseph Haydn, the kinship with his works does appear to be more than mere coincidence. Perhaps VIId:4 is the work of a Joseph Haydn student or someone else intimately familiar with his work, but it would seem that Joseph Haydn more than anyone else would be likely to reproduce the details of his work. Georg Feder's study of similarities among Haydn's works points out a number of instances in which identical or similar melodic ideas are thematically important in two different compositions and, as in the examples presented in this paper, the same melodic idea is developed differently in each work.[28] Haydn consciously did this at least some of the time, as he makes clear in his comment about a set of sonatas published by Artaria in 1780:

> Among these six sonatas there are to be found two movements which begin with a few bars of similar meaning, viz. the Allegro scherzando of Sonata no. 2 [Hob. XVI:36] and the Allegro con brio of Sonata no. 5 [Hob. XVI:39]. The composer gives notice of having done this on purpose, changing, however, in each of them the continuation of the same opening.[29]

Each of the compositions once attributed to Joseph Haydn must fall into one of the following categories: verifiably authentic Haydn, possibly by Haydn, or demonstrably spurious. Although several recent scholars have argued that VIId:4 is spurious, the new evidence presented here warrants a reconsideration. It has been shown that the selection of horn pitches in VIId:4 makes it more similar to the works of Joseph Haydn than those of Michael Haydn, especially in its avoidance of certain stopped notes. It has also been shown that melodic material in VIId:4 bears some remarkable similarities to that of several authentic Joseph

Haydn works of the 1760's.[30] Barring an unlikely event such as the discovery of an autograph manuscript of VIId:4, it may be impossible ever to know for certain who is its author. Considering that many details of VIId:4 bear such a strong resemblance to authentic Joseph Haydn works and that the "spurious" argument has not been proved, however, Joseph Haydn's authorship of this concerto should be regarded as quite possible.

NOTES

[1] I would like to thank James Webster, Charles Sherman, Johnny Pherigo, and Susan Thompson for generously giving of their time to react to various aspects of this study. I would also like to thank Judy Resop of the University of Wisonsin Center-Fond du Lac Library for her help in obtaining a copy of the earliest manuscript of the disputed concerto.

[2] Anthony van Hoboken, *Joseph Haydn. Thematisch-bibliographisches Werkverzeichnis, I. Instrumentalwerke* (Mainz: B. Schott's Sohne, 1957), 535.

[3] H. C. Robbins Landon, *The Symphonies of Joseph Haydn* (London: Universal Edition & Rockliff, 1955), 3.

[4] Barry Brook, ed., *The Breitkopf Thematic Catalogue: The Six Parts and Sixteen Supplements, 1762-1787* (New York: Dover, 1966). J. G. Immanuel Breitkopf (1719-1794) was himself aware that his catalog named some composers incorrectly (p. xiii).

[5] Robert Dearling, "Annotations to the Breitkopf Thematic Catalogue and Supplements," *Haydn Yearbook* IX (1975): 256-302.

[6] Facsimiles of early editions illustrating this point appear in D. W. Krummel, *Guide for Dating Early Published Music* (Hackensack, NJ: Joseph Boonin, 1974), 222; and Gottfried S. Fraenkel, ed., *Decorative Music Title Pages* (New York: Dover, 1968), 174. In the latter example, the composer is identified as being in the Esterhazy employ; hence one would conclude Joseph Haydn, but the given name does not appear.

[7] Stanley Sadie, ed. *The New Grove Dictionary of Music and Musicians* (London: Macmillan, 1980), s.v. "Haydn, Michael," by Reinhard G. Pauly and Charles H. Sherman.

[8] Landon, Symphonies, 3.

[9] Alan Tyson and H. C. Robbins Landon, "Who Composed Haydn's Op. 3?," *The Musical Times* 105 (1964): 506-7. The issue was not settled by this paper, nor has it been since. See Daniel Brantley, "Disputed Authorship of Musical Works: A Quantitative Approach to the Attribution of Quartets Published as Haydn's Op. 3" (Ph.D. dissertation, University of Iowa, 1977); and Scott Fruehwald, *Authenticity Problems in Franz Joseph Haydn's Early Instrumental Works: A Stylistic Investigation* (New York: Pendragon, 1988); the latter is based on his Ph.D. dissertation at City University of New York, 1984. See also a critique of Fruehwald's book, by Bernard Harrison, *Music and Letters* 71, no. 1 (1990): 98-100.

[10] James Webster, "External Criteria for Determining the Authenticity of Haydn's Music," in *Haydn Studies*, ed. J. P. Larsen, H. Serwer, and J. Webster (New York: W. W. Norton, 1981), 75-78.

[11] Jens Peter Larsen, *Drei Haydn Kataloge in Faksimile* (Copenhagen: Einar Munksgaard, 1941).

[12] Webster, "External Criteria," 75-76.

[13] Georg Feder, "Worklist" in Jens Peter Larsen, *The New Grove Haydn* (London: Macmillan, 1982), 157.

[14] *Breitkopf Thematic Cataloque*, 732.

[15] Hoboken, *Joseph Haydn*, 535.

[16] Alois von Fuchs, *Thematisches Verzeichnis der sämmtlichen Kompositionen von Joseph Haydn... 1839,* ed. Richard Schaal (Wilhelmshaven: Heinrichshofen, 1968), 147.

[17] C. F. Pohl, *Joseph Haydn* (Leipzig: Breitkopf und Hartel, 1882), 2:302.

[18] Karl Geiringer, *Haydn: A Creative Life in Music* (New York: W.W. Norton, 1946), 232; Horace Fitzpatrick, *The Horn and Horn-Playing and the Austro-Bohemian Tradition from 1680-1830* (London: Oxford University Press, 1970), 87, 196.

[19] H. C. Robbins Landon, "Haydniana (I)," *Haydn Yearbook* 4 (1968): 199-202.

[20] Paul Bryan, "The Horn in the Works of Mozart and Haydn: Some Observations and Comparisons," *Haydn Yearbook* 9 (1975): 189-255.

[21] H. C. Robbins Landon, *Haydn: Chronicle and Works* (Bloomington: Indiana University Press, 1976), 1:519.

[22] Pauly and Sherman, "Haydn, Michael," 411. In a telephone conversation on December 16, 1991, I discussed this attribution with Charles Sherman, co-author of the worklist. He has no documentary proof of Michael Haydn as composer of the work but felt that the style of VIId:4, especially the bass line, is unlike Joseph Haydn. He also explained that the date given in this worklist for the Michael Haydn *Concertino* should be revised to ca. 1767. Feder's "Worklist" for Joseph Haydn lists VIId:4 as one of several "selected doubtful and spurious works," without saying whether he feels it to be "doubtful" or "spurious."

[23] Geiringer, *Haydn*, 232.

[24] Karl Geiringer, *Haydn: A Creative Life in Music* (New York: W.W. Norton, 1982), 235.

[25] Fruehwald, *Authenticity Problems.* The study is "quasi-statistical" in the sense that it involves numerical tests for decision making but not formal hypothesis tests based upon mathematical probability models.

[26] Makoto Ohmiya and Sonja Gerlach, "Apokryphe Bläserkonzerte: Hornkonzert Hob. VIId:4*," *Joseph Haydn Werke* III:3 (Munich: G. Henle, 1985), 68-72.

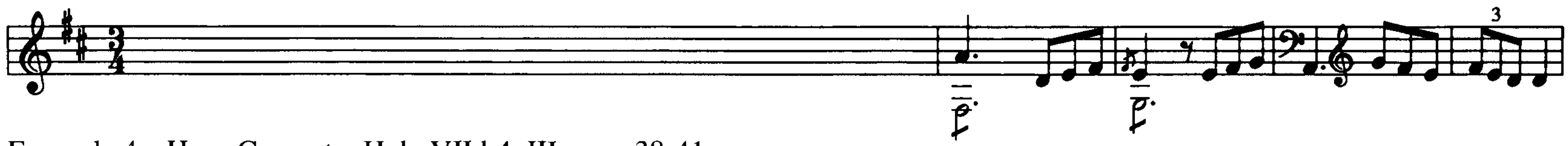
[27] Joseph Haydn, *Konzert für Horn und Orchester*, ed. Makoto Omiya and Sonja Gerlach with piano reduction by Stefan Zorzor (Munich: G. Henle, 1991).

