Chapter 1
The Evidence

"What everyone knew then, no one knows now."[1]

There was no particular reason in Monteverdi's or Bach's time to provide a record of absolute pitches for posterity. It would probably have astonished people to know we would even be interested.

Nor have pitch standards always been necessary. Until the late 16th century church music was vocal, so pitch was a question of the range of the human voice. Instruments were represented in church only by the organ, and even then playing only *alternatim* passages, alternating with the singers. When secular instruments like the violin and cornett did finally enter the church, the process of matching pitches produced discussions that left records: although they were not intended for us, such discussions represent valuable evidence for our study. And as secular instruments tended to mutate more quickly than organs, more discussion (= evidence) was produced.

The situation in the baroque period was especially complicated by the quick dissemination over Europe of newly developed woodwind instruments with pitches that were not only relatively fixed but different from that of traditional local instruments. A number of practical solutions to the resulting pitch discrepancies were developed, but being of an *ad hoc* nature, they were not completely documented. Nor was the terminology consistent; the same name might be used for different frequencies, and the same pitch level might have different names. As Bessaraboff wrote in 1941, "The elusiveness of some factors [in researching historical pitch] was of such a nature that it seemed as if someone had devised the whole thing with devilish ingenuity to mock and tease unfortunate twentieth-century organologists."[2]

But enough clues have now appeared to allow a picture to emerge. Chance has left a number of written descriptions of pitches in relation to each other, some usable scientific measurements and tuning devices, and many original instruments that give direct evidence. The written material clarifies the relationships between pitch standards (such as the difference of a M2 or m3 between *Chorton* and *Cammerton*). It also gives pitch standards their names. But it does not tell us the frequency values of pitch standards.

Absolute frequencies come from original instruments (and to a much lesser extent, reports of early research into acoustics). In a sense, this information is the opposite of that supplied by written sources, because it yields pitch levels without names.

It is by coupling these two types of evidence that the frequencies of historical pitch standards can be discovered, and with them, insights into the pitch levels at which particular pieces were played. It happens, rarely, that both kinds of information come together, as, for example, when the original pitch frequency of an organ survives, as well as an original contract or contemporary description that identifies the pitch standard to which it was tuned (see Appendix 1). With these few lucky pairings, a very strong case exists for matching a pitch name to a Hz value. When several such combinations occur, we begin to be confident of the frequency level of the pitch (limited, of course, to a particular time and locality).

In practice, instruments can often be plausibly associated with named pitch standards (for instance, recorders made in Leipzig with Bach's *Cammerton*). In these cases, the number of instruments examined and the consistency of the results are relevant (i.e., how many Leipzig recorders have survived and do they all give the same pitch?).

1-1 Paper Evidence: Pitch Names and Relationships

Brief allusions to pitch and descriptions of how pitch standards related to each other appeared fairly frequently in instruction books, theoretical works, dictionaries and other compendia, and documents by instrument makers such as letters, bills, and contracts. Normally they were included incidentally as parts of more general discussions.

There are also many examples of music from the 17th and 18th centuries notated in more than one key. German composers of the early 18th century who were faced with the problem of writing in "German" and "French" pitches simultaneously, for instance, were obliged to develop an informal system of notation to accommodate instruments at *Chorton* and *Cammerton* playing together. The interval between the parts, either a whole-tone or tone and a half, indicates the relation between the pitches involved.

Another strategy that can be used for locating and comparing pitch standards is to track the activities of wind instrument virtuosi whose concert tours took them to many parts of Europe. Mendel (1978:91) thought the traveling virtuoso was primarily a 19th-century phenomenon, but we will see that many celebrated woodwind players in the 18th century continually crossed borders, both political and cultural. Obviously, soloists would rarely have switched instruments merely to accommodate pitch standards.

1-2 Original Instruments and Original Pitch Frequencies

Pitch frequencies are the product of the physical nature of musical instruments. It follows, then, that a history of pitch standards will be similar to a history of how instruments adapted and mutated with time. Our knowledge of changes in pitch is related, then, to how much or little we know of the great and small revolutions in instrument design.

A new factor is used in the present study that was not available to researchers in the past like Ellis and Mendel. This is the increased understanding of how historical instruments were played (that is, instruments that used to be considered historical). Many of these instruments are once again being used in concerts, and not only do we now know enough about them to determine their ranges of pitch, we can often distinguish stages of their evolution and their pitches at specific dates. This new evidence signals a significant change in the way this subject can be studied.

The pitches of original instruments are usable as evidence only if they are credible. On this question there are a number of factors to consider, including the nature of the instruments (discussed in Section 1-3 to 1-5 of this chapter), their present condition, how their pitch is measured, and the suitability of the techniques used to play them (discussed in 1-6). The credibility of evidence from original instruments also depends on a sense of what degree of precision is appropriate in studying pitch, a subject treated in Section 0-2 of the Introduction.

In terms of numbers, I was able to consult the pitches of many surviving original instruments, thanks to a grant from the Canadian Social Sciences and Humanities Research Council. The present book regularly refers to this information, which is included in summary form in the appendices; these list the pitches of some 127 cornetts, 28 Renaissance flutes, 292 traversos, 317 recorders, 70 clarinets, 540 organs, and 13 pitchpipes, for a total of 1,387 original instruments.[3] The appendices include only instruments whose reliability I trust. Of these instruments, about 222 are Italian, 208 French, 544 German, 192 English, 110 Dutch, 77 Belgian, and 31 Austrian.[4]

Together with three automatic instruments, this makes a total reference base of 1,390 original pitches. This is not a complete survey, as it probably includes less than half the instruments of these types that have survived and are still able to give plausible pitches. But it represents a larger sampling than any previous study (Ellis, for instance, based his work on about 300 original pitches listed in his tables). My data is the result of several years of correspondence, reading, listening to recordings, and visits to museums and private collections.[5] (I understand Ellis's feeling when he wrote in 1880 of his collection of historical pitches: "I wish [these facts] were more complete, but the difficulty of getting information is, sometimes, exceedingly great, and the time spent over obtaining a single pitch has often been so long that I should despair of living for years enough to render my investigations really complete."[6])

It might seem that the foundation on which we know the levels of historical pitches can never be tested by direct experience, since we cannot hear the music as it was originally played. But we can hear some of the same instruments (the ones that survive), and measure their pitches with the same accuracy we use in tuning modern instruments. The difference lies in the possible changes original instruments may have undergone with time, and changes in performing technique. These issues can be addressed by choosing the instrument types that are the least flexible in pitch, and by an awareness of the variables that affect pitch on each instrument.

One pitch standard that was used continuously as a point of reference in written descriptions throughout the 16th, 17th, and 18th centuries in both Italy and Germany is the so-called *Cornet-ton* or "tuon del cornetto di mezo punto." We will discuss below why the pitch of cornetts acts as a reasonably reliable index for locating the pitch levels of other standards that were described in relation to it.[7]

There was also an important standardizing factor that we easily overlook in this secular age: the organs. Organs tended to stabilize pitch over relatively long periods in preindustrial Europe. As long as a major proportion of art music was sacred, as it was in that period, it was played alongside the highly elaborated organs of the church. These instruments were made by men who tended to stick to well-known patterns and standards, and once made, an organ was too expensive and venerable for casual alteration. We will see, for instance, that Bach's organs at Leipzig were still using the pitch level described over a century before by Praetorius.

The new French woodwinds, once they were established, also began to act as a stabilizing factor. Organs were usually tuned so they could function with other instruments, and harpsichords were often tuned to flutes. Adlung wrote on tuning clavichords (1726:II:163), "It does happen that the weather causes the pitch to fluctuate; in that case, one should have a flute or other instrument of invariable pitch handy, so one can find the normal pitch again."

Sorge (1744:35) wrote, "One begins then on f, and tunes in *Chorton* or *Cammerton* (depending to which the harpsichord is tuned) approximately to the pitch of a recorder or traverso."[8]

A chamber organ by Kirchmann made *ca.*1740 was "geïntoneerd na de Fluyt Travers" ("tuned to the traverso").[9]

The history of pitch is thus integrally connected to these two types of instrument: the organ and the woodwinds. Praetorius, speaking of pitch, cited "alten Orgeln und andern blassenden *Instrumenten*" ("old organs and other wind instruments") as indicators.[10] Organ makers often specified pitch in reference to woodwinds, especially the "Flute" (recorder): *Fluytedou toon* (1724), *Hauboistoon* (1721), and *ordinaris Flute dous toon* (1727).[11] Woodwinds tended to influence pitch because they were unable to adjust very much. The lack of pitch flexibility in these instruments makes them now the major source of evidence on historical pitch frequencies. The pitches of these instruments are easier to visualize through graphs. I have included a number of graphs at the end of the book that organize pitches by region and period: organs are shown by country in Graphs 18-25 and by period in Graphs 4-8; Graphs 12-17 show woodwinds by country and Graphs 26-30 show them by period.

In addition, pitch has been measured by physicists since the 17th century, and some of these reports are useful for this study.

1-3 The Most Useful Instruments

1-3a Cornetts

Cornet-ton derived its remarkable stability from the simplicity and perfection of the instrument's design. (We are speaking here of the normal curved instrument,[12] usually with a separate mouthpiece, that gives a six-fingered A). The cornett's one-piece construction makes it difficult to shorten without disturbing its internal intonation, so alterations are easy to detect. Its basic design remained stable over a long period, and during that period the majority of cornetts (like other woodwinds) came from one place: Venice. The available data shows consistent patterns, suggesting that it is fairly accurate. Sounding length can be roughly correlated to pitch, offering a cross-check on accuracy.[13]

Two historical indications of just how specific the concept of cornett pitch was are provided by Michael Praetorius in 1618 and Bartolomeo Bismantova in 1677. Praetorius (35) wrote that "even a cornett can be helped into tune by moving the mouthpiece in or out."[14]

Bismantova's description of how the pitch of a cornett could be minutely adjusted with the help of various small additional pieces was discussed in 0-2a.

Despite these early indications of how precise cornett intonation was, the common wisdom nowadays is that differences in pitch between cornett players is extreme, and therefore pitch data from the instrument is unreliable. I have found, however, that the present generation of practicing cornett players (those who Rainer Weber graciously calls "wirkliche Zinkenisten"[15]) do not share this attitude. Players who use the most common historical embouchure (off to the side rather than in the center like a trumpet) find it relatively difficult to bend notes. And players can hear if a note is at the right pitch when it becomes brighter in tone, and when it stops "hissing" (which it does when it is either too low or too high).[16] There are thus several checks on the plausibility and accuracy of pitch measurements in cornetts.

The pitches of 127 surviving original Italian and German cornetts of the 16th and 17th centuries are listed in Appendix 2.[17] Included are only those examples in reasonable playing condition. These pitches indicate an unambiguous level that we can assume was considered "cornett pitch:" although it was less specific in the 16th century, its center was never far from A+1.[18]

Comparing the lengths and pitches of surviving cornetts with the instruments depicted in Praetorius's *Sciagraphia* of 1618, it is possible to estimate that one of the cornetts at 58.3 cm would play at about 460 and the other (at 57.6 cm) at about 464.[19] Mersenne's treble cornett depicted in the *Harmonie universelle* (1636-37) at one and three-quarters *pieds du Roy* (or 56.8 cm),[20] would on this same basis yield A≈469.[21]

The playing reports on mute cornetts (Haynes 1995:421-28) are less reliable, since few modern cornettists regularly play this type of instrument. The mute or straight cornett also seems often to have had a different musical role than the curved one. This may be reflected in the difference in pitch between curved and straight cornetts; the latter are lower (see Graph 1b and 1c); most straight cornetts are at A+0.

1-3b Renaissance Flutes

The instrument known as the "Renaissance flute" is particularly reliable as a pitch indicator because of its physical properties. Like the cornett, it is made in one piece, so its pitch is difficult to alter. Also, as Herbert W. Myers* writes,

> The scaling of Renaissance flutes is extremely consistent, due to their acoustical simplicity: surviving examples were invariably cylindrical . . . the influence of the player's blowing technique on pitch tends to be rather small, because of the propensity of some notes to be flat and others sharp. Specifically, g" [fingered 123] overblows flat and a" [fingered 12 456] overblows sharp, requiring extreme embouchure corrections in both directions; the average playing pitch is thus "bracketed" by the natural, uncorrected pitches of these notes. That is to say, the player has little choice but to play at about that average.