[28] Georg Feder, "Similarities in the Works of Haydn," in *Studies in Eighteenth-Century Music: A Tribute to Karl Geiringer on His Seventieth Birthday,* ed. H. C. Robbins Landon and Roger E. Chapman (New York: Oxford University Press, 1970), 186-197.

[29] H. C. Robbins Landon and David Wyn Jones, *Haydn: His Life and Music* (Bloomington: Indiana University Press, 1988), 167.

[30] Heinz Herbert Steve's edition of VIId:4, *Concerto No. II in D* (London: Hawkes & Son, 1953), gives the work a date of 1767, which, with the data presented in this paper, seems plausible.

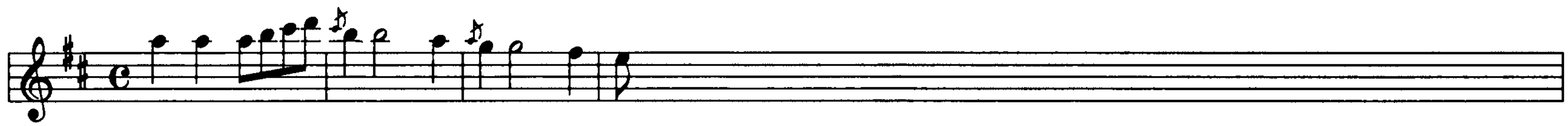
Horn



Example 4a. Horn Concerto, Hob. VIId:4, III, mm. 38-41.

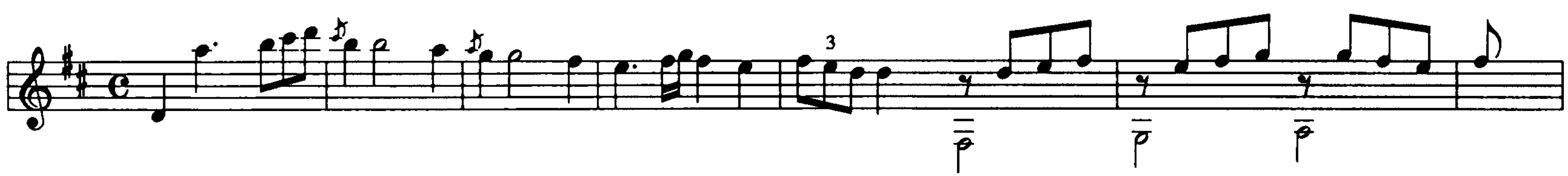
Manuscript Mus. 3356-0-503, Sächsische Landesbibliothek Dresden. Used by permission.

Violin I



Example 4b. Haydn, Horn Concerto, Hob. VIId:3, I, mm. 47-50.

Violin I



Example 4c. Haydn, Symphony No. 24, IV, mm. 5-12.

THE OPTIMAL DESIGN AND FAIR COMPARISON OF VALVE SYSTEMS FOR HORNS

by Frederick J. Young, Ph.D.

Introduction

The design of better valve systems has been important to hornists for a long time. Although horn players can fine tune by adjusting their hand in the bell, too much alteration in hand position may be detrimental to tone quality. If the hand is pulled too far out of the bell the sound may become too bright, and if it is inserted too far the tone becomes muffled. In addition, such expert use of hand position requires an almost perfect ear. Today most serious musicians have access to electronic tuners that can be used to tune any note. The unwise use of an electronic tuner may result in the tuning of only one note, however. The real goal of tuning is to make all of the notes in the playing range close to being in tune when blown in a centered but relaxed manner. When this goal is attained some notes will be sharp and others flat by two or three cents (there are 100 cents in a semitone). This allows the player with a keen ear the option of easy intonation adjustment by bell hand position or lip and puts the average player close enough to the correct pitch for all but the most professional of performances. All intonation references in this paper are based on the equal tempered scale, and all the calculations are based on the assumption that the open tones of the horn are well in tune in relation with one another. The taper of the horn determines the relationships between the open tones.[1] German horn builders have access to technical documents that set forth the proper tapers for tuning the open tones. It is the primary goal of this paper to establish valve tubing lengths that minimize the intonation discrepancies caused by the use of various valve combinations. In addition, answers are given to some rather old questions concerning intonation as influenced by the valve and tuning system. These questions include: Is the intonation of a horn using an ascending third valve better than one using a descending third valve? Is the intonation due to the use of the first and second valve combination better than it would be if the third valve were used alone? Is it better to tune the open tunes slightly sharp and, if so, by how much?

In the evolution of valve horns the valves were first used to obtain horns in various different keys. Thus, a first valve would have just the amount of tubing required to lower the original horn two semitones; the second valve, one semitone; and the third valve, three semitones. Horns were slow to become truly chromatic. For a chromatic horn there must be a criterion for the judgment of the accuracy of the valve tubing lengths. Without a fixed criterion an optimal valve system cannot be found and competing valve systems cannot be compared.

In this paper a criterion favoring small deviations in tubing length from the ideal is used along with simple mathematical methods for minimizing the tubing length errors. It is shown that better overall intonation is possible if the open tones are tuned sharp and that the use of valves one and two in combination is better than three alone.

Valve Tubing Length Criterion

There is a perfect or ideal length for the valve tubing needed for the lowering of each different degree of a scale. Correspondingly, there is an actual length of valve tubing available which is obtained by pressing valves singly or in various combinations. It is clear that for any given combination, the difference between the actual and ideal valve tubing lengths should be minimized. This difference can be either positive or negative and thus it would not be wise to examine the total error (the sum of the errors for each degree of the scale) because the sharp and flat combinations might cancel each other. A better method is to minimize the sum of the squares of the errors. It is rather like an effort to smooth a clay tennis court where bumps and small cavities are not desirable. A roller would be used flatten the bumps with the hope they will fill the cavities. When the sum of the average heights of bumps and depths of cavities is minimized, the best clay court has been prepared. For the calculations in this article it is most convenient mathematically to deal with the minimization of the squares of the tubing length errors. The sum of the squares of the errors is called the variance and the square root of the variance is referred to as the RMS error.

Experience indicates that flatness and sharpness beyond a certain degree is not exhibited by good musicians. Intonation measurements made[2] during a performance of the first twenty measures of the second movement (*Larghetto*) of the *Quintet in A Major for Clarinet and Strings, K. 581* by Mozart showed the clarinet intonation was within ± five cents of equal temperament. Many of the clarinet tones were accurate to within ± two cents. Other studies[3] indicate that the intonation of the soprano clarinet alone varies over a range of about ± ten cents. Thus it seems that clarinetists must make a great effort to achieve good intonation in the aforementioned *Larghetto*. Since these papers were written electronic tuners of small size have become widely available. On these tuners the smallest major subdivision indicated is about five cents. Although perfect intonation is always a performer's goal, it seems that on the average deviations of ± five cents would be acceptable. One of the goals of this paper is to establish valve tubing lengths that minimize intonation discrepancies caused by the use of valves in combination. These discrepancies are well known.[4]

The squared error for the valve system is defined as the sum of the squares of the errors in valve-tube length for each degree of the scale. The criterion is that the smaller the square root of the mean squared error, or the RMS error, the better the valve system. In many scientific activities, RMS quantities (e.g., voltage and current) are used when the quantities can reverse in sign. The RMS value is the effective magnitude of these quantities. In this paper the RMS error in frequency is minimized for each different valve system considered.

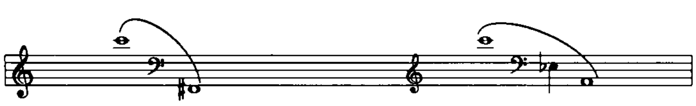
Three-Valve Systems

These systems are considered using the techniques outlined in Appendix A. Their operation is defined in Table I on the next page.

TABLE I: Three-Valve Systems

Descending third-valve horn fingering	0	2	1	12	23	0
Ascending third-valve horn fingering	0	2	1	12 or 3	23	0

The descending horns are designated as type An and type Bn while the ascending horns are called type Cn and Dn. All these instruments are F horns considered to descend from the open tone only four semitones, and their valve tubing lengths are adjusted to minimize the variance in that range. The player starts on the eighth open tone or harmonic shown in Table I. In order to descend chromatically, the standard descending third valve system adds tubing by depressing valves two, one, one/two and two/three. The next step in the scale is the sixth open tone or harmonic and the process repeats. The horn with the ascending third valve system adds tubing to descend the first two semitones, then when the third valve is depressed the player aims for the sixth open tone, which is raised one whole tone to produce the desired note, A. Hornists usually do not use the seventh open tone because it is too flat. Next, the second valve is added to the third valve to produce A♭. The descending valve system is approximately chromatic to the F♯ below the second open tone. The ascending valve system is chromatic down to E below the third open tone. This is illustrated below.



Descending system Ascending system

Thus a single horn with an ascending third valve cannot be useful over the entire low horn range for it lacks the E♭[5] shown above and low A♭, G and F♯. Because of this we establish the optimal valve tubing length only in the chromatic range of the ascending system.

The fingerings given in Table I are the best for intonation. In the case of the descending third valve horn the use of the third valve alone could be considered. The resulting tube lengths do not provide as good intonation as does the use of the first and second valves together. In the illustration above the chromatic descent of the single three-valve horn to low F♯ is noted, necessitating the use of the valve combinations 13 and 123. The tubing lengths of the type An and Bn horns could be adjusted to make these fingerings better in tune. This is not done in order to optimize and compare the intonations of ascending and descending horns over their common range of chromatic usefulness. Instead, horn type F12, a six-semitone descending horn, is presented to examine the entire range of the descending third valve horn. This procedure also allows an investigation of the idea[6] of tuning the open note slightly sharp to minimize intonation errors. The method of least squares described in Appendix A is used to yield the optimal valve tube fractional lengths, with the results given in Table II.

As mentioned previously, horns of type An and Bn are equipped with descending third valves while types Cn and Dn have ascending third valves. The open tones of types An and Cn are tuned exactly to the standard pitch. Types Bn and Dn are tuned purposely sharp on the open tones to minimize the tuning discrepancies on five rather than four notes.[7] For comparison we include also type E3 and type F12 horns. For a type E3 horn the open tone and valve tubing lengths are chosen so that the musical pitches C, B, B♭ and A are exactly in tune. On the type E3 horn the third valve is used to produce A. The type F12 horn is the standard three valve horn with valve tubing proportioned for six semitones descent from the open tone, with the open tone purposely tuned sharp to minimize the RMS error. Mathematical details are in Appendix A.

TABLE II: Optimal Valve Tube Fractional Length for Three-Valve Descending and Ascending Horns

Horn Type	Descending		Ascending		Unadjusted Descending	
Valve number	A12	B12	C3	D12	E3	F12
1	0.12489	0.1261	0.13503	0.14155	0.12246	0.13464
2	0.06189	0.062104	0.06189	0.070832	0.059463	0.06568
3	0.19803	0.19864	0.12489	0.13179	0.18921	0.2102
TSP[8]	0	-0.00091	0	-0.005685	0	-0.0037
	normal	sharp	normal	sharp	normal	sharp

All entries except the TSP in Table II are the quotient of the actual valve tube length and the effective length of the open horn. The minus signs on the Tuning Slide Pull (TSP) row indicate shortening of the tuning slide from its length when tuned at standard pitch. For both descending and ascending horns the valve tubing lengths are all a bit longer when the open tone is purposely tuned sharp. The type E3 horn has about two inches less valve tubing than type A12. Type F12 has almost four inches more valve tubing than type B12. These length are for F horns assumed to have an effective length of 147.68 inches (3.75 meters). The intonation of each system is presented in cents in Table III.

The suffixes 12 and 3 in Table III mean the horns are meant to use the first and second valve combination or third valve, respectively, for three semitones descent. Type A12 horns are optimized for the use of the first and second valves to produce A, for example. Type An and Type Cn horns are tuned exactly on an open tone. Type Bn and Dn horns are purposely tuned sharp on their open tones to minimize intonation error. The ascending valve must be engaged when tuning horns of type Cn and Dn. Types E3 and F12 are explained later.

TABLE III : Minimum Intonation Errors in Cents for Three Valve Systems
(Negative entries indicate flat pitch.)

Horn type	Errors					RMS Error
A12	0	-3.96	-3.74	3.54	0	2.91
A3	0	-6.12	0	5.45	0	4.33
B12	3.15	-2.97	-2.81	2.65	0	2.60
B3	4.88	-4.59	0	-4.09	3.87	3.91
C12	-1.23	1.16	-6.70	6.35	-9.26	5.90
C3	-3.74	3.54	0	0	-3.96	2.91
D12	3.15	-2.97	-2.81	2.65	0	2.60
D3	-2.81	2.65	0	3.15	-2.97	2.60
E3	0	0	0	0	15.53	6.95
F12	12.82	1.90	-7.39	-5.43	-11.69	8.82
Pitch	C	B	B♭	A	A♭	

The type Cn and Dn natural horns would be two semitones higher than the type An and Bn horns because of the ascending third valve, which adds fundamental length in the valve rather than the tapered section. That is the reason the note A is exactly in tune in the type C3 horn. These calculations show that the RMS error of intonation is 2.91 cents for horns of type A12 and C3. One has no net intonational advantage over the other. The calculations also show that the RMS error for horn types A12 and C3 is reduced from 2.91 to 2.60 cents by making the tuning open note 3.15 cents sharp as shown in horns of type B12 and D3. The descending horn which uses the third valve alone (type A3) has an RMS error of 4.33. Tuning the open note 4.88 cents sharp also improves the type A3, lowering the RMS error from 4.33 to 3.91 cents as seen under type B3. The ascending horn which is meant to use the first and second valve combination (type C12) is not well in tune. Allowing the open tone of that horn to seek its own tuning produces the ascending horn of type D12, which has an RMS error of 2.60.

At their best, ascending and descending horns can have equally good intonation. On one note (B) there is a 7.5 cent discrepancy between descending (type A12) and ascending (C3) horns. On that same note, the discrepancy between the type A3 and C3 is more than 9.5 cents. The ascending (type B12) and descending (type D12) horns have the same errors on each note and both have an RMS error of 2.60. The ascending (type D3) horn also has am RMS error of 2.60. There are discrepancies, however, between the notes produced by the horns of types D12 and D3.

The type E3 horn uses the third valve alone to produce A and second and third valves to produce A-flat, with the A-flat being rather sharp and the RMS error high. Usually any variation of more than ten cents is considered unacceptable. Inserting the hand further into the bell could correct it at the expense of altering the tone color, but this is the most straightforward way of adjusting the tubing lengths for a descending horn. Although the type E system is not as good as the type A system, it could be made to have zero RMS error by adding another valve. The additional valve for a type E3 horn would lower the open tone by four semitones. Single horns of that kind were made long ago in Germany.

When the open tone is tuned exactly the type A12 system is the best three-valve horn that can be devised to descend four semitones. Since valves were introduced the valve systems have approached type A12 by an empirical process. The type B12 horn, which is tuned sharp by 3.15 cents, has an RMS error which is ten percent less than for the type A12 horn. Over the given range of frequencies the ascending and descending horns are equally good. The ascending horn has the advantage that it's valve tubing lengths can be chosen so that a horn which uses the first and second valve combination is as good as one that uses the third valve alone. The valve tubing lengths for each of these horns are different, and if one uses the third valve alone on a horn constituted for the first and second valve combination, a large intonation error may result. Although the ascending horn may not be as heavy in weight as the descending horn because it has less tubing, it suffers from the need of an additional valve for the missing note. The addition of the extra valve would make the ascending horn heavier than the descending horn.

Low Horn Considerations

If the chromatic descent of Table III is attempted by beginning on the third open tone, the systems presented here do not function as well because they must descend six rather than four semitones. This is depicted in Table IV.

TABLE IV: Intonation Errors in Cents for Three Valve Systems
(Negative entries indicate flat pitch.)