The cylindrical bore of this instrument makes it possible to compare pitch based on speaking lengths.[22]

Renaissance flutes were probably used from the early 1500s to late in the 17th century.[23] Pitches of 28 surviving original Renaissance flutes are listed in Appendix 3. Their provenance is in most cases difficult to assess. By implication most are from the Venetian Republic (except for the flutes by Rafi, which are known to be from Lyon). While the Renaissance flute played in consorts, it is associated both in pitch and instrumental settings with mixed groups involving the mute cornett and strings.[24] Among surviving instruments, the predominance of tenors (the size that corresponds to the later baroque flute) suggests that tenors may have had more extensive use in mixed musical situations than other sizes.

Myers* determined, on the basis of dimensions, that the transverse flutes depicted in Praetorius's Plate ix must be about a minor 3d below A+0, or about A-3. The first two instruments listed in Appendix 3 are in A-3 if the six-fingered (lowest) note of the tenor is assumed to be d1.[25] Smith (1978:27) suggests that these instruments were built so low for the beauty of their sound, and were meant to be played in consorts. Praetorius wrote, "Flutes and other instruments are also more beautiful when tuned below our normal pitch, and at the lower pitch give quite another effect to the listener."[26]

The great majority of surviving Renaissance flutes are at about 400, and a smaller number are at 425-435. The higher level corresponds to that of most surviving mute cornetts.

1-3c Traversos

There is no question that "different players can arrive at a different ideal pitch for the same flute."[27] Quantz wrote that "Depending on whether the embouchure is more or less open, a player can sound a flute a quarter, a half a tone, and even a complete whole tone higher or lower."[28] This is of course theoretical; as on the cornett, the scope of possible pitches produced when the player is actually making music is considerably smaller.

The traverso maker Roderick Cameron* believes the instrument's pitch "can be up to 25 cents different among good players depending upon embouchure." On a museum visit to measure traverso pitches, Barthold Kuÿken* noticed that "I had a colleague with me who played everything ± 3-4 Hz sharper . . . and another who played ± 2 Hz flatter." This is a range of 5-6 Hz, or 21-25 cents.[29] In playing situations, the modern Boehm flute certainly gives the impression of carrying a specific pitch; Leipp & Castellengo (1977:12) determined that the normal margin of intonation of a modern flute is 4 Hz around its supposed base-pitch, or about 17 cents.

The existence of *corps de rechange* (alternate joints) indicates the traverso's limited flexibility in pitch; *corps* would not have been necessary if such adjustments could have been made by the player (as on the bassoon and the early 18th-century hautboy, where alternate joints were less common). Traversos were designed so that only one or two *corps* were used regularly. For a pitch study, it is interesting to know which these were. The *corps* were normally numbered, the longest being number 1. In the late 18th century Ribock (1782:34) compared traversos in Berlin style with those of Saxony. The Berlin instruments were by Quantz and Kirst and the Saxon were those of Augustin Grenser and Tromlitz in Leipzig. Most were provided with six *corps de rechange*, and Ribock was of the opinion that the Saxon flutes were best towards the top of their range (with joints 3 and 4, in other words), while those of Berlin were best at the bottom of theirs (joint 1). Modern makers and players have also reported[30] that traversos made by Quantz play best with the longest middle joint, as the head bore is quite large;[31] this joint also shows the most wear on surviving instruments.

As discussed in the Introduction, it seems that the narrowness of the intervals between the *corps* on later 18th-century traversos shows an attempt to adjust pitch within a single pitch standard. The earlier instruments, such as those of Jacob Denner with fewer *corps* and wider intervals between the joints (10 Hz or more), probably reflect actual differences of standard (and if this is true, these early traversos are particularly useful for showing the exact spacing between pitch standards). To consider the pitches of all the *corps de rechange* would confuse matters; the most accurate results probably come from referring to the pitches of joints 3 or 4 on most traversos, with the two exceptions just mentioned: joint 1 of Quantz and Kirst flutes, and all the joints of the earliest traversos.[32]

Adjustments to the placement of a traverso's cork or the length of its foot have to do with the internal intonation of the instrument,[33] not its basic pitch. The cork is moved when *corps* are interchanged to compensate for changes in the instrument's sounding length.

Physical alterations to original traversos that would raise their pitch are detectable. Enlarging an embouchure-hole affects the tone;[34] a better method of raising pitch is to shorten the (upper) middle *corps*, but this can adversely affect the internal intonation and is visible (there is normally a short blank section on the tenon at the extreme end of the joint beyond the thread grooves—called the "tenon ledge"—that would be missing on a shortened joint).

Some of the original traversos listed in Appendix 4 have reconstructed embouchures. Given our present knowledge of the playing characteristics of intact original instruments, these reconstructions generally give accurate pitches and are as trustworthy for the purposes of this study as restorations on other kinds of instruments. Each case of this type was considered individually, however, and a few instruments were excluded.

In sum, within a tolerance of 15-25 cents traverso pitch can be regarded as reasonably accurate historical evidence. While some traversos may have been raised in pitch, there is no way to lower them, so it is likely that the present pitch of early specimens cannot have been higher, although it might once have been lower. Traversos can also serve as a control on other instruments, such as recorders, by the same maker.

1-3d Recorders

Mattheson (1721:434), in discussing tuning, was of the opinion that hautboys and bassoons were rather difficult to "force" (that is, to modify in pitch by blowing), while "Recorders are absolutely intransigent in tuning, which is why they produce the worst intonation problems, and increase the jangle with their regular howling. They always want the tuning higher or lower. Traversos are much more tractable."

A more positive take on this characteristic of recorders was offered by Louis Mercy (1718): "But I must say something more in praise of the Flute . . . [it is] never out of tune, nor can you well Stop [finger it] out of Tune." Recorders can in fact be considered, as Friedrich von Huene once said, relatively reliable 18th-century "pitchpipes," since of all the woodwinds (except perhaps the clarinet), they are the least flexible in pitch. Even more than traversos, differences in wind pressure are only possible within a narrow range.[35]

An original recorder has no separate parts (such as reeds or mouthpieces) that might now be missing. If its scale is reasonably in tune, it has probably not been shortened. An enlarged window will raise a recorder's pitch, but such doctoring, if it is significant, is easy for an expert to detect.[36] And from a historical point of view, since the recorder fell into disuse during the course of the 18th century, there would have been no reason at the time to alter the instrument in an attempt to raise its pitch.

Praetorius showed eight sizes of recorder, intended to be played in consort. Consorts are less useful as pitch indicators, since they were not necessarily played with other kinds of instruments and could therefore have been tuned independently of any pitch standard. Recorders that are most interesting to this study are those made in three sections, of the type made after the middle of the 17th century.

Both the recorder and the traverso were regularly used in typical ensembles of their time, so their pitches can be taken as representative of general pitch standards.

1-3e Clarinets

A few pitches are available from clarinets made in the early 1700s, but the instrument is especially useful for the latter part of the century. From the point of view of pitch, the emergence of the clarinet counterbalances the slow eclipse of the organ's influence in instrumental music during the 18th century. In a sense also, the clarinet filled the gap left by the demise of the recorder. Thanks especially to Mozart's Viennese works, the clarinet took on an important role in ensembles. An indication of the time when clarinets became a significant presence is the general edict of Louis XV in France in 1756 replacing hautboys with clarinets in regimental music.[37]

The clarinet is one of "the least tractable of the woodwinds"[38] in regard to tuning changes. There are several reasons for this. It overblows a twelfth, making tuning relationships unusually sensitive (the other woodwinds over-blow an octave). More important, because it uses a single reed attached to a mouthpiece, embouchure adjustments are less effective at changing overall pitch than on the other woodwinds. Eric Hoeprich* writes,

> Pinching and relaxing the embouchure simply don't make very big differences in pitch without a huge difference in sound quality. So if one keeps the sound at an "acceptable" level, then there won't be much room for pitch change. . . . [The clarinet] is by far the most stable instrument among the woodwinds. It has been shown that it is possible to make a clarinet with nearly perfect intonation—very difficult, but possible—and as a maker/player I must say that you make the instrument as well as possible, figure out the fingerings that play in tune and then just play. This doesn't apply to the other woodwinds where embouchure flexibility is essential to playing in tune since the instruments themselves are relatively speaking, out of tune.

According to David Ross*,

> Aside from the obvious expedient of pulling out at the joints, the clarinet's sounding length cannot be varied by much, pointing towards stability. I have found that by varying the width and strength and reeds, I could alter the overall pitch level by a bit, perhaps 5-8 cents, but the pitch on a functioning clarinet seems to be fairly fixed.[39]

Nicholas Shackleton* also points out that where changing the distance from the top tone hole to the sound producer (embouchure hole, reed) on a flute or hautboy has "approximately twice the effect on c [i.e., on hole 1, the highest] as on d [i.e., on hole 7, the lowest]. On a clarinet the equivalent has three times the effect. . . ." Tolerances for barrel-mouthpiece length are very small; in other words, an inappropriate setup is easily noticed.[40] Convincing internal intonation is therefore the criterion that indicates if one is playing at the original pitch level.[41]

A number of early clarinets are now missing their original mouthpieces. Many "wooden mouthpieces are now unplayable because of damage to the end of the beak and others have been worn so thoroughly on their lays that they are now unplayable."[42] Such instruments might still be reliable as indicators of historical pitch if they could be made to play in tune internally with another mouthpiece. Albert R. Rice writes,* "Replacement mouthpieces often became necessary for playing and are sometimes very difficult to distinguish from originals." The use of new mouthpieces is considered valid for determining original pitches by most experts, since the principal criterion for determining pitch is that the clarinet play reasonably in tune with itself.[43]

Pitch levels of historical clarinets are useful information when it is known in what nominal pitch they were conceived (e.g., in A, B♭, C, D, etc.). It also gains weight when compared to the pitch levels of other contemporary instruments. The tone color of the clarinet varies noticeably depending on its fundamental pitch; as a result, the standard modern orchestral clarinet is tuned to 392 rather than 440. Its parts must therefore be transposed up a step to sound in the same key as the other woodwinds. Nowadays we express this fact by saying that the clarinet is "in B♭." The clarinet in C (the pitch of the other woodwinds) has an unmistakable character and tone quality, brighter and colder than that of the standard B♭-instrument. Many clarinetists also use an instrument another semitone lower "in A;" here, too, timbre is a factor. Although the basic reason for the B♭/A alternative is to avoid excessive numbers of sharps, it is significant that clarinetists do not resort to a C instrument (which would solve the same problem) as much as to one in A.

As for accuracy, Shackleton believes that

> To judge the pitch [of a clarinet] accurately within better than 20 cents the instrument must be in full playing condition with an appropriate design and size mouthpiece, must demonstrably be internally in tune, and must be played long enough to have reached a stable pitch in a room of appropriate temperature.

As a test of pitch, Shackleton suggests beginning by checking the transition across the break and the C below that.

> Then judge the pitch on written C above the break, noting how the rest of the clarinet register pans out. I say that because sometimes an instrument is retuned upwards with some hole enlargement, but the A♭/E♭ hole is usually already so large that there is little scope for bringing the note any higher; often they [i.e., a later tuner] were too sloppy to bother with the F#/C# hole either.[44]

Ross described his testing procedure as

> quite straightforward, even somewhat pragmatic. . . . Once a general pitch level was established (for instance in the upper register or between the octaves of c', c", and c'"), I then attempted to find suitable fingerings to bring the rest of the range reasonably in tune.

Ross has found only a few instruments with impeccable intonation; most had a workable upper register with intonation problems in the lower register. He still considers these instruments usable, since "most 18th century clarinet writing emphasized this upper register, and such instruments might have served this literature well."[45]

Since competent players of the early clarinet are rare, not all the pitches of the approximately 100 surviving early instruments have yet been measured.