Horn type	Errors			RMS Error
A12	Same as in Table III	15.53	36.37	15.15
B12	Same as in Table III	15.53	37.13	15.37
E3	Same as in Table III	30.32	53.56	24.00

These intonation errors fall into the unacceptable range, but they can be corrected to a limited extent by optimizing the lengths of the valve tubes to cover a six-semitones descent. In that case the fractional lengths given in Table II in column F12 are used. The intonation errors are given below:

Semitones descent	0	1	2	3	4	5	6
error	12.82	1.90	-7.39	-5.43	-11.69	-3.34	13.66

The RMS error for this configuration is 9.15 cents. The open note as well as the fourth and sixth semitones of descent are not satisfactory. Clearly, a double horn would be helpful because it would not have to descend by five and six semitones except for the notes based on the second harmonic on the low side of the horn. Perhaps the high side of the double horn should have type Bn valves and the low side should have type F12 valves. Additional study for double horns should be done.

The addition of a horn tuned five semitones higher alleviated the problem occurring at the third open tone on the low horn by making use of the second open tone of the higher horn. However, it did not cure the problem. It shifted it down to the second open tone of the lower horn. Given the excellent intonation of the type B horn over most of the useful range, it seems a type B double horn is adequate. The low F♯ and G, which tend to be 36.37 and 15.53 cents sharp, become a problem in a sustained passage, where a combination of lip, right hand, and temporary slide adjustments can be employed to solve the problem. The double ascending horn does equally well and in fact better on low F♯ and G but cannot produce a low G♯ without the use of an extra valve made solely for that purpose. However, if the separation between the low and high side of the ascending double horn is made to be six rather than five semitones, then low G♯ and all the rest of the notes on the chromatic scale can be produced. This implies descant horns pitched in high E and B♭ or high F and B♮ and standard horns pitched in low E and B♭ or low F and B♮. Although these may seem unattractive combinations they have many advantages. For example, with a E/B♭ double descending horn the 123 valve combination is never needed, and its elimination helps to reduce the RMS error in intonation.

Conclusions

It has been shown that single horns with an ascending third valve can be as well in tune as the more conventional single horns but have gaps in their chromatic range. The double horns of these kinds are comparable, but the double horn with the ascending valve lacks a low A♮. There appears to be an advantage to tuning the open tones of the horn sharp by about three cents and thirteen cents for descending horns that descend four and six semitones, respectively. The ascending (type D3) horn nominal open note, C, must be tuned about three cents flat as indicated in Table III. The real open tone obtained by depressing the third valve must be tuned about three cents sharp. However, the use of both type D3 ascending and type B12 descending horns in the same ensemble may present problems because the intonation errors on the open tone and second valve notes are in opposite directions, as indicated in Table III. On the other hand, the use of the type D12 ascending horn alleviates the problem completely. In that respect, one concludes that the ascending horn with the open tone tuned 2.7 cents sharp and using the first and second valve combination rather than the third valve alone is the best solution. In the case of ascending horns that are tuned sharp with the valve tubing lengths optimized, use of the third valve alone does not raise the RMS error. In all other cases examined here, use of the third valve alone results in a significantly greater RMS error in valve tubing length than does the use of the first and second valves together. Although using valves in combination generally reduces the RMS error, it can lead to stuffiness. Because the first and second combination does not seem stuffy, it is concluded that the use of the first and second combination is more desirable than the use of the third valve alone. Although there is an intonation advantage to separating the high and low sides of the double horn by six rather than five semitones, many innovations in horn valve system design are possible.

Practical Application

It is clear that the adjustment of horn valve slides must be done carefully and probably requires the use of a tuning meter. In order to tune the horn, an open note which is normally in tune in the middle of the best playing range on the main horn side should be selected. Set the tuning meter response to fast and practice that note before the meter until it feels centered and remains very steady in pitch. If the desired pitch level is A440, raise the calibration on the meter by about three cents for a type B12 horn. This action sets the meter to be three cents sharp. Have some other person adjust the tuning slide while sustaining the note until it is in tune with the meter. Next use the second valve and have that person pull the second valve slide to make it about six cents flat to the meter zero. To complete the process also tune the first valve slide to be six cents flat to the meter. Observe that the first and second valve combination is slightly sharp (close to zero) and the second and third valve combination is about three cents flat. Then reset the tuning meter to A440 and obtain the results given for a type B12 horn in Table III. This process can be repeated for the other side of the double horn. It is best to tune the side having an independent tuning slide last. If the horn is constructed as a type F12 instrument, then the valve slides may need to be shortened before it is possible to make the adjustments given in Table III. If it is a type E3 instrument it can be easily converted to type B12 by appropriately adjusting the slide pulls.

The Future

The elimination of the kind of tuning problems presented here awaits the development of a triple horn built in different keys than the F, B♭, high F presently used. If the horns are designed to be separated by four semitones, then valves one, two, and three never will be used in combination, and the correct length of tubing will be available for every note.

APPENDIX A: Mathematical Details

The calculations are based upon a simplification of the actual physical phenomenon. To the order of the accuracy of this simplification, the length of tubing required to lower the pitch of a horn of length L_0 by k semitones is given by

$$L_k = L_0(2^{k/12}-1) \tag{1}$$

The validity of this relationship shall be discussed in Appendix B.

If a horn has j sets of valve tubing, the length of each set of valve tubing is denoted as L_0S_j. S_j is the fraction of the natural horn length required. When a valve is used there may be a discrepancy in length between the length of valve tubing and the desired length given in equation (1). Although it is possible to make the discrepancy zero in particular cases, it is not advisable.

Conventional Three-Valve Horn
Adjusted for Six Semitones Descent

In the case of a conventional three valve instrument the discrepancies are listed in the following setup table:

TABLE A1: Setup for a Common Three Valve Horn (Type F)

Semitones Lowered	Fingering	Discrepancy
1	2	$S_2 - L_1/L_0$
2	1	$S_1 - L_2/L_0$
3	12	$S_1 + S_2 - L_3/L_0$
4	23	$S_2 + S_3 - L_4/L_0$
5	13	$S_1 + S_3 - L_5/L_0$
6	123	$S_1 + S_2 + S_3 - L_6/L_0$

The sum of the squares of these discrepancies is given by

$$E = (S_1 - L_2/L_0)^2 + (S_2 - L_1/L_0)^2 + (S_1 + S_2 - L_3/L_0)^2 + (S_2 + S_3 - L_4/L_0)^2 + (S_1 + S_3 - L_5/L_0)^2 + (S_1 + S_2 + S_3 - L_6/L_0)^2 \quad (2)$$

Similar expressions hold for any number of valves, including compensating valves. It is possible to find single values of S_1, S_2, and S_3 that minimize the sum of the squares of the discrepancies. These values are optimal for the minimization of E_s. Differential calculus tells us that this extremum is approached when the rate of change of E_s with respect of S_1 and S_2 and S_3 (each taken separately) is zero. This is akin to the lowest or highest point on a surface. In the notation of the calculus

$$\partial E_s/\partial S_1 = 0,\ \partial E_s/\partial S_2 = 0,\ \text{and}\ \partial E_s/\partial S_3 = 0$$

This yields three simultaneous equations, solvable for S_1, S_2, and S_3 in terms of L_1/L_0, L_2/L_0, L_3/L_0, L_4/L_0, L_5/L_0, and L_6/L_0. To simplify the notation we define the ratio

$$R_k = L_k/L_0 = 2^{k/12} - 1$$

The values of R_k are given in Table A2.

TABLE A2: Semitones Versus Fraction of the Tube Length Increase

k	R_k
1	0.059463
2	0.12246
3	0.18921
4	0.25992
5	0.33484
6	0.41421

Then for a three-valved horn the simultaneous equations become

$$\begin{aligned} 4S_1 + 2S_2 + 2S_3 &= R_2 + R_3 + R_5 + R_6 \\ 2S_1 + 4S_2 + 2S_3 &= R_1 + R_3 + R_4 + R_6 \\ 2S_1 + 2S_2 + 3S_3 &= R_4 + R_5 + R_6 \end{aligned} \quad (3)$$

or in a matrix form (a kind of mathematical shorthand)[9]

$$\mathbf{M\,S = R} \quad (4)$$

where

$$\mathbf{M} = \begin{bmatrix} 4 & 2 & 2 \\ 2 & 4 & 2 \\ 2 & 2 & 3 \end{bmatrix}$$

$$\mathbf{S} = \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} R_2 + R_3 + R_5 + R_6 \\ R_1 + R_3 + R_4 + R_6 \\ R_4 + R_5 + R_6 \end{bmatrix} \quad (5)$$

If it had been decided to use the third valve alone to lower the open tone by three semitones, then the third row of Table A1 would be altered to read

3	3	$S_3 - L_3/L_0$

necessitating slightly different values for **M** and **S**. In that case

$$\mathbf{M} = \begin{bmatrix} 3 & 1 & 2 \\ 1 & 3 & 2 \\ 2 & 2 & 4 \end{bmatrix} \qquad \mathbf{R} = \begin{bmatrix} R_2 + R_5 + R_6 \\ R_1 + R_4 + R_6 \\ R_3 + R_4 + R_5 + R_6 \end{bmatrix} \quad (6)$$

and $\mathbf{S} = \mathbf{M}^{-1}\mathbf{R}$.