1-3f Organs and Church Bells

In 1696 Sir Christopher Wren referred to Bernard Smith's (now famous) new organ at St. Paul's Cathedral as that "confounded box of whistles."[46] Many a wind player trying to match the pitch of an organ has used even stronger language, since both types of instrument are unyielding in pitch.

Pitch information from early organs complements that of other instruments. Organs are rarely moved, so their pitch, if original, can usually be taken to represent a standard for the place where they are located. Because they are expensive and usually associated with institutions like churches, there is often comprehensive archival documentation (contracts, proposals, descriptions, etc.) on their construction and modification over the years.[47] These records sometimes mention pitch standards; when they can be combined with surviving pitches, they are especially useful in providing links between named pitch standards and frequency levels.

Until at least the mid-18th century, the significance of the church's role in daily life meant that organs were implicated in much of the mainstream music that was performed. Since this music also frequently involved other "figural" or orchestral instruments, there was of necessity a direct relationship of some kind between the organ's pitch and the pitch of other instruments. Bédos wrote (1766:432) "*Ton de Chapelle* is a fixed pitch in France; it best matches the range of both the voice and all musical instruments . . ."[48] Organs were thus in a relation of whole intervals to other instruments, and organists had often to transpose (*Cammerton* was a discrete number of semitones from *Chorton*, for instance). Organs were often higher-pitched than other instruments, for the sake of tone quality and because the pipes were shorter and thus less expensive to make. By the late 18th century the musical relationship between the organ and other instruments had broken down, and there was a general trend in all countries for organs to remain where they had long been, while the pitch of orchestral instruments went its separate way.

Of course, if it is still functioning, an instrument of the size, complexity, and age of a baroque organ cannot have escaped being altered. Organs were regularly repaired, retuned, rebuilt, and restored. As Peter Williams wrote, "The big organs of the great builder-families . . .

were like living organisms, changing their shape and style from generation to generation."[49] It is therefore not enough to know the present pitch of a historical organ.

The most reliable information on original organ pitches comes from recently restored organs, because the process of restoration usually reveals the earliest state of an organ in at least a few pipes, and consequently its original pitch. The organ-builder Dominic Gwynn* writes that "The commonest way of changing pitch in an organ is to move the pipes . . . it is only possible to arrive at the original pitch by tracing pipe movements, estimating cutting down, etc. Most of my [pitch] evidence I have gained by examining the building history of instruments." Evidence a restorer would use for determining original pitch includes pitch marks on pipes (peculiar to particular builders), changes to the keyboard or key mechanism, and archival records.[50] Physical changes to pipes could include cutting down or extending open pipes (Gwynn writes that "it is difficult to gauge the amount, but because of the option of transposing pipes, one can assume it is less than a semitone. Sometimes there are pitch marks at the top of the pipe which have been partially cut off."), repositioning stoppers on stopped pipes, displacement of tuning ears on stopped metal pipes, and soldering up or cutting down the tuning slots on front pipes. Ton Koopman* points out that pitch was not the only reason pipes were changed: in the 19th century the ideal organ timbre was much less brilliant, and since shortening a pipe makes it proportionally "fatter," it tends to result in a "rounder" sound. There was thus a motive for moving pipes even more than a semitone.

Many earlier organs survived in close to their original states until well into the 19th century. By that time, antiquarian interest had produced a number of pitch reports, so that the original pitches of some important organs are known even when the instruments have since disappeared.

The pitches of organs can sometimes be checked with the bells in their churches, both "Cymbel Glocken" operated by the organist, and the tower bells, which (for practical reasons) were normally tuned to the same pitch.[51] In a description of organs published in 1772, William Ludlam commented,

> If an organ was to be erected in *St. Margaret's* church [in Leicester], its pitch should by all means be made to agree with that of the bells; so that if the organ should begin before the sermon bell is ceased, they need not be at variance. So noble a bell would add to the harmony of the organ.*
>
> * In this church is the noblest peal of ten bells in England, without exception; whether *tone* or *tune* be considered.[52]

A respected organist, Gustav Leonhardt*, warns that the pitches of historic organs must "be taken with a grain of salt: conclusions often have been made too easily, disregarding later changes on pipes or wind pressure." This warning is appropriate; there are a number of pitfalls in considering historical organ pitches. Factors that need to be considered include knowledge of an organ's history, the effects of repeated tuning, temperature, standard pipe-scaling and details of manufacture, wind pressure, dust, the differences between flue pipes and reeds, between wooden and metal pipes, etc. These issues are addressed in detail in Haynes 1995:480-92.[53]

One problem with data from organs that have been restored is that at restoration their pitch may be purposely brought to a preconceived level that the restorer believes is "historical." The levels commonly considered to be in this class are 415 or 466, which are an exact semitone (in equal temperament) on either side of 440; some restored organs that were originally near these levels may have been rationalized to meet them literally.

Given a knowledge of these elements, a plausible (if approximate) original pitch can be determined for many historical organs. There is no doubt, however, that in specifying organ pitches, Jean-Albert Villard, the organist of the famous Clicquot organ at Poitiers, is correct in saying* that an organ pitch is "à l'entour" ("around") a particular number of cycles per second.

In 1978, Mendel listed 48 "reliable" historical organ pitches. I checked his data (some of which, inevitably, turned out to be mistaken), and in Haynes 1995:502-39 was able to add 416 new organ pitches (I had to exclude, for various reasons, about 200 others). Most of this information came from the many recordings of historical organs that have appeared in the last generation.

One particular category of organs that must be carefully considered are those with original pitches that no longer survive. For those with pitches that were reported prior to their destruction (in the 19th century, for instance), there is no ambiguity. But there are others for which it is only possible to make deductions. The Gottfried Silbermann organ at St. Johannis, Zittau, for instance, was destroyed in 1757, but its contract is practically identical with the one for the Frauenkirche in Dresden (which we know was at 414) and it (like the Frauenkirche organ) is described as in "Cammer-Thon." The 8' Gedackt stop on the Jacobikirche main organ at Hamburg, replaced in 1761, was a minor 3d below the rest of the instrument, which is now at 489. The organ at Hohnstein (Schmieder, 1732), played by Sebastian Bach in 1731 and 1732, is now at 437, but its action was shifted a whole-step lower in 1935. At Weingarten, now at 440, the original contract states that the lowest C of the organ was supposed to sound the same as the large tower bell; that bell now gives 440 minus 130 cents. In most cases like these, plausible original pitches can be deduced. These pitches, like all the others in Appendix 7, are situated along a gamut of probability.[54]

On the positive end of this gamut is an important list of the original frequencies of 42 organs with pitch standards that were identified by name (see 1-8 and Appendix 1).

1-3g Pitchpipes

How did instrumental ensembles find their reference pitch in the days before electronic tuners? Where did the harpsichord get its note? To judge from considerable historical evidence, the pitchpipe was the usual means of carrying pitch in the preindustrial music world.[55] Mendel (1978:82) cites "a pitch-pipe which Handel constantly carried with him," [56] and Hawkins recounted that John Shore in the early 18th century used a fork to tune his lute; apparently it was a curiosity: "At a concert he would say, 'I have not about me a pitch-pipe, but I have what will do as well to tune by, a pitch-fork.'"[57] The implication of Shore's remark is that a pitchpipe was the normal device used for tuning.

The pitchpipe was like a small recorder fitted with a movable wooden plunger or piston, on which a scale of notes with a range of about one octave was marked. Fontenelle (1700:137) indicated that such a "Sifflet de bois" was used in France during the 17th century:

> To determine the pitch at which voices and instruments should tune in an ensemble, the performers use a kind of wooden or metal whistle made to a particular length. Since they intend this pitch to be always the same, they think the whistle always yields the same pitch.[58]
> But this is an assumption that is not always true. 1. A 4' organ pipe which is by its nature more accurate than a short whistle does not always produce exactly the same sound. 2. The material from which the whistle is made is quite subject to alteration from being used over a period of time, the weather, and one hundred accidents that can occur change its pitch noticeably after a number of years. 3. There is no question that by blowing harder or softer in the whistle, the pitch rises or falls, and there is no way to be sure of blowing the same way every time. Finally, if the whistle is lost, it is no longer possible to locate the pitch that was used.

To put Fontenelle's statement in context, he was presenting a partisan position in favor of an alternative to the pitchpipe; he was also applying the criteria of the acoustician rather than those of the musician. Most of his objections can be answered: it is quite conceivable that a pitchpipe is less sensitive to change than an organ pipe because the latter is thin-walled; certainly alterations to the material in a pipe might affect the pitch but not significantly in musical terms; blowing at about the same pressure would probably (depending on how the pipe was made) be close enough for the practical needs of a musical ensemble; and any sensible musician would have another backup pipe at the same pitch. In other words, a pitchpipe was not required to give a pitch to the same exact Hz in order to be perfectly usable in musical practice.

An Italian source in 1774 indicates the general use of the pitchpipe in instrumental groups,[59] and they are described as commonplace for tuning pianos in a publication from Vienna in 1805.[60]

Pitchpipes were often used to fix the basic pitch of keyboards. There is evidence that Joannes Couchet, whose instruments have always been highly prized, was concerned that they be tuned at a particular pitch for the sake of their "resonantie," or tone quality. He advised Constantijn Huygens, to whom he had just delivered a new clavecimbel,

> that if he will always tune it to the standard pitch, wherefore Your Honor has a little flute, to which the G *sol re ut* should be tuned, then the most satisfying sound will result, since if the instrument is too low or too high, the tone quality will be spoiled and not as it should be, and [the instrument] will not speak as it was made to do; but if it is done in this way, I will have honor from my work.[61]

For tuning a harpsichord, Roger North wrote in *ca.*1710-1726:

> Most begin on C; but following the example of some organ builders, I have chosen F for an entrance. The first thing is to tune that F to its consort pitch, which is done by the help of a pipe, usually made for that end.[62]

And in 1739 Van Blankenburg wrote of harpsichords:

> To tune the first string, if *opera-toon* [Opera-pitch] is desired, the sound can be obtained from a flute at this pitch, or else, you can make a square flute without finger holes, in which a sliding rod fits. On the four sides of the rod, different levels can be marked to test organs. This is called a pitchpipe. But since any pipe is unstable in sound because of warmth and cold, humidity and dryness, and because it can be raised or lowered quite a bit by blowing harder or softer, the best reference for a stable pitch is a sounding metal [i.e., perhaps a tuning fork].[63]

That pitchpipes were commonly used for tuning has not been generally known, and may be one reason they have not previously been displayed in most instrument collections or listed in catalogues.[64] Pitchpipes operate on the same level of accuracy as recorders, since they use the same blowing technique. They are thus well within a usable range of tolerance for conveying musical pitch. They usually include the names of each of the notes they produce. Unlike forks, they can offer

clues as to how their pitches were used, such as the maker's stamp; occasionally a date is added, and an identification of the name of the pitch or the place where the pipe was used.

De la Fage (1859:29ff) noted that pitchpipes were commonly used instead of tuning forks in France as late as the beginning of the 19th century. A number of early pitchpipes have survived. Most can be dated from the end of the 17th to the mid 19th centuries.

The Museo Civico in Bologna possesses a *corista a fiato* or pitchpipe[65] that was apparently made in the 18th century, and "has a sliding device inside, producing three different tones. They are indicated on the wooden plunger as two Milanese pitches (a' = 425 and 375) and one Neapolitan pitch (a' = 411)."[66]

A pitchpipe with a plunger on which there are marks in ink, going chromatically from E through its octave to G (skipping only the high F natural) is described in Byrne 1966. The pipe is inscribed with the date "July 14th, 1774," and seems to be of English origin. Careful measurements by Byrne yielded a mean value of 425±1 Hz for A (because of wood shrinkage, this pitch was probably originally about 5 Hz lower).

Three pitchpipes preserved at the Paris Conservatory are especially interesting. One, probably made after 1711, gives "*Ton de l'opera*" as 399 (probably originally 394) and "*Plus haut de la chapelle a versaille*" as 412 (probably originally 407). Another is believed to be by the maker Dupuis (*fl.*1682), and is at about 396 (probably originally 391). The third, made in the late 18th century by Christoph Delusse,[67] gives two sets of pitches, neither named, at 400 and 424 (probably originally 395 and 419).

Such small portable pitchpipes are distinct from the *Stimmpfeife* used by organ makers, as described in Adlung 1726:II:56, Adlung 1758:312, and Wolfram 1815:328.[68] The latter were usually made of metal and were blown through the organ's wind-channel rather than by mouth. A "*Temperatur-Pfeiffe*," usable both for tuning and checking the temperament of a previously tuned organ, is also described in some detail in Sorge 1758:27-28. Using a pipe for tuning to the fineness of a temperament indicates how accurate pipes were considered. The *Temperatur-Pfeiffe* was to be operated by each individual instrument's wind pressure, "but for each separate organ a special *Stimmpfeife* must be made."[69]

The pitches of 13 surviving original pitchpipes are listed in Appendix 8.

1-4 Less Direct Evidence

1-4a Strung Keyboard Instruments and Lutes

In 1965, Frank Hubbard wrote of harpsichord pitch:

> Any sort of reasoning which attempts to deduce the pitch of harpsichords from string length rests on very shaky foundations since it is possible for a string of a given length to vary about a fifth in pitch and still sound fairly well.[70]

As noted previously, Couchet was concerned about the pitch of his clavecimbels and its effect on tone quality and response. At the time Hubbard wrote this, he was not considering the principle applied by recent researchers (such as Huber, O'Brien, Koster, Wraight, and Martin) that keyboard strings were tuned close to their breaking points.[71] O'Brien, for instance, writes that

> The early builders of virtually all European traditions designed their instruments so that the strings were, with a small safety factor, very close to the breaking point of the material being used. Instruments designed to sound at pitches different from one another would therefore have string lengths which differed in a regular way.[72]

Denzil Wraight (1997:87-90, 164, 189-90) discusses this same principle, and points out (164) that "the breaking length of a wire is, theoretically, independent of the diameter, which may not be intuitively obvious." The "small safety factor" cannot be determined, but Wraight believes it was probably less than a whole-tone. He notes that

> modifications to instruments often only changed the pitch by a semitone (≈80 cents) which shows that the scales were considered to have a well-defined relationship to the intended pitch and that the safety factor was sufficiently narrow to make it imprudent simply to tune a harpsichord a semitone higher.[73]

As O'Brien pointed out, if a consistent relationship is established between tension and string lengths, it is possible to compare relative (if not absolute) harpsichord pitches by reference to the ratio of their string lengths.

Martin Pühringer* noticed that two harpsichords by the Dresden organ and harpsichord builder J.H. Gräbner show significant differences in their string lengths.[74] In examining the two instruments, he found that their string lengths work especially well at A-2 and A-1, respectively. As in the case of Venice, the frequency of those Dresden pitches may be guessed from corollary information (in this case, normal *Cammerton* at A-1 and *tief-Cammerton* at A-2).

Wraight was able to compare the pitches of many Italian instruments by determining what kind of stringing material was originally used (iron or brass, a critical factor for pitch), and their original string-lengths. In addition, he was able to identify or ascribe many anonymous instruments, thus allowing them to be dated. While avoiding absolute pitch values, he could nevertheless observe which string-lengths (each of which would correspond to a pitch level) were the most common, and how they related to each other.

Wraight found that the most common string-lengths for the note f2 of Venetian instruments made between 1523 and 1594 were 235, 246, 255, and 265 mm, particularly 235 and 265 mm, which would produce notes a whole-tone apart from the same key of the keyboard. Since at that time there were two important Venetian pitches a whole-tone apart, *mezzo punto* and *tuono corista*, it is logical to associate the two string-lengths with the two frequencies (about 464 and 413 Hz, respectively).

Using the same principle, Darryl Martin has found that the "design-scale note" of 17th-century English virginals (i.e., the length unit from which other string lengths are proportionally derived) can be grouped into four pitches separated by semitones.[75] These can, in turn, be related to absolute pitch frequencies that correspond well with other evidence on English pitch levels (see 2-5a).

If string lengths can be equated to pitch levels, length information from original harpsichords might be used to extrapolate pitch frequencies, and since strung keyboards are often dated or datable, their frequencies might be related to specific places and periods. At the moment, these possibilities are speculative, but with positive correlation arriving from several angles, they are quickly taking on a more important status as usable evidence.

The string-lengths of lutes might also offer pitch information of a parallel kind to that of harpsichords, although less is known about stringing materials. The "breaking point" principle that is currently accepted among harpsichordists and violinists is not as popular among lutenists, who generally use strings well below breaking point.[76]

E.G. Baron (1727:116) mentions that *Chanterelle* lute strings had earlier been tuned to g1 in *Chorton* but by the time he was writing were at f1 in *Cammerton*. In Baron's time and place, these standards were probably A+1 and A-1, which suggests that lutes had gone down four semitones. Hodgson (1985:58-60) calculated that the lute depicted in Baron has a string length of about 68 cm, and would therefore have sounded best at A-1. Hodgson nevertheless thinks that "The proper and common size of Lute in Germany during the 18th.C. had an open string length of around 72cm and would usually be pitched at *tief Cammer-Ton* (about a tone below modern pitch)."

W.L. von Radolt wrote in the introduction to his *aller treueste Friendin* (Vienna, 1701) that, of the three sizes of lute for which the music was written, the "Sopran" is very small and "is tuned at least a half-tone higher than *CORNET*." The next size, somewhat larger, "is tuned a whole-tone lower," and the third, the large common "Ordinari" lute, "is tuned two and one-half whole-tones lower."[77] If "*CORNET*" was normal *Cornet-ton* at A+1,[78] "at least a half-tone higher" would have been A+2 to A+3, a whole-tone lower would have been A+0 to A+1, and two and one-half whole-tones lower would have been A-3 (370) to A-2. This latter pitch was for the "Ordinari" lute.

When he was in Paris in 1712-1716, Friedrich von Uffenbach bought a "*Stimm-pfeife*" ("pitchpipe") from none other than the woodwind maker Jean-Jacques Rippert "damit er den Ton der Opera für seine Laute allzeit hätte" ("with which he would always have *Ton d'Opéra* for his lute").[79] *Ton d'Opéra* would have been A-2.

1-4b Trumpets

From about Praetorius's time, the trumpet sounded in C→A+1 (which = D→A-1). Brass instruments could adjust their pitch downward by adding short lengths of tubing called crooks; otherwise, as Roger North succinctly put it in *ca.*1710-28, "the Trumpet is confined to a key."[80] Pitch was thus a function of crooking, and to change key was to change pitch. Smithers wrote that "The standard trumpet was in D and sometimes E flat, but was capable of 'crooking' down to C."[81] According to Majer (1732:40), trumpets could play as much as a m3 below their normal level: "There are different mouthpieces [*sic*, Mundstücke] available, whereby a trumpet can be tuned a half-tone, a whole-tone, or even a tone and a half lower, when a crook [Krum-Bügel], slide [Krum-Bogen], or other kinds of accessories [Setz-Stücke] are added."

The pitch of a trumpet was also changed by muting, which raised its pitch a tone. Muted trumpets were used until the end of the 17th century, but were rare thereafter until modern times.[82]

Van der Heide (1996:49) suggests that "most of the extant instruments have been altered many times in order to adapt to the pitch requirements of following generations." But if it is unmodified and uncrooked, and its lowest note is assumed to be C, a trumpet is a kind of pitchpipe, carrying a historical pitch.

Two remarkably early trumpets have been discovered recently, and neither appears to have been altered. One was salvaged from a sunken ship near Texel Island in Holland.[83] It is signed and dated 1589, and has been under water since just after it was made. A replica plays in D at 466 (that is, its nominal G, the third note, sounds at 233 Hz, and its 6th at 466). The other, found down a well in the Dordogne, is preserved in mint condition with its original mouthpiece, and is signed and dated 1442.[84] It plays at the same pitch. This is a whole-step higher than the trumpets of the 18th century. Praetorius wrote that trumpets began to be made at C→A+1 rather than D→A+1 in his own lifetime:

> While the fundamental or bottom note up to now has been *D*, in *Cammer-Thon*[85] (military trumpeters have retained this standard), over the last few years in some princely and noble courts either the trumpet's dimensions have been increased, or a crook has been inserted at

the mouthpiece end, to give a fundamental of C, in the Hypoionian mode.[86]

Brass instruments normally read their parts in C, so the pitch of the instruments that played with them can usually be deduced from the key in which they were written. In Leipzig, for instance, when the trumpets were in C→A+1, most of the other parts were in D, showing that (because they had to transpose up a tone to match the trumpets) they were tuned a tone lower at A-1. It is curious that most surviving music for hautboy band that involves trumpets is written in E♭ (except for the trumpet parts, which are, as usual, in C). This probably means that the composers of these pieces assumed that the hautboys and bassoons involved were pitched a tone and a half below the trumpets, thus at A-2.[87]

1-4c Automatic Instruments

Some automatic instruments give pitches that are probably original. These are produced by open wooden pipes, open metal pipes that show no traces of later tuning, and stopped metal pipes with caps soldered into place. The problem with these instruments is again one of context; playing alone, there was no particular reason to tune them to a pitch standard. Still, examples given in Haspels (1987:122ff) are quite plausible for their times and places:

Minerva carriage	
Langenbucher (Augsburg, *ca.*1620)	418
Bracket clock with organ	
Jaquet-Droz (La Chaux-de-Fonds, *ca.*1780)	392
Serinette	
Bourdot-Bohan (Mirecourt, *ca.*1820)	437

1-5 Unreliable Evidence

1-5a Double-Reeds

On hautboys and bassoons, there are basic obstacles to determining original pitch. First, the reed is missing (no original reeds from before about 1780 are known), and few original bassoon crooks are known (even fewer can be connected to specific instruments). Second, on the same hautboy and reed setup, scales can be easily influenced by embouchure to accommodate pitch levels as much as 40 cents apart. This flexibility increases on larger instruments; on the bassoon, the difference can be a semitone. The bassoonist Walter Stiftner (of respected memory) once told me he had played a concert with the same instrument, bocal, and reed at 440 before the interval and at 415 after it (not all players have Stiftner's talent, of course). Some hautboys that are normally played at A-1 can be convincingly played by the same player ¼-step higher and ½-step lower, and an hautboy that normally plays at A-2 can be played at A-1½ by using reeds for an instrument at A-1.[88]

Surviving original hautboys are made in various lengths, and while there is some correspondence between length and pitch, other factors (the size of tone-holes, for instance, and the type of reed being used) make a direct connection between dimensions and pitch difficult to establish.

The existence of alternate top joints implies a certain decisiveness of pitch, but unlike the *corps de rechange* on traversos, hautboys did not begin to use alternate joints regularly until after the mid-18th century. This is probably because so much more could be done to change pitch with the reed setup. The same, presumably, was the case with bassoons. It is thought that the bottoms of the wing-joints of many surviving original bassoons were shortened in the later 18th century to accommodate rising pitch.

There are ways to guess original pitches of double reeds, such as comparing lengths and comparing other types of instruments by the same makers.[89]

But based on the physical qualities of the instruments themselves, the only objective method of determining their pitches may be by a method of measuring the acoustical impedance of resonant cavities that was developed some years ago.[90] This method makes it possible to determine the impedance and thus the resonance frequency of each fingering of any woodwind instrument without playing it. In the case of hautboys and bassoons, a further calculation is necessary using an imagined staple or bocal.[91] The process is still rather cumbersome, and it has not yet been established whether it is capable of yielding results that are specific enough to be useful.

1-5b Bowed String Instruments

Approximate estimates of the pitches of string instruments might be made based on the breaking point of strings, but the physical properties of early strings are not yet completely understood.[92] Segerman (1983a:28) writes,

> The highest pitch for the string band was governed by gut first-string [e-string] breakage on the violin.
> The small-sized violin (with string stop [*sic*; = vibrating string length] of about 30 cm, that was popular in the 17th and less in the 18th century) could go up to about a semitone above modern pitch. The larger size of violin (with string stop of about 33 cm, that was also used then, and is the standard today) could not comfortably go much higher than modern pitch.[93]

But even for the larger violins, a top string limit of modern e2 is probably conservative. Herbert W. Myers* points out that

> the g-d'-a'-d"-g" tuning of the pardessus de viole and quinton (musically the same instrument, despite different body shapes) . . . commonly has a vibrating string length of about 33cm; even at a'=392 the top string would have sounded a modern f".