Although **M** and **R** are derived by calculus, they can be found from the setup table by simple arithmetic. Here

R =	1.0607	0.9228	1.009			
S =	0.13021	0.061255	0.20868			
E =	-2.9253	-11.915	-3.2889	-13.704	-5.2486	17.305

The RMS error over the first four semitones descent is 9.34 cents, and the complete RMS error is 10.62 cents. If the third valve is used alone for the third semitone of descent, the RMS error becomes -28.118 instead of -3.2889 cents, comprising a very large error in intonation. It is useful to repeat the above calculation for the case where the third valve is to be used alone. Here

R =	0.87152	0.7336	1.1982			
S =	0.13621	0.067253	0.19781			
E =	-12.683	-21.079	-12.483	-7.0551	1.0574	15.908

The RMS error over the first four semitones of descent is 14.237 cents and the complete RMS error is 13.323 cents. If the first and second valve combination is used instead of the third valve, then the error for three tones descent is -21.079 instead of -12.483 cents. The comparison of these two cases indicates that the valve system setup for the first and second valve combination is best unless the hornist wishes to specialize on the three lowest notes. In that case a valve system setup for the use of the third valve alone is best.

Horn A
Conventional Horn Descending Four Semitones

Horn A from Table II is a three-valve single horn with a descending third valve tuned so that the open tones are exactly in tune. To construct the setup table one first lists the number of semitones lowered in column one and the fingering in column two. Then the discrepancy column follows logically. The setup table is given here as Table A3. To form the discrepancy column the ideal or exact tube length, R_j (j is the number of semitones lowered), is subtracted from the total valve tube length, S_i (i is the valve number).

Table A3: Setup for a Three-Valve Horn with Descending Third Valve Limited to a Four Semitone Descent

Semitones Lowered	Fingering	Discrepancy
1	2	$S_2 - R_1$
2	1	$S_1 - R_2$
3	12 or 3	$S_1 + S_2 - R_3$ or $S_3 - R_3$
4	23	$S_2 + S_3 - R_4$

When a lowering of one semitone is desired, the length of the second valve tubing, S_2 must be used. From that is subtracted the exact length necessary for a lowering of one semitone, denoted as R_1. When more than one valve is depressed the sums of the valve lengths must be used. The **R** vector and the **M** matrix are constructed row by row, beginning on the first row with a scanning of the discrepancy column for entries involving S_1. These occur in rows two and three if the first and second valve combination is used or in row two only if the third valve is used alone. The first and second valve and the third valve alternatives for the three-semitone lowering must be examined separately, with the first and second valve combination considered first. The first number in the first row of the M matrix, 2, is obtained by determining how many S_1 terms occur in rows two and three of the discrepancy column. The second number in the first row is 1, which is the number of S2 terms in rows two and three of the discrepancy column. The third number in the first row of the M matrix is 0 because rows two and three of the discrepancy column have no S_3 terms. The first term of the **R** vector is the sum of the R terms in rows two and three of the discrepancy column or $R_2 + R_3$. The second row of the **M** matrix is determined from the rows of the discrepancy column in which S_2 terms occur, that is, rows one, three, and four. Then the second row of the M matrix reads 1 3 1 and the second term of the **R** vector is $R_1 + R_3 + R_4$. The third row of the **M** matrix is determined from the rows in the discrepancy column in which S_3 terms occur, namely, row four. Then the third row of the **M** matrix is 0 1 1 and the third term of the **R** matrix is R_4. Thus, equation (7) is the **M** matrix and **R** vector when the first and second valve combination is used.

$$\begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & 1 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix} = \begin{bmatrix} R_2 + R_3 \\ R_1 + R_3 + R_4 \\ R_4 \end{bmatrix} \quad (7)$$

Equation (8) is used if the third valve alone is used instead of first and second valves.

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 1 \\ 0 & 1 & 2 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix} = \begin{bmatrix} R_2 \\ R_1 + R_4 \\ R_3 + R_4 \end{bmatrix} \quad (8)$$

Horn B
Conventional Horn Descending Four Semitones Tuned Sharp

R. W. Young[10] indicated that it might be advantageous to tune the open notes of brass instruments to a different pitch level to aid in the compromises necessary for good intonation when valves are used in combination. In this case, the open tone from which chromatic descent is made is set to be out of tune in order to help minimize the RMS error. Now the setup table must include a row for zero semitones of descent, as in the following example:

Semitones Lowered	Fingering	Discrepancy
0	0	S_4
1	2	$S_2 + S_4 - R_1$
2	1	$S_1 + S_4 - R_2$
3	12	$S_1 + S_2 + S_4 - R_3$
4	23	$S_2 + S_3 + S_4 - R_4$

Then equation (9) results:

$$\begin{bmatrix} 2 & 1 & 0 & 2 \\ 1 & 3 & 1 & 3 \\ 0 & 1 & 1 & 1 \\ 2 & 3 & 1 & 5 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \end{bmatrix} = \begin{bmatrix} R_2 + R_3 \\ R_1 + R_3 + R_4 \\ R_4 \\ R_1 + R_2 + R_3 + R_4 \end{bmatrix} \quad (9)$$

Here [R] = 0.31167 0.50859 0.25992 0.63105
[S] = 0.1261 0.063104 0.19864 0.0018205

In this case S_4 is negative indicating sharp tuning of the open tone. If the third valve is used rather than the first and second valve combination, the equation to be solved for valve tubing and tuning slide pull (push) would become as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 2 & 1 & 2 \\ 0 & 1 & 2 & 2 \\ 1 & 2 & 2 & 5 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \end{bmatrix} = \begin{bmatrix} R_2 \\ R_1 + R_4 \\ R_3 + R_4 \\ R_1 + R_2 + R_3 + R_4 \end{bmatrix} \quad (10)$$

Here $[R] =$ 0.12246 0.31938 0.44913 0.63105
$[S] =$ 0.12527 0.065089 0.19483 -0.002813

Horn C
Ascending Three Valve
Horn to Descend Four Semitones

With First and Second Valves

Here the most difficult task is the creation of the setup table. Actually, an ascending horn is two semitones higher than its nominal key. An F ascending horn is a G horn that only sounds its tapered length when the third valve is pressed to remove enough cylindrical tubing to produce the open notes of the G horn. Thus the setup table begins with two semitones of descent. It is given by the following:

Semitones Lowered	Note	Fingering	Discrepancy
2	C	0	$S_3 - R_2$
3	B	2	$S_2 + S_3 - R_3$
4	B♭	1	$S_1 + S_3 - R_4$
5	A	12	$S_1 + S_2 + S_3 - R_5$
6(1)[11]	A♭	23	$S_2 - R_1$

In order to obtain the desired four semitones of descent, the hornist goes to the next lower lip position on the G horn and then uses second valve to lower the tone by one semitone. The fingering is identical to the normal descending horn, but in principle, the ascending horn is rather different than the normal descending horn. The matrix equation for this case is given by

$$\begin{bmatrix} 2 & 1 & 2 \\ 1 & 3 & 2 \\ 2 & 2 & 4 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix} = \begin{bmatrix} R_4 + R_5 \\ R_1 + R_3 + R_5 \\ R_2 + R_3 + R_4 + R_5 \end{bmatrix} \quad (11)$$

The use of the first and second valves for A corresponds to the standard use and might seem to be best. However, if the second-valve tubing gives good results when valve two is used to produce B, then A♭, which uses that same valve in combination with the shorter horn in G, may be very flat. When the values of R_i are substituted into equation (11), the following equations result:

$\mathbf{R} =$ 0.59476 0.58351 0.90643 (12)

The solution to equation (11) becomes

$\mathbf{S} =$ 0.14155 0.065148 0.12326 (13)

This yields an error vector **E** given by

$\mathbf{E} =$ -1.231 1.1632 -6.7003 6.3481 -9.2639 (14)

The resulting RMS error is 5.8972 cents over the total descent of four semitones below C and including C itself. This analysis adjusted the C to be 1.23 cents flat to help minimize the RMS error. The notes C and B are well within the limits of good intonation. B♭ is flat by 6.70 cents and A is sharp by 6.35 cents. Perhaps they are acceptable, but the A♭ is flat by 9.26 cents. Assuming that the valve tube lengths should increase in inverse proportion to small changes in frequency, the first and second fingering is the best that can be done.