If at A-2 (*Ton d'Opéra*), the top string sounded modern f2, at *Ton de chambre* (A-1½) it would have sounded even higher. Strings must then have been commonly available that allowed even the larger sizes of violin to be tuned at least as high as A+1, and possibly A+2. (As

Myers* notes, this assumes there were no changes in string-making technology between the 17th and 18th centuries.)

That wind instruments were considered more "constant" in pitch than strings is demonstrated by this comment by Charles Butler (1636:103):

> becaus *Entata* [stringed instruments] ar often out of tun; (which soomtime happeneth in the mids of the Musik, when it is neither good to continue, nor to correct the fault) therefore, to avoid all offence (where the least shoolde not bee givn) in our Chyrch-solemnities onely the Winde-instruments (whose Notes ar constant) bee in use.[94]

There are several examples of a distinction in the pitch of specific violins in earlier times. An inventory of musical instruments at Kremsmünster Abbey, drawn up in 1739, lists 17 "Violin," including 2 Amatis, one dated 1619, and 2 Stainers. Listed separately are "2 (Geigen) französischen Tons," one by a "Francesco Amati di Cremona" dated 1640.[95] These 2 violins were used in chamber music ("bey der Cammer"). The differentiation in the list implies that the other 17 violins were not at *französischen Ton* (which would have been A-1); presumably they were played, like most other instruments at the Abbey at the time, at A+1.

At the court in Württemberg in 1736, members of the ensemble known as the *Bock-Musik* used two kinds of violins distinguished as "große Violin" and "Chor Violin."[96] The latter were presumably at *Chorton*.

1-5c Vocal Range

Of all musicians, singers are probably the ones who benefit most from performing at original pitches. Ironically, the numerous attempts to establish historical pitch standards based on vocal range and voice types are quite undependable except as corroboration of information found by more reliable means.

An indication of the relative nature of conclusions based on vocal ranges was Mendel's attempt to estimate Praetorius's *CammerThon*. In 1948:106ff, he suggested a level "a minor third higher than our standard" (A+3).[97] In two later publications he revised his opinion downward: in 1955:477 to A+2, and in 1978:43 he apparently accepted Bunjes's conclusion (see 2-3b); in the end, it seems none of these conclusions was accurate.[98]

More recently, articles appeared (remarkably, in the same book) that are in disagreement by a m3 on the pitch of vocal music in England in the late 16th century.[99] One of the authors based his arguments exclusively on the overall compass of the parts and compared them with modern voice types; the other presented an argument that was marginally stronger because it was based on the little that is known of organ pitch at the time.

In fact, individual singers each have their own range, so that generalizations are meaningless. As long ago as 1511, Schlick (who ought to have known) commented that "people sing higher or lower in one place than in another, according to whether they have small or large voices,"[100] and Praetorius commented on vocal ranges, "In this matter no firm conclusions can be drawn, and no strict limits imposed. There is so much variety about God's gifts, and one singer will always be able to go higher or lower than another."[101]

Based on laryngology, Simon Ravens has made the interesting suggestion that "the average human voice would have had a higher natural pitch in the 16th century than today."[102] Whether or not his idea will stand examination, it demonstrates the unreliability of arguments for absolute pitch frequencies based only on vocal ranges.

The most convincing use of vocal ranges is not for indicating absolute pitch values, but for comparing ranges within a single medium, as in different Bach cantatas or Handel operas. If a Bach cantata written for a certain venue has a higher average mid-range than one written for a different place, for instance, it may indicate a pitch difference between the locations.

1-5d Xylophones and Glass Armonicas

Xylophones probably preserve their pitch well. Until the 19th century, however, they were used mainly by itinerant musicians, so their connection to other instruments is difficult to establish.[103]

Although glass armonicas were often played together with other instruments, those instruments were usually strings and voice, where the pitch was not necessarily fixed.[104] The exact pitch of an armonica can also be affected by the mounting of the cups.[105] These instruments are consequently not reliable indicators of historical pitch levels.

1-5e Tuning Forks: Accurate But without Musical Context

Tuning forks were probably in use by the beginning of the 17th century (indeed, possibly as early as 1486[106]). But most references to them through the 18th century imply they were a novelty and not commonly used.

Forks are little affected by changes of temperature or other real or imagined problems discussed in the section on pitchpipes (1-3g).[107] They are therefore more trustworthy as frequency references. Tans'ur in 1772 considered them superior to "any tubical or stringed Instrument whatsoever,"[108] and Adlung (1726:II:163), in suggesting a flute as a normal tuning reference, mentioned, "In England they make rather large steel forks for this purpose, which preserve pitch with great accuracy, and are quite clear in sound."

The problem with tuning forks is to relate them with assurance to a particular place, time, or usage. Unlike pitchpipes (which are often stamped and which give note-names), forks offer few clues to their date of manufacture and use, or even where they originated.

Mendel was dubious about the authority of the two most famous historical forks: that of Handel, and the one associated with Stein and Mozart (the pitches of these two forks are 423 and 422 Hz, respectively). It seems the extreme accuracy of tuning forks is often cause for incautious claims for how and when the frequencies they give were used. The Stein fork (discussed in Haynes 1995, Section 9-2) is the most flagrant example. It has even been suggested that a fork at 409, owned by Pascal Taskin in 1783 (see 8-2b), represented "Lully's opera pitch."[109]

Leipp & Castellengo (1977:9), as skeptical as Mendel, make some appropriate comments on the limitations of tuning forks: "A touch of a file at the critical place can seriously alter the frequency," and "The fact that I personally own a tuning fork that gives 432 Hz does not mean I use it to tune my violin."

The above will explain why evidence from historical tuning forks has not been given much attention in this study. It has been useful mainly as corroboration of evidence from other sources.

1-5f Length Standards as Indications of Pitch Standards

Organ builders talk of "5 1/3 foot pitch," etc., as if pitch and length are almost synonymous concepts. Adlung wrote (1758:376):

> It could perhaps be . . . that on [someone's] organ, this would not be the exact measurement; but I would answer briefly that the Foot ["Schuch"] is perhaps longer in one place than another,[110] or perhaps one organ is simply a bit lower than another. We already noted above (§94, which mentions Sauveur's proposal to find a standard pitch that would be recognized everywhere)(d) that they are not always quite the same in one city, not to mention between cities.
>
> [Note (d)]: Once again, concerning such a uniformity of standard. Since if such pipes, if they have the same length and inner diameter, and are blown with the same wind [pressure], would necessarily have the same pitch level, would it not be surest (since the German Foot is so variable) to use the constant and therefore unerring Parisian *Pied de Roi*, when fixing the length and diameter of the 8' Principal?[111] If each organ builder accepted this standard, all organs would be in agreement. If some makers intentionally design their organs at a different [pitch] standard (as for example the new organ being built in Dresden that will be pitched in *Cammerton*,[112] C cannot be at the normal 8' length, though I suppose it will have the same name. Since all [the pipes of this organ] will be at this lower [pitch] standard, a larger Foot must be employed in building it.

Just before 1829, Ignaz Bruder (1780-1845), a student of a student of J.A. Silbermann, wrote,

> Here in my book I have continued to use the scaling of the late great Silbermann, and recommend it as exemplary, as well as some from the French organ. I should note however that the dimensions of the latter are based on the *Pied de roi*, which causes organs to sound 3/4 of a tone lower. To have *Chorton*, one should systematically read 3/4 of a tone higher or convert the *Pied de roi* into the *Nürnberger Fuß*."[113]

Bormann suggests that, assuming the same scaling, the difference in pitch between pipes at the *Pied de roi* (324.8 mm) and the *Nürnberger Fuß* (303.9 mm) would produce a "reichlichen Halbton."[114] (A large halfstep; "*Chorton*" in Silbermann's scheme was A+0, a whole-tone above *französischer Thon*; see 7-5.)

Pipe-lengths are often used casually rather than literally. An example is the English "10-foot" organ. It used to be that early English pitch was calculated on the assumption that original pipes were exactly 10 feet long, but the organ-builder Martin Goetze (1994:61) writes "I can see no reason to use 10ft (or 5ft) as a basis on which to calculate pitch, unless pipes are discovered which are indeed that length; extant pipes all seem to be slightly longer."[115]

Herbert Heyde (1986: Chapter 6) proposes a correspondence between the dimensions of surviving woodwinds and the logical subdivisions of the local ell, foot, inch, etc.,[116] of the place they were made.[117] There are three factors that reduce the effectiveness of this idea.

First, it is difficult to know which standard was being applied at a given place. In some cases we know as little about historical length standards as we do of pitch; often more than one Foot-rule was in use simultaneously.[118] Mendel (1978:42-43) noticed that in Diderot 1765 Planche XI a proportion of 17:18 is given for a length called the "*pié harmonique*" (possibly a special length used by instrument makers) and the standard *Pied de roi*. A direct correspondence between hypothetical pitches and corresponding length standards may thus be difficult to find. Also, as is evident from Heyde's study, an instrument and its pitch may be the product of a multiple or a fraction of a standard length unit. It is of course possible to take almost any length and match it to some standard or other. It is thus difficult to know whether a maker was consciously following a given length standard.

Second, makers copied existing instruments that had sometimes been made elsewhere. It is a safe assumption, for instance, that Denner and Schell, when they began to make the new "französische Musikalischen Instrumenta," were modeling them on actual woodwinds that had come from France and were thus presumably made to French lengths/pitches.[119] How long they used those measurements is unknown; if they functioned well, there would have been no reason to change them. And which other makers outside of Nuremberg in turn copied Denner's instruments?

Finally, a correspondence between length standards and pitch standards is frequently not borne out by surviving instruments. To take an obvious example, the pitch relation between Rome and Venice is pretty well established as a rather large whole-step in the early 18th century, with Rome being the lower, and similar to Paris. For a simple Foot correspondence, then, we would expect Rome's foot to be similar to Paris's and longer than that of Venice. But in fact, the three were 297.8, 324.9 and 347.4 mm, respectively. Venice, with the highest pitch, had the longest Foot-rule, and Rome and Paris, with similar pitches, differed considerably in length.[120]

If we take the pitches of woodwinds made in different areas of Germany during the same period (1700-1730), we can compare the possible relationship of Foot-rule to pitch standard. Graph 2 shows the pitches of woodwinds made in this period in eight different towns. We would expect those of Berchtesgaden (317.6 mm, the Vienna Foot)[121] and Berlin (313.85 mm, the *rheinische Fuß*) to be the lowest, since their Foot-length is longest. The shortest is the Saxon or Dresden Foot at 283.1 mm (used also in Leipzig), with the lengths of Butzbach, Munich, and Roding almost as short. Nuremberg (at 303.8 mm for the *Werkfuß*) is in about the middle. What we see is that the instruments from Berchtesgaden and Berlin are not exceptionally low, nor are pitch standards in places using shorter standards unusually high. No clear generalizations that link pitch and Foot-lengths are in fact possible.

Another way to test the validity of the hypothesis that instruments were made following local length standards is to compare the pitches of individual makers. If the instruments vary in pitch, we can conclude either that a length standard was not applied, or that a number of different standards were used (which amounts to the same thing as far as we are concerned). Graph 3, for instance, shows the pitches of woodwinds made by a number of individual Nuremberg makers; the

spread is wide enough to make it impossible to detect a particular pitch that might be the result of a woodwind maker's Foot-rule used there.

A one-to-one correspondence between length standards and pitch standards thus appears difficult to find. Rather than match instruments to given length dimensions, it seems this approach is more fruitful in observing geometric proportions, as this will give insights into general instrument design.[122]

1-6 Factors That Determine the Accuracy and Credibility of Evidence from Instruments

The two essential qualities of usable pitch information are accuracy and relevance. The pitch frequency must be plausible, in other words, and must be linked to a specific time, place, and/or function. The tuning fork usually satisfies the first condition well, for instance, but fails the second, because it is difficult to know whether, when, and how most forks were used.

Factors that can distort the accuracy of a pitch observation include temperature, physical alterations, wood shrinkage, the nominal pitch of the instrument, the place and date of origin, the quality of information, and anachronistic playing techniques.

1-6a Temperature

Aside from wind pressure (which has a relatively small influence on pitch), temperature is a major factor in organ pitch. It has been calculated that a difference of 7°C corresponds roughly to a difference of 5 Hz. J.-A. Villard, organist at Poitiers Cathedral, wrote me that

> the organ was originally tuned by Clicquot in *December* 1790; for this reason it is only 3/4 of a tone below the modern pitch of 435 [*sic*]. As a result, it is noticeably higher in summer when it is 25 or 26 degrees [centigrade] in the loft in July or August; a difference, therefore, of more than 15° to 18° with the temperature in December.

This means that the Poitiers organ, measured at 400 Hz, could vary about 50 cents, or as much as 12 Hz between extremes.[123] Such a variation in flue pipes was probably normal in the 18th century, depending on the local weather.

Temperature is much less of a consideration on woodwind instruments, which are activated by the breath of the player rather than a bellows. Woodwinds play low when cold, but reach a "warmed up" steady temperature after a few minutes of playing. Players warm their instruments not only to bring them to pitch, but because they do not otherwise respond or resonate as well as possible. If it is extremely cold or warm, the ambient temperature is a factor, particularly in larger ensembles where winds do not play constantly. But in a room at a moderate temperature, a woodwind instrument will begin to speak and sound normally after 7-8 minutes, and its pitch will have risen about 15 cents.[124] The pertinent question is really how long a woodwind instrument has been continually played when its pitch is measured; in other words, whether it is considered by the player to be warmed up.[125] At that point, ambient temperature measurements (unless extreme) are irrelevant.

1-6b Physical Alterations

Later doctoring of woodwinds was usually for the purpose of raising their pitch. Removing material was the most common method, either by enlarging recorder windows and traverso embouchures, or shortening joints (as discussed previously). Alterations of this kind are usually detectable. Obviously, in measuring pitch, instruments should be examined for possible modifications.

1-6c Wood Shrinkage

Wood is the primary material of most of the musical instruments that yield historical pitch evidence. But with age, wood shrinks, and this affects pitch. Shrinkage (and cracking) of woodwinds is caused by water loss as a result of ambient humidity. Water content in living boxwood (the wood normally used for smaller woodwinds until the early

19th century) is about 30 percent; by the time the wood is worked, it is about 10-15 percent,[126] and an instrument made in the first half of the 18th century will probably now have a level of about 6 percent.[127]

The recorder maker Philippe Bolton* reports that bore shrinkage is quite common on recorders he has made and reserviced after 10 years.

On a recorder or traverso, a smaller air volume results in a higher pitch. Mathiesen and Mathiesen concluded that a change of 1 percent in the humidity of the wood of a recorder corresponds to a rise of 1/3 Hz (3.84 cents) in the tone a1.[128] Since the percentage of humidity loss for instruments made in the 18th century—that have not been regularly played since then—is on the order of 6 percent, this theory suggests that an 18th-century recorder's pitch was originally about 23 cents (or about 6 Hz at a1) lower than it is now.

Because most woodwinds are made from quartered sections and wood shrinks to a different degree in different directions, original woodwind bores are almost always oval now rather than round.[129] Cary Karp[130] has estimated that the present bore diameter of an early boxwood instrument is probably about 0.985 of its original one.[131] Axial shrinkage (i.e., length) is less: about 0.993.[132]

A common rule of thumb for calculating original bores is the relation

$$D \approx 2 \cdot a - b$$

where D is the original diameter and a and b are the present major and minor axes.[133] Thus, if a and b are different (in other words, if the original instrument's bore is oval), D, the original diameter, was even larger than the present maximum bore. Fred Morgan reported that if he took the maximum axis of an original recorder, his copies played 5 Hz lower than the model had.[134] But considering the discussion above, even the present maximum axis is not as big as the bore when the instrument was first made, as both axes have shrunk to some degree.

Ivory was also sometimes used for woodwinds. It does not react to humidity in the same way as wood. In the short term, it is less stable; an ivory instrument will change measurably in dimensions after an hour of playing, but the changes are only temporary. Although ivory does shrink somewhat with time,[135] an ivory instrument is probably closer now to its original dimensions than one made of wood. It is therefore instructive to compare the pitches of instruments by makers who worked in both materials.[136]

In the case of cornetts, the amount of shrinkage would have an insignificant affect on pitch because of the proportionally large size of the bore.[137]

The effect of shrinkage on clarinets and hautboys, whose bores do not contract, is the reverse of the "flutes;" re-reaming of new instruments after they have been played in causes them to go up in pitch. A shrunken hautboy thus plays lower than when it was new, not higher.

The factor of shrinkage also affects the internal intonation of woodwinds, as Ronald Laszewsky* has observed.[138] Because the patterns of change to different sections of the range are complicated to analyze and no doubt vary in different kinds of instruments, they have not been considered here, except in the effort to avoid taking a general pitch based on only a few notes or a single note.

1-6d Nominal Pitch

Nominal pitch is an issue with recorders in different sizes. An F-alto recorder at A+0 could also have been a G-alto at A-2, for instance: to which pitch was it in fact tuned? By the 18th century, the treble or alto with f1 as the 7-fingered note had become the standard size. In *ca.*1732, Thomas Stanesby Jr. indicated that recorder players played any instrument as if it were in F (i.e., recorder parts were normally transposed):

> when the size of the Flute is chang'd, tho' the Performer is told by the Tone of the Flute that the lowest Note speaks B, or C, or D, yet he still calls it F, and so every Note is call'd F, in its turn, tho' at the same time it is insensibly to the Performer Transpos'd to its proper Note by help of the Flute.[139]

Montéclair used the same system in his opera *Jephté* (1732:164). All the various sizes of recorder were notated "comme si on joüoit de la taille" ("as if one were playing the alto").[140] This same notational device is seen in Sammartini's concerto for "fifth flute," notated in F for the other instruments but in B♭ for the recorder (which, if played on a fifth flute, i.e., a soprano recorder, but read as on an alto, would sound in F, the key of the other instruments).

For the sake of comparison, all recorders used in this study have been assumed in principle to be in either F or C except the following:

1. Voice Flutes in d1;
2. Those that would end up in pitches beyond the range of A-2 or A+2.[141]

1-6e Locating and Dating

If pitch changed at various times and places, it is important to know the date and location of an instrument's manufacture. In general we can assume that the pitch of an early instrument represents a standard in use in the place where it was made. Although well-known makers like the Denners probably received orders from outside their region, it is reasonable to assume they worked with standard models.[142]

Establishing exact dates of surviving early woodwinds is problematic. The instruments are rarely dated, and woodwind makers' stamps could sometimes represent the work not of individuals but of workshops run by family members or successors. Woodwind stamps could therefore indicate company names just as "Ford" does for automobiles.

Indications of period (if not date) are often present, however. Examples are the style of turnery and the numbers of keys. Some workshops, like that of Jacob Denner, operated under special permission from the relevant guild, and authorization to use the master stamp would not have been transferable after a master's death.[143] Some of the uncertainty in dating is also balanced by approaching pitch history in short periods as is done here, since active workshop dates seldom exceeded this span by much.

1-6f Quality of Information

All the instrumental pitch information listed in the Appendices came from named sources who were aware that the data they supplied was to be used in a pitch study. Most sources are professional players and makers. When possible, instruments were tried by more than one player. The range of pitch of the early woodwinds when played by professional players was about 15 cents, about the same as differences on instruments of the modern orchestra.

As discussed above, since the concern here is with pitch *standards*, which in practice vary around a center depending on many factors, the degree of exactness is considerably less than what is normally used in the science of acoustics. That difference in tolerance is conscious and deliberate (cf. 0-2 on appropriate frequency tolerance).

Because musicians tend to think in terms of standards rather than cycles per second, some instruments get classified according to preconceived pitch "frequencies." A generic concept like "415," for instance, used approximately (exactly as we use the term "A-1" here) is sometimes applied to instruments that are more specifically at, say, 410 or 422. As in the case of organ restorations, there is a tendency to gravitate towards the reference points musicians know, especially 440 and 415, and these values are probably represented more commonly than they deserve.

1-6g Anachronistic Playing Techniques

The data used for this study obviously depends on the playing techniques of modern musicians. The last generation has seen the development on a large scale of professional performers on historical instruments and copies of them. The pitches used by these players are not necessarily reliable historically, and may be influenced by anachronistic techniques or preconceived notions of pitch standards. But the variation is limited by the inflexibility and general playing tendencies of the instruments they play, especially the winds.

In my own experience, the natural tendency of players trained on modern instruments is to use more pressure and tension on early instruments than necessary (in the form of tenser stringing, faster airstreams, tighter embouchures, and heavier reeds). The longer players work with 18th-century instruments, the more relaxed their technique seems to become. This is, I think, a measure of the distance they are gradually able to take from their original training. Since higher tension and pressure normally result in higher pitch, the logical conclu-

sion is that, coming from a matrix of modern technique, contemporary players are more likely to play early instruments higher than they were originally meant to be played, rather than lower.

1-7 Frequency Measurements in 17th- and 18th-Century Studies of Acoustics and Vibration Theory

Frequency measurements in studies of acoustics and vibration theory from the 17th and 18th century resemble the information available from tuning forks; it is of great exactness and accuracy, but is usually difficult to associate with real musical situations. As with forks, its main use is for corroborating other evidence. Here is a short survey of significant developments:

John Wallis established the existence of vibration nodes in 1677. As Dostrovsky wrote,[144] "The basic ideas of vibration theory were formulated during the seventeenth century. . . . That pitch can be identified with frequency was a major discovery of the seventeenth century, and this identification made possible very precise measurements of relative frequencies."[145]

In about 1682, Christiaan Huygens developed an instrument using rotating wheels that produced a sound against which another could be compared, thus allowing him to measure frequency. Using this method, he measured the *D* of his harpsichord at 547 cps (= A-409, or A-1½).[146] His notes also contain a sketch that may depict a siren that could have been used to measure frequencies.

The writings of Joseph Sauveur on music, published by the Académie Royale des Sciences at Paris,[147] dealt with, among other subjects, standard frequency, including specific pitch indications.[148] Sauveur made important advances in the study of frequency in relation to pitch.[149] His report in 1700 (p.131) of the pitch of a harpsichord, accurate to within a few percent,[150] yields an a1 at 404 Hz, or A-1½.[151] Sauveur seems to have been the first to determine frequency by means of beats.[152] As Dostrovsky explains, "The absolute frequencies of a pair of tones can be calculated from their frequency difference (given by the beat rate[153]) and their frequency ratio. . . .[154] Newton used Sauveur's result for his check on the velocity of sound . . ."[155] Sauveur later used another method for determining frequency based on the properties of a string. Dostrovsky writes, "In 1713 Sauveur ingeniously derived Mersenne's Law with a constant of proportionality for the ideal string that was [nearly] correct. . . . In the same year Brook Taylor[156] also gave a derivation. His style of analysis belongs to the 18th century, Sauveur's to the 17th." [157] Sauveur's recorded measurements of the pitch of a harpsichord in 1713 can be calculated to yield an a1 at 404/405 Hz.[158] Other indications of pitch found in Sauveur's writings yield a1's at 421, 415 and 410 Hz.[159]

Although Ellis (1880:36) observed that "Sauveur mentions no particular clavecin, or organ, or opera, so that his results can only be looked upon in the light of experiments," it can be reasonably assumed that his frequent mention of *ton de chapelle* and *ton d'opéra* refer to the standard pitches in Paris in his day.