With Third Valve Alone

The case where the third valve is used alone was also investigated. In that case the setup table becomes

Semitones Lowered	Note	Fingering	Discrepancy
2	C	0	$S_3 - R_2$
3	B	2	$S_2 + S_3 - R_3$
4	B♭	1	$S_1 + S_3 - R_4$
5(0)[12]	A	3	0[13]
6(1)	A♭	23	$S_2 - R_1$

The equation constructed from the setup table is

$$\begin{bmatrix} 1 & 0 & 1 \\ 0 & 2 & 1 \\ 1 & 1 & 3 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix} = \begin{bmatrix} R_4 \\ R_1 + R_3 \\ R_2 + R_3 + R_4 \end{bmatrix} \quad (15)$$

Where $\mathbf{R} =$ 0.25992 0.24867 0.57159 (16)

The solution to equation (15) is as follows:

$\mathbf{S} =$ 0.13503 0.06189 0.12489 (17)

This leads to errors in cents of

$\mathbf{E} =$ -3.7398 3.5373 0 0 -3.9619 (18)

The resulting RMS error in this case is 2.905 cents over the entire series of intervals. In the examples above C and B are not as well in tune as they were when the valve tubing lengths were optimized for the use of a first and second valve combination, but B♭, A and A♭ have improved by about six cents each.

If the valve tubing lengths are not been adjusted by the above method, and each valve tube is adjusted to be perfect alone, then the results are as follows:

$$\mathbf{E} = \quad 0 \quad 0 \quad 0 \quad 0 \quad -11.859 \qquad (19)$$

Here the RMS error is 5.3035 cents. However, the A♭ is too low to be comfortable. If the same is done for the ascending horn using the first and second valve combination, A is 10.63 cents sharp while A♭ remains 11.859 cents flat. The RMS error increases to 7.12 cents. In this instance the situation is worse than the RMS error indicates because the interval between A and A♭ is only 72.5 cents when it should be 100, constituting a tuning discrepancy that is clearly unacceptable in a chromatic context.

Horn D
Ascending Three Valve Horn to Descend Four Semitones Tuned Sharp

To treat this case one more term is needed in the **S** vector. S_4 is the tuning slide pull (push). Then the setup table becomes

Semitones Lowered	Note	Fingering	Discrepancy
2	C	0	$S_3+S_4-R_2$
3	B	2	$S_2+S_3+S_4-R_3$
4	B♭	1	$S_1+S_3+S_4-R_4$
5(0)	A	3	S_4
6(1)	A♭	23	$S_2+S_4-R_1$

The matrix equation to be solved is given by

$$\begin{bmatrix} 1 & 0 & 1 & 1 \\ 0 & 2 & 1 & 2 \\ 1 & 1 & 3 & 3 \\ 1 & 2 & 3 & 5 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \end{bmatrix} = \begin{bmatrix} R_4 \\ R_1 + R_3 \\ R_2 + R_3 + R_4 \\ R_1 + R_2 + R_3 + R_4 \end{bmatrix} \qquad (20)$$

where

$$\mathbf{R} = \quad 0.25992 \quad 0.24867 \quad 0.57259 \quad 0.63105 \qquad (21)$$

$$\mathbf{S} = \quad 0.13564 \quad 0.063104 \quad 0.1261 \quad -0.0018208 \qquad (22)$$

$$\mathbf{E} = \quad -2.8056 \quad 2.6523 \quad 0 \quad 3.1546 \quad -2.9723 \qquad (23)$$

Here the RMS error is 2.6 cents. To tune the ascending horn open tones one must depress the third valve to remove the valve tubing. Equation (23) indicates the tuning should be 3.15 cents sharp, which results in an overall reduction of 0.3 cent in the RMS error.

Horn F
Common Three Valve Horn Adjusted for Six Semitones Descent Tuned Sharp

An extra length of tubing represented by S_4 is needed in the setup table to simulate a tuning slide push. The setup table becomes

Semitones Lowered	Fingering	Discrepancy
0	0	S_4
1	2	$S_2+S_4-R_1$
2	1	$S_1+S_4-R_2$
3	12	$S_1+S_2+S_4-R_3$
4	23	$S_2+S_3+S_4-R_4$
5	13	$S_1+S_3+S_4-R_5$
6	123	$S_1+S_2+S_3+S_4-R_6$

The matrix equation to be solved for **S** becomes

$$\begin{bmatrix} 4 & 2 & 2 & 4 \\ 2 & 4 & 2 & 4 \\ 2 & 2 & 3 & 3 \\ 4 & 4 & 3 & 7 \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \end{bmatrix} = \begin{bmatrix} R_2 + R_3 + R_5 + R_6 \\ R_1 + R_3 + R_4 + R_6 \\ R_4 + R_5 + R_6 \\ R_1 + R_2 + R_3 + R_4 + R_5 + R_6 \end{bmatrix} \qquad (24)$$

Here

R = 1.0607 0.9228 1.009 1.3801

and the solution is given by

S = 0.13464 0.065682 0.21015 -0.0073779

The error in cents is given by

E = 12.82 1.8957 -7.3881 -5.4316 -11.691 -3.3396 13.66

with an RMS error for the first four semitones of descent of 8.82 cents and a total RMS error of 9.15 cents for the total descent.

APPENDIX B: Validity of the Basic Assumption

It is well known that the length of the single horn in F is about twelve feet exclusive of valve tubing. R. Morley-Pegge[14] says the length is 3.751 meters or 147.68 inches or 12.307 feet. He also says that certain lengths of tubing must be added to lower the F horn by intervals of one, two, and three semitones. His figures are given below in a table along with valve tubing lengths measured on two F horns manufactured by Alexander and King as well as with lengths obtained from equation (1) in Appendix A.

TABLE B1: Valve Tubing Lengths Measured on F Horns (in inches)

Semitones Lowered	Morley-Pegge	Alexander (Model 103)	King (Circa 1930)	Eq. (1)
1	8.86	9.56	9.69	8.78
2	18.15	18.25	18.75	18.09
3	27.99	28.38	30.00	27.94

If it is assumed that the total effective length of the horn is $L_0 = 147.68$ inches (a careful measurement on a King F horn gave 148.8 inches) and that

$$L/L_0 = C/f^p$$

it is possible to determine the values of C and p best fitting the data. Using a method due to Marquardt[15] the results of Table B2 are obtained.

Table B2: Variation of F Horn Length with Frequency

Source	C	p	Variance
Morley-Pegge	87.709	1.001	0.0007
King F horn	103.81	1.0391	0.0372
Alexander F horn	89.26	1.0046	0.0823

For trumpets R. W. Young obtained p = 1.5 by measurement.[16] For baritones and tubas he obtained p = 1. The above calculations reveal that the horn behaves more like the tubas than the trumpets. One might be led to think of the horn as a close relative of the trumpet because the mouthpiece and tubing of both instruments look almost the same in overall diameter. The ratio of length to tubing diameter seems to be the important variable. For horns in F it is about 315. Tubas vary between 260 and 360 and trumpets are at a ratio of about 105. This leads one to believe that p = 1 for horns. The past literature and the above calculations indicate horns behave as assumed earlier in this work.