Sauveur was well-known in his time as an advocate of pitch standardization; both Adlung and Mattheson mention him in their writings.[160] The *son fixe* that he proposed in 1701 as a standard frequency reference was 100 cps. In 1713 he revised this and proposed instead a new theoretical pitch for use in physics (still known as "*Sauveur pitch*" or "*philosophical* [i.e., scientific] *pitch*"). Middle c1 was to equal 256 Hz, making a1=431. The attraction of this frequency to Sauveur and later physicists was its mathematical logic: it was based on C calculated by powers of two. It seems to have had no particular reference to the musical practice of Sauveur's day, however.[161] Rasch comments, "It was never applied in musical practice, but it has been and is being used from time to time in papers of a scientific or pseudo-scientific nature."[162]

In 1706 the physicist and mathematician V.F. Stancari, building on Sauveur's work, reported experiments with a toothed wheel of his invention that he believed made it possible to measure the vibration frequencies of sound. The experimental method involved appears to have been valid,[163] and Stancari measured the pitch of the organs at S Petronio in Bologna. His results can be calculated to give an A at 386 Hz. Since Bologna was at the time politically under the control of the Vatican, and *Corista di S Pietro* was A≈384, this pitch is quite plausible. But Barbieri notes that the organist L.F. Tagliavini is certain that the Bolognese organs were never that low (Barbieri reluctantly concludes that Stancari's measurement was in error).[164]

In 1712 the English mathematician Brook Taylor (of whom we possess a portrait holding a recorder and another beside a harpsichord) first published the correct derivation of a vibrating string equation ($f = 1/2L^2\sqrt{T/m}$),[165] which later became known as "Taylor's Formula" and served as the basis for further experimentation in acoustics during the 18th century.[166] In 1713 Taylor reported experiments indicating pitches for a harpsichord at 383 and about 390.[167]

Leonhard Euler, working with Taylor's theories, measured a pitch of A-395.7 for an instrument in *chorali modo* (*sic*) in 1727, a "keyboard" in *ca.*1731 at 392.2, and an "instrumentis musicis" at 418.[168] Euler worked at various places during his lifetime, including Berlin, Basel, and St. Petersburg.[169]

In a letter written in 1742, the physicist Giordano Riccati stated that the C of the organ at S Antonio, Padua sounded at 146 vibrations per second (= A-493 or A+2), whereas the C of a French organ sounded at 122 vibrations per second (= A-409 or A-1½; perhaps from Sauveur's measurement). From this he concluded that Italian organs were a m3 higher than those of France.[170]

Robert Smith published his *Harmonics* in 1749. Smith used a weighted monochord to measure the pitch of the Trinity College organ at Cambridge built by B. Smith, which had originally been exactly a tone higher.[171] The results are calculated in Ellis under 395.2 and 441.7.

In 1762 Daniel Bernoulli described experiments on the sound and pitch of organ pipes, using the French "pied de roi" and "pouce de Paris."[172] He reported that the note he called "C choral" was "environ 116 vibrations dans une seconde de temps,"[173] which translates to an A of about 390 Hz.[174]

Heinrich Lambert, working at Berlin, reported in 1775 that his flute produced an a1 at 415.25 Hz.[175] He concluded that

> the pitches on my flute are about a semitone higher than those produced by the instruments that were used for terms of comparison in the experiment by Messrs. Euler and Bernoulli. . . . Such differences are frequently observed in instruments made in different countries and by different makers.[176]

In 1787 Ernst Chladni at St. Petersburg is said to have recorded certain frequencies in terms of musical pitches.[177] Also at St. Petersburg, the composer Giuseppe Sarti repeated in 1796 Sauveur's famous experiment published in 1701.[178] Sarti recorded an A at 436 cps.[179]

Chladni in 1802 talked of a gradual pitch rise since the earlier reports of Euler in 1727 and Marpurg in 1752. Euler had given pitches of 396, 392, and 418. A report in 1859[180] claimed that Marpurg had given the Berlin opera pitch in 1752 as about 422, and in 1776 Marpurg had estimated the Berlin A as 414 Hz.[181] According to Chladni, certain orchestras (presumably in Germany) had already risen above his proposed pitch of 427.[182]

1-8 Cases Where Both Standard and Frequency Are Known

Forty-two organs survive from Austria (2), England (2), France (2), Germany (27), and Holland (9)[183] with original pitch frequencies that are known and with pitches that were also identified by name in contracts or reports at the time they were built. They are listed in Appendix 1. This evidence has obvious authority, and indicates the following relationships:

1. There are 12 organs at *Cornet-ton* within a range of 450-467, averaging 462. This level agrees well with the pitch of cornetts (see 1-3a).
2. There are 10 examples of *Chorton* which, although they average 465, range over three levels (A+0, A+1, and A+2), and are pitched as high as 487 and as low as 437.
3. *Cammerton* (12 examples) is remarkably consistent with a narrow range from 408 to 416 and an average of 414.[184]

From this, it is apparent that *Chorton* was a general concept rather than a specific frequency; in the 18th century it could have been any pitch from A+0 to A+2. *Cornet-ton* and *Cammerton*, by contrast, were specific and consistent in frequency even over several periods, and can therefore be used as reference points for finding other pitches. We will discuss all these standards in more detail in the chapters that follow.

Notes

1. Boyden 1965:2.
2. Bessaraboff 1941:357.
3. The data is given in a more complete form in the appendices of my doctoral dissertation (Haynes 1995).
4. These lists include more instruments than the ones I used in my dissertation.
5. I sent at least one letter (and often several follow-ups) to every owner of traversos, clarinets, and recorders listed in Young 1993. I have also corresponded with a number of organists, builders, and organ experts. Information is difficult to collect, however, because (beyond failure to respond at all) many individual owners and small museums lack the expertise to measure instrument pitches.
6. Ellis 1880:32.
7. This is true on the Continent. English pitch being different, instruments made there (including cornetts) must be regarded as an exception.
8. As late as 1801, a handbook written by Johann Andreas Streicher and put out by the Stein piano company, then in Vienna, sternly instructed its clients to tune "*allezeit* nach der Stimmgabel," and that this latter "muss auf das richtigste mit den Blasinstrumenten, wie sie in dem Orte üblich sind, gleich stehen."
9. Gierveld 1977:183.
10. Praetorius 1618:15.
11. "Toon" in Dutch is pronounced approximately like "tone" in English. See further examples in 4-3a.
12. Praetorius (1618b:III:122) used the word "Schwarz" to distinguish the curved cornett ("Cornu buccina") from the straight "Gelbe" mute cornett.
13. For a more detailed discussion, see Haynes 1994c, section 3.
14. Tr. Crookes 46. I am indebted to Herbert W. Myers for this reference.
15. Mendel 1978:24.
16. Graham Nicholson*.
17. See also Haynes 1994b and Haynes 1995:421-28.
18. Cf. also 2-2a1.
19. Mersenne stated in Proposition XXII that he had been careful to give the cornett's dimensions very exactly.
20. Length calculations made by Herbert W. Myers*.
21. Cornett pitch is discussed further in 2-2a1.
22. Filadelfio Puglisi*; in determining pitch, he states "For Renaissance flutes I very much prefer to go by speaking length." Pitches and speaking lengths of surviving instruments correlate well.
23. Puglisi 1988:76.
24. Cf. Haynes 1995:418 and Thomas 1975.
25. For a discussion of nominal pitch on Renaissance flutes, see Haynes 1995:430.
26. Praetorius 1618:16. Tr. based on Crookes.

27. John Solum*.
28. Quantz 1752, Ch. IV §15.
29. Kuÿken also reports playing a Bizey traverso at the Horniman Museum (Ex Dolmetsch M43-1982) on two different occasions, once at 392 and once at 402 (a difference of about 43 cents); this was, however, an exceptional case.
30. Roderick Cameron*; Friedrich von Huene*; Jeffery Cohan*; Oleskiewicz 1998a:144.
31. Cohan points out that the bore of the longest joint appears shinier (from swabbing), the tone holes are a little rounded, and the tenons are compressed on the outside much more than the other joints (although the bore has been re-reamed to remain as big as the other joints).
32. Heyde (1986:175) suggests that when a traverso has alternate joints, it is possible to determine which is the main one because the spacing of its tone holes are in a logical geometrical proportion, while those of the others are extensions. Cf. Bouterse 2001:473, who finds that with Dutch traversos, the longest *corps* was probably the best; I have accordingly given this pitch in Appendix 4.
33. By convincing "internal intonation" I mean that standard fingerings produce notes reasonably close to a 55-part octave (approximately ¼- to 1/6-comma meantone), as described by 18th-century sources on non-keyboard tuning such as Tosi, Telemann, Quantz, and Mozart (see Haynes 1991).
34. Embouchure shape is discussed in Powell 1995e in connection with a reconstruction of a traverso whose embouchure hole was replaced.
35. The differences in recorder pitch noted by Bouterse (2001:226-27) are difficult to understand unless the players were inexperienced or untrained.
36. On most recorders, the sidewalls of the window are close to 90° with respect to the labium slope (with a few exceptions, such as Van Aardenberg; see Bouterse 2001:219). The pitch is raised when these walls are opened up, so original instruments with open sidewalls may have been altered.
37. Fleurot 1984:129.
38. K. Ridley quoted in Mendel 1978:22n17.
39. Cf. Ross 1985. Nicholas Shackleton* points out that other factors that may not be obvious can affect pitch, such as a barrel, mouthpiece, or top joint that has been shortened. Shackleton showed me a clarinet made by Hale (successor to Collier soon after 1785) with small dots marked on the tenon ledge that would have been removed if the instrument had been shortened; another Hale at the New York Metropolitan Museum has the same dots. Their existence is a guarantee that the instruments were not shortened.
40. Nicholas Shackleton*. Shackleton adds that most late 18th-century clarinets can be pulled apart a little between the joints, making the effect of an inappropriate mouthpiece a little less evident.
41. Shackleton finds that in order to achieve good intonation over the range, instruments often require tuning rings in the lower socket of the barrel that extend the instrument's length, and he surmises that such rings were used in the 18th century as well.

42. Albert R. Rice*.
43. Eric Hoeprich*.
44. Nicholas Shackleton*.
45. David Ross*.
46. Hopkins 1880:594.
47. Archival evidence can include churchwardens' accounts, vestry minutes, organ builders' books, diary entries, and letters.
48. Original text quoted in 7-4a.
49. Williams 1980:100.
50. Domenic Gwynn* writes that "What one looks for is evidence of the building history, to give the provenance of the pipes, pipe movements, and the odd reference to a type of pitch."
51. For more discussion on this point, see Haynes 1995:384ff.
52. Quoted in Barnes & Renshaw 1994:312.
53. A good account of methods of assessing historical organ pitch can also be found in Gwynn 1985:65-66.
54. In order not to weaken confidence in actual reported pitches, I distinguished deduced pitches from direct measurements.
55. Cf. Mersenne 1636:169, Fabricius 1656, William Turner, 1697 (Tilmouth 1957:58), John Shore (Hawkins 1776:II:752), Petit *ca.*1740:31 and 33, Tans'ur 1746:57 quoted in Haynes 1995:540, a Hofkapelle inventory from Darmstadt made in 1765 (Noack 1967:269), Dom Bedos 1766:35, Tans'ur 1767:71, Schulz 1771:465, and Kiesewetter 1827:146, quoted in Haynes 1995:542-43.
56. In W.S. Rockstro's *The Life of George Frederick Handel* (1883).
57. Hawkins 1853/R1963:II:752.
58. This passage is cited by Mattheson 1721:428.
59. G. Mancini (1774:82:n). Text quoted in Haynes 1995, Section 1-5d.
60. Gall 1805:66.
61. Worp 1915:IV:489.
62. North 1959:208.
63. Van Blankenburg 1739:110. In 7-4a, there is mention of a "Mémoire" in the archives of the Opéra reporting that in 1755 "le sieur Lot, maitre lutier," provided the Opéra at Paris with "nine bellows-blown [pitchpipes], needed to fix the pitch of the Opéra's harpsichord."
64. Ellis, whose sense of precision led him to list his pitches to the tenth of a Hz, was not enthusiastic about pitchpipes compared with tuning forks (cf. 1880:115). Cf. also Mendel 1955/1968:188.
65. Inv. no. 1845. It is described by Dr. J.H. van der Meer* as a duct flute.
66. I am grateful to Rainer Weber for sending his measurement notes. The side of the plunger that gives the Naples pitch also gives a whole octave scale. The pitches were obtained by using a wind machine, and "the first note was the same pitch as when blown with the mouth."
67. E.244.
68. Cf. Barbour 1951:85-87.

69. Cf. also Jean Baptiste Clicquot's "diapason ambulant" of 1746 and van Heurn's "Stemfluit" (1804:293), mentioned in Haynes 1995:546.
70. Hubbard 1965:64.
71. The concept of "critically stressed strings" seems to be accepted among violinists as well (cf. Segerman in 1-5b below).
72. O'Brien 1990:56. Darryl Martin (2001:2, note 2) believes that strings sound best just below their breaking point because of a reduction of inharmonicity in the string.
73. Wraight 1997:190.
74. 1722, now in the Villa Bertramka (Mozart Museum), Prague; and 1739, now in Schloß Pillnitz near Dresden. Cf. also Kinsky 1940:15. The bigger instrument was probably played by W.A. Mozart at the Nostitz Palace in Prague in the Fall of 1787 when *Don Giovanni* was premiered.
75 . Martin 2001:27ff.
76 . Ray Nurse*.
77. Original text quoted in Hodgson 1985:59.
78. See 3-6.
79. Preußner 1949:128.
80. North 1959:230.
81. Smithers 1988:204.
82. Smithers 1988:96-97.
83. Van der Heide 1996:47,49,51.
84. Graham Nicholson*. Cf. Madeuf, Madeuf, and Nicholson (1999).
85. As will be discussed in 2-3b, Praetorius used the word *CammerThon* here to mean A+1.
86. Praetorius 1618:32-33. Trans. based on Crookes.
87. This principle does not always work, as for instance in the 2d Brandenburg Concerto, apparently written for a trumpet a whole-step higher than normal (see 6-3).
88. Cf. also the observation by Michel Piguet (1997) on his experience playing the same instrument at 415 in 1963 and 405 in 1982.
89. Cf. Haynes 2001:93-99 on "Hautboy pitch," which distinguishes four general lengths among surviving instruments and suggests corresponding pitch levels.
90. Gibiat and Laloë 1990.
91. Escalas, Gibiat, and Barjau 2002.
92. Cf. Segerman 1985e and Segerman 1988a.
93. See also Thomas and Rhodes 1971:63 on Praetorius's illustration of a violin with string length of 30.5 cm.
94. Butler used a particular English orthography he had himself invented.
95. Kellner 1956:357. Amati would probably have thought of his instrument as at *tuono corista*.
96. Owens 1995:330.
97. Not "somewhere between 466.16 and 493.88," as Bunjes 1966:731 thought.

98. Mendel (1978) states his basic principles in using voices in a section starting on page 47.
99. Roger Bowers and David Wulstan in *English choral practice, 1400-1650*, ed. John Morehen.
100. Schlick 1511, "Das Ander Capittel."
101. Praetorius 1618:18. Tr. based on Crookes.
102. Ravens 1998:126.
103. See Blades 1980:20:564.
104. Mozart's Quintet KV 617 was an exception.
105. I am obliged for this information to Prof. Dr. W.M. Meier of the Institut für Kristallographie und Petrographie, ETH-Zentrum, Zürich.
106. Mendel 1978:80, Stradner 1994.
107. See Lloyd 1954:797-98. Cf. also Ellis 1880:15, although the degree of accuracy he discusses is meaningless in a musical context: "As forks are tuned by filing, which not only heats them, but unsettles their molecular arrangements—at least, in part—it is necessary to let them cool and rest for several days, sometimes for weeks, before their pitch can be depended on for scientific accuracy."
108. Quoted in Mendel 1978:80 n.90.
109. Thomas & Rhodes 1980:14:782. For another view of Lully's pitch, see 2-6c.
110. Dähnert (1985:71) points out that Adlung used the Rhenish Foot in his measurements. He was also able to determine by a comparison of pertinent documents that Saxon organ builders, including G. Silbermann, as well as organists and cantors responsible for organ examinations, reckoned according to the Saxon Foot.
111. Adopting the French length measurement would presumably imply adopting French pitch as well, a prospect that seemed not to have bothered Adlung at all in 1758.
112. The Catholic Court Chapel organ by G. Silbermann and Z. Hildebrandt, completed in 1754.
113. See Bormann 1968:102.
114. It is difficult to judge how literal Bormann's transcription of Bruder's original is; length measurements, for instance, are converted to mm.
115. See 2-5a.
116. The metric system was not in general use until about the middle of the 19th century.
117. This assumes occasional rounding off and tolerance, the degree depending on the instrument and its condition. Other mitigating factors include wood shrinkage (usually more relevant for diameters than lengths) and a lack of sufficient documentation on early length measurement standards. See also Ellis 1885:511.
118. See Heyde 1986:70.
119. Cf. Kirnbauer & Krickeberg 1987:272, who found little evidence that Denner and Schell followed the length standards at Nuremberg.

120. See Coates 1985:22, which suggests that the Brunswick inch was common in many places, including Venice.
121. These figures are taken from Heyde 1986:71ff.
122. Cf. Coates 1985 and Adkins 1999.
123. 394 to 406.
124. Leipp & Castellengo (1977:16) determined that the air-column of modern woodwinds stabilizes after only about 3 to 4 minutes of normal playing. This seems short to me. J. Mollenhauer & Söhne wrote that a clarinet that plays at A-435 at a temperature of 15°C will rise to A-443 at 25°C (see Zöpf 14).
125. The same question is discussed in Rousseau 1768:57.
126. Karp 1978:14 gives "usually 12%." A.M. Moonen* reports that the recorder maker Hans Coolsma in Utrecht has found the ideal water content to be 12 percent.
127. Mathiesen and Mathiesen 1986. There is disagreement about the amount of shrinkage that has occurred on 18th-century boxwood woodwinds.
128. Mathiesen and Mathiesen 1986. On the effect of bore diameter on the pitch of cylindrical and conical woodwinds, see Myers 1981:47-48.
129. I use the word "oval" in a general sense; as Paul Hailperin* observes, the deformity caused by drying is not regular. I do not mean to imply here that all ovality is caused by shrinkage, although shrinkage is no doubt a factor in one way or another on any woodwind two to three centuries old.
130. 1978:16-17.
131. Based on his correction factor of 1.015 for an unshrunken bore; cf. his Formula 2 in Appendix 4, p.26. Many factors are involved in extrapolating original bores from existing ones: among others, wood-type, current humidity of the wood, place of manufacture, current age, details of manufacture (windway on flitch or rays), etc. A.M. Moonen*, in studying the process of woodwind bore measurement, has concluded that boxwood shrinks initially but remains relatively stable thereafter.
132. Mathiesen and Mathiesen 1986:177.
133. This formula was kindly passed on to me by Ronald M. Laszewski*. Paul Hailperin* writes that he was told about it by Bob Marvin and has used it since 1970 or 1971.
134. Morgan 1982:17-18.
135. Cf. von Huene 1995:108.
136. The highest pitch of three wooden traversos by Jacob Denner averages about 5 Hz higher than his surviving ivory instrument, which suggests that the wooden instruments were originally about 5 Hz lower than they now play.
137. Graham Nicholson*.
138. Cf. also Bouterse 2001:228-29, 232.
139. Quoted in Higbee 1962:57.
140. Cf. Eppelsheim 1961:75. J.G. Walther, also in 1732, gives the range of the "Flûte à bec, oder Flûte douce" as f1 to g3 without mentioning any other sizes or ranges. In France, the "flûte à bec" had this same range at least as early as Freillon-Poncein's *Veritable manière* (1700). Cf. also Hotteterre's *Principes* (1707). On the fingering of Dieupart's suites for "fourth flute" and more on the general question of nominal pitch on the recorder, see Lasocki 1983:512ff. The same principle applied to the tenor hautboy in a hautboy band, often written in C2 clef so it could be fingered as if it were a normal treble hautboy (see Tilmouth 1959:202).
141. The result of this method, of course, is to exclude the possibility of instruments built in pitches more extreme than the major third discussed in this study.
142. Cf. Kirnbauer & Krickeberg 1987:251 and Kirnbauer & Thalheimer 1995:91.
143. See Kirnbauer and Thalheimer 1995.
144. 1975:169-170.
145. Clear overviews and explanations of 17th- and 18th-century indications of the pitches of musical instruments by physicists are given in Karp 1984:9-16 and Karp 1989:159ff.
146. Dostrovsky 1975:201. This harpsichord may have been the Couchet bought by his father, Constantijn Huygens, in about 1648, which was tuned to "corista" or "den rechten toon" (see 2-3 and 1-4a).
147. Sauveur was a member of the Académie. For a general assessment of Sauveur's work related to music, see Cohen 1981:24ff.
148. Sauveur was a tutor at the court of Louis XIV, and held the chair of mathematics at the Collège Royal (Dostrovsky 1975:201). See also Mendel 1978:89 and Thomas & Rhodes 1980:782.
149. See Truesdell 1980:16:524.
150. Dostrovsky 1975:201.
151. Barbieri 1980:19n6. A detailed list of the weights and measures used by Sauveur can be found in Rasch *Introduction* (see Sauveur), p.24. Cf. also Lindley 1987:219 and Ellis 1880:36 under 406.6.
152. Dostrovsky, Bell, and Truesdell 1980:665.
153. Defined by Dostrovsky 1975:202, as "periodic fluctuations of loudness produced by the superposition of tones of close, but not identical, frequencies." Dostrovsky points out that "there is no indication that beats were understood before Sauveur."
154. Fontenelle 1700 (which is an introduction and resumé of Sauveur 1701) explains the method concisely and clearly. He points out there (p.139) that Sauveur was, for an unknown reason, unable to repeat his experiment for a committee appointed to test it. Mattheson (1721:428ff) discussed Sauveur's and Fontenelle's articles.
155. See Rasch 25.
156. See below.
157. Dostrovsky, Bell, and Truesdell 1980:666. Karp 1984:16 analyzes Sauveur's report.
158. See Rasch 26. Ellis 1880:36 gives 408.
159. Reported in Rasch 25-26.
160. Adlung 1758:376, Mattheson 1721:428ff.

161. This fact leads one to wonder if Sauveur's other *Son fixe* at 100 cps was determined with any more relation to practical music. Sauveur was, in fact, deaf (Bardez 1975:31).
162. Karp (1989:161) comments, "It may be worth noting that many tuning forks have been made to the scientific scale (i.e., "Sauveur pitch"), and it may not always be possible to distinguish them from tuning forks made for musical reference."
163. Barbieri 1980:17.
164. This is confirmed in Barbieri 1987:225.
165. Where f = frequency, L = length, T = tension, and m = linear mass or weight per unit of length.
166. Sauveur in 1713 had published similar observations (see Dostrovsky 1975:189).
167. See Cannon and Dostrovsky 1981:19, Karp 1984:10, and Karp 1989:160.
168. Ellis 1880:36 under 418.0. Marpurg 1776:65 cites Euler's pitch at 392.
169. Anonymous article "Leonard Euler," NG1 6:292. See also Ellis 1880:35 under 392.2.
170. Quoted in Barbieri 1987:II:141. Cited also in Barbieri 1980:23n14. Barbieri writes that a new organ was commissioned by Pietro Nacchini in 1743, so the pitch in question would have been that of the organ built by Michele Colberz in *ca.*1718-22, which replaced a Casparini (cf. Oldham 1980d:3:859).
171. Smith 1749:202: the D on the Trinity College organ gave 262 vibrations: an octave higher would be 524; modern *C* = 523. This was measured in September (Smith 1749:204). In November it was 254, on a hot day in August, 268. This is a range of about 380 to 403 Hz. See Ellis under 441.7.
172. See Cohen 1981:34 for comments on this paper. Bernoulli had published other reports on transversally vibrating rods (1742, pub. 1751) that measured pitch frequencies, though not of specific musical instruments.
173. Pages 34-35.
174. See Karp 1984.
175. Karp 1984:14-15. This value is almost exactly a modern g#1 in equal temperament.
176. According to Ardal Powell*, Lambert also left Ms measurements of his flute, with notes on its tuning.
177. According to Dostrovsky, Bell, and Truesdell 1980:669. I was not able to locate these indications in the copy of Chladni 1787 that I examined.
178. Sarti 1796. See Barbieri 1986.
179. Barbieri 1986:225; also reported by Cavaillé-Coll 1859:170