Other measurements of the intonation of the King F horn made by the author indicate it was built with elongated valve tubing lengths to help minimize errors due to valve combinations and that it is of type F12. For example, when a 123 valve combination was used, it was necessary to make a slide pull of four inches to make it in tune for six semitones lowering. Actual measurements and evaluations based upon R. W. Young's formulas[17] indicate that for the above horns $0.90 \le p \le 1.1$. However, differing values of p are obtained on different harmonics. These measurements, while easy technically to make, have large standard deviations due to extreme variability in pitch exhibited by many hornists. If these measurements could be made with small standard deviations they could be used to optimize the valve tubing length according to any criterion desired.

When performing these measurements it is best not to remove the right hand from the bell or change hand position in any way. It is best to have help in recording the data and the player must not be determined to play perfectly in tune. Instead, the player should find the most centered way to play each note in a very steady manner. Care also must be taken to keep all parts of the horn warmed-up before each measurement. Given the aforementioned difficulties encountered in such measurements, it is simpler to base the choice of p on the measurements of valve tubing lengths of actual horns.

NOTES

[1] Friedrich Blume, ed. *Die Musik in Die Geschichte und Gegenwart* (New York: Bärenreiter, 1962), s.v. "Posaune Akustik," by F. J. Young; F. J. Young, "The Natural Frequencies of Musical Horns," *Acustica* 10 (1960): 91-97.

[2] R. W. Young, "Sur l'intonation de divers instruments de musique," *Acoustique Musicale*, Editions du Centre National de la Recherche Scientifique, ed. F. Canac (Paris VII, 1959), 169.

[3] R. W. Young and J. C. Webster, "The Tuning of Musical Instruments (III) The Clarinet," *Gravesaner Blätter Heft* 11/12 (1958): 182-186; J. Meyer, "Über der Messung der Frequenzskalen von Holzblasinstrumenten," *Das Musikinstrument Heft* 10 (1961): 614.

[4] R. Morley-Pegge, *The French Horn*, 2nd ed. (New York: W. W. Norton, 1973), 53.

[5] On the ascending third-valve system, the low E♭ is available only with an extra valve.

[6] R. W. Young, "Optimum Lengths of Valve Tubes for Brass Wind Instruments," *Journal of the Acoustical Society of America* 42 (1967): 224-235.

[7] These type designations have nothing to do with the fundamental pitch of the horn and apply to horns in all keys.

[8] Tuning Slide Pull, Negative numbers represent a push. Here 0.00091, 0.005685 and 0.00037 correspond to about 0.134, 0.840 and 0.546 inches, respectively.

[9] F. E. Hohn, *Elementary Matrix Algebra*, 2nd ed., (New York: MacMillian Co.) See Chaps. 1, 2, and 3.

[10] R. W. Young, "Optimum Lengths," 224-235.

[11] The next lower harmonic or open tone is used when the second and third valves were depressed.

[12] The next lower open note or harmonic is used.

[13] The discrepancy of zero is due to the assumption that the open tones of the horn are in tune.

[14] Morley-Pegge, *The French Horn*, 53.

[15] Hohn, Elementary Matrix Algebra, See Chaps. 1, 2, and 3.

[16] R. W. Young, "Optimum Lengths," 224-235.

[17] Ibid.

CONTRIBUTORS

John Jay Hilfiger (*Who Composed "Haydn's Second Horn Concerto?"*) is Assistant Professor of Music at the University of Wisconsin Center-Fond du Lac and Music Director of the Fond du Lac Chamber Orchestra. He is a graduate of the University of Rochester, Temple University, and the State University of New York at Binghampton. He also earned a M.S. in biostatistics and was a professional statistician before completing a Ph.D. in music from the University of Iowa and embarking on a new career in college music teaching.

Frederick J. Young (*The Optimal Design and Fair Comparison of Valve Systems for Horns*) owns a consulting/research firm in Bradford, Pennsylvania that specializes in electrodynamics. He holds a Ph.D. from the Carnegie Institute of Technology and owns many patents outside the music field. An amateur hornist and tubist, he studied with Forest Stanley and played in the Pittsburgh Symphony under Fritz Reiner as a student. He does musical/acoustical research as a hobby and was first published in that area in 1959.

CORRESPONDENCE

Congratulations to John Ericson for his article "The Valve Horn and Its Performing Techniques in the Nineteenth Century: An Overview" (*Horn Call Annual* 4 (1992)). Not only has Mr. Ericson given us a useful survey of four important valved horn proponents, but he has also demonstrated just how much work remains to be done in the area of nineteenth-century horn performing practices. In response to his article, however, I find some points he makes need or deserve some clarification, particularly with regard to Joseph Meifred, whose *Méthode pour le Cor Chromatique ou à Pistons* (actually from 1840, not 1841 as Mr. Ericson reports) was the subject of my recent dissertation ("Joseph Meifred's *Méthode pour le Cor Chromatique ou à Pistons* and Early Valved Horn Performance and Pedagogy in Nineteenth-Century France," University of Wisconsin-Madison, 1991). While Mr. Ericson's descriptions of Meifred's positions on various technical and musical issues are essentially correct, there are specific details, arising from closer examination, that may prove especially interesting to hornists who aspire to perform literature of this period in an historically-informed manner.

First, Mr. Ericson points out that Meifred's use of two valves seemed to have certain inclinations away from the second, "inferior" valve, according to Mr. Ericson, evidenced by the use of lightly-stopped halfsteps instead of the valve itself (page 10). Mr. Ericson's feeling that this was due to technological inferiority is perhaps only partly true. While Meifred does say that, in terms of technology, less is more, he also says that the use of both valve combinations and handstopping is important for different types of halfsteps, for both sound and intonation. Meifred suggests that all halfsteps in leading tone positions should be lightly stopped to "preserve their countenance" (Meifred, page 4). He says and also demonstrates several times in the course of the method that, in general, sharped notes should be treated as leading tones (thus lightly-stopped) but that flatted notes should be fingered (see, for example, page 10 and especially page 30). He further suggests that opting for lightly-stopped notes in softer passages can be preferable <u>only</u> because the change in timbre is less noticeable (Meifred, page 7). This all leads to two possible, relevant considerations: 1) a slightly covered sound on the leading tone helps to emphasize the open timbre of the tonic, and 2) the intonation of the leading tone (vs. a generic halfstep) is precarious and thus can be controlled better by the hand than the valve. Both considerations show a concern for enharmonic intonation and musical effect, not merely a cautious attitude toward the technology.

Second, I agree completely with Mr. Ericson that Meifred was very anxious to avoid technological problems of valves and the acoustical problems of fully stopped notes. His contention, however, that Meifred did not "explore fully the advantages of the valve" (page 13) seems a bit overstated in view of Meifred's discussion in the *Méthode* itself. In the second major portion of the work (pages 28ff.), devoted to advanced performing issues, Meifred discusses at length how the player can develop many different performing options for expressive music-making. Not only does he show the reader how to use the valves extensively as crooking devices, he describes at some length how a performer can choose from as many as four different hand/valve combinations (including fully-stopped) for each note on the instrument to contribute to musical expression. Meifred goes further to show that a performer can use expressive timbre changes even on repeated notes, for example, much like a singer may choose to move from head voice to chest voice for effect (page 57). He also discusses options for ornaments, transpositions, and even ideas regarding ways of performing difficult natural horn passages in various works by Dauprat, Domnich, and others. After reading Meifred's discussion, it is hard to imagine any aspect of valve technology and hand technique, individually or combined, that he did not consider.

Finally, though Meifred did treat his method as a supplement to Dauprat's monumental *Méthode...*, it is interesting to note how Meifred disagrees with his mentor (politely, of course). His most controversial suggestion is that the valved instrument could not only improve on Dauprat's of First (High) and Second (Low) Horns, but could even replace them (Meifred, page 4). It is true that Meifred prescribes crook changes in his exercises, but these seem to be a compromise for beginning practice because eventually all exercises cover all ranges and the crook prescriptions disappear, culminating in a table of transpositions such that a horn in F could play in all keys. Meifred says plainly that with practice the valved-horn performer can cover all that either First or Second horns are asked to do, and many times with a more satisfying result. These statements ring of the *cor mixte* which Dauprat and others frowned upon as uncharacteristic of the horn. Surprisingly, however, Dauprat was very supportive of Meifred's work in many of his later writings, because he felt that if valved horns were to be used, Meifred's ideas preserved the best of the old while utilizing the new.

The addition of slides to the valve tubing was not the only innovation attributed to Meifred's horn at the 1827 Exposition. His was also the first horn to have the two-valve cluster permanently attached to the bell branch, so crooks could be added internally. The ramifications of this design include the focus on the *cor solo*, instead of the orchestral horn with terminal crooks, thus reducing the practical number of crook choices, if only in terms of changing from one crook to another efficiently. The choice of two valves was a conscious one; Meifred states late in his method that a performer could use his method with a three-valved instrument, but three valves meant more technology with which to contend (Meifred, page 80). In that vein, it is interesting to note that another horn was displayed at the 1827 Exposition, one made by Antoine (Halary) with a detachable three-valve cluster, which received no award. Obviously, Meifred saw valves as a serious, permanent addition to the instrument, particularly for solo performance. It is true, however, as Mr. Ericson points out, that French performers prefered the detachable clusters. Two factors seem to have participated in this bias: the conservative orientation of the Opéra and Conservatoire repertoire which reduced the need or desire for valved horns, and the general orientation among most horn players toward orchestral rather than solo performance. Still, as Mr. Ericson points out, the color changes of the natural horn were generally considered more expressive in spite of the problems of projection and timbral consistency.

In spite of his bias toward the valved instrument, however, Meifred was an important figure in Paris horn playing. As fourth horn and principal valve hornist in the Opéra orchestra, he was in an important position for many firsts: the premiere of Berlioz's *Symphonie Fantastique* (1830) and Jules Halévy's *La Juive* (1835), the first full scale opera at the Paris opera to include valved horns. It is not clear how far beyond Paris his influence on horn-playing was felt, but in Paris he was a prominent performer and teacher, as well as a director of military bands; he participated directly in the conversion from woodwinds to valved brass instruments as the foundation for French military band instrumentation. It is ironic that Meifred's performance at the inaugural concert of the Société des Concerts occured in the very same month as J. R. Lewy's premiere of Schubert's *Auf dem Strom* (March 9th/28th). It is also interesting that an extended visit to Paris by Richard Wagner coincided with the publication of Meifred's method. By the time he arrived in Paris, Wagner was well underway with *Rienzi*, his first major work to use valved horns. It is interesting to speculate, however, about what Wagner heard at concerts at the Société and the Conservatoire, especially a performance of Beethoven's Ninth Symphony Wagner refers to in his memoires, where Meifred was the likely fourth hornist. So many things to consider! So many things yet unknown! One thing rings clear, however: knowledge of Joseph Meifred's activities in Paris is extremely important to the performance of pertinent literature today. In spite of the relative infancy of the instrument itself, mature decisions and considerations were made regarding its contributions and potential.

Once again, congratulations to John Ericson for opening the can of worms. It seems that, as the field of historical performance moves to embrace the 19th century, it is about time for horn players to venture into this still very grey area.

Sincerely,
Jeffrey L. Snedeker
Ellensburg, Washington

P.S. A survey of Meifred's life and his *Méthode* appears in the Fall, 1992, edition of the *Historic Brass Society Journal*.

Ericson responds:

The response by Dr. Jeffrey L. Snedeker to my article, "The Valve Horn and Its Performing Techniques in the Nineteenth Century: An Overview," adds significant information on the subject of Joseph Meifred. I congratulate Dr. Snedeker for his recent dissertation, which contains the first full English translation of the *Méthode* of Meifred, and for his excellent article in *The Historic Brass Society Journal*. His translation of the *Méthode* in particular will open this important source to many, and was not available to me during the preparation of my article. However, I do wish to respond to a few issues.

A major point made by Dr. Snedeker is that it was my contention that Meifred did not fully explore the advantages of the valve. This was assuredly not my contention, especially in light of what had just been presented in the section on Meifred. What I was trying to communicate in the sentence in question was that, while from a modern perspective it might appear that Meifred did not fully explore the advantages of the valve (especially because he retained some hand-horn technique), he was a truly innovative pathfinder on the new instrument in France; and through his technical approach, Meifred was able to retain much of the tonal character of the natural horn.

Among the performing options Dr. Snedeker points to in the *Méthode* of Meifred is that of using the valves as crooking devices. This is true, but only in a very restricted sense. Meifred is primarily concerned with preserving the proper relationships of open and half-stopped sounds in new tonal areas. The valves are used as crooking devices only in the sense that a short-term modulation is found in the music to a key area that has many notes available using one fingering, the "effective" key being those produced by a crook and the "false" keys being those produced by the valves (Meifred, pages 28, 47, and 70). There is no reference made in the *Méthode* to using the valves to crook the instrument into new keys for long-term use as a hand-horn; he clearly did not see the valve horn as a type of omnitonic horn. Furthermore, in the preface to the section on transposition, Meifred states in regard to orchestral playing that "It will always be better, in the interest of execution, to use the crook indicated by the Composer..." (Meifred, page 71, trans. Dr. Snedeker).

As Dr. Snedeker noted, the valve horn which Meifred displayed at the 1827 exposition used crooks which were inserted into the body of the instrument in the same manner as the *cor solo*. This choice not only reflected the aspect of valves being a serious, permanent addition to the horn, as Dr. Snedeker stated, but also reflected two other important issues of horn design.

The first issue is the physical stability of the instrument. Terminal crooks wear and become loose in their fit. According to natural horn maker Richard Seraphinoff, this can happen within only ten years if a horn is subjected to heavy or improper usage. The physical stability of the valve section is also a related problem; detachable valves were not attached solidly to the body of the instrument. The second issue of horn design is a reduction of the differences between the playing qualities of the various crooks. Terminal crooks required the use of a different leadpipe in each key, and each crook, due to the inevitable small variations in the rate of this critical taper, has slightly different playing qualities, even if the crooks are very well matched. Internal crooks, however, always used the same leadpipe in performance, giving the instrument more nearly the same playing qualities in every key. Taken together with the previously noted addition of tuning slides to the valves, all of these aspects combined to make Meifred's horn a very well-designed instrument.

It is significant that Meifred twice mentions the problem of air "répercussion" (resistance) when referring to the valves in his *Méthode* (Meifred, pages i and 80), as well as in his 1851 article, "Notice sur la fabrication des instruments de musique en cuivre" ("Notice on the manufacture of brass musical instruments"). Meifred states that resistance of air is caused by the angles found in the tubing of the valves; he further states that because of this, the valve horn lacked some of the sonority of the natural horn, and, due to their combined effect, the three-valve horn has a more muted sonority than that of the two-valve horn (Meifred, page 80). Meifred was not cautious with regard to technology but rather very knowledgeable of its shortcomings at that time, and he clearly applied his acoustical knowledge to his technical approach to the valve horn.

During the preparation of my article I had the opportunity to test at some length a two-valve Stölzel valve instrument by Guichard Breveté from the collection of Louis Stout. As I stated, when one makes valve changes, there is a subtle difference in the way the two valves interrupt the airstream. While there were clearly other strong reasons to continue to use some hand-horn technique on the valve horn, it is interesting that Meifred's suggested use of the right hand also helped to minimize this acoustical defect in a very musical manner.

Dr. Snedeker presents evidence that Meifred and his *Méthode* were known outside of France. One important additional source should be noted. A *Grand Method for the French Horn* by "Meifred, Gallay, and Dauprat" was published in London by J. R. Lafleur & Son sometime in the second half of the nineteenth century. Although the text was freely translated from all three sources and combined by an unknown editor, this method presented the technical ideas and exercises of Meifred in an abridged but understandable form to English-speaking horn players.

Finally, please note one minor correction to my article. Henri Kling's work on orchestration was originally published under the title *Populäre Instrumentationslehre* in 1882 by Louis Oertel in Hannover. The date of 1902 given in my article was the date of the first edition of the English translation.

Thank you for giving me the opportunity to respond to Dr. Snedeker's thoughtful and insightful letter. I congratulate Dr. Snedeker again on the significant contribution he has made toward the modern study of the use and technique of the valve horn in the nineteenth century. We have only scratched the surface of this fascinating and broad topic.

Sincerely,
John Q. Ericson

Honorary Members:

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Bernhard Bruechle, Germany
Domenico Ceccarossi, Italy
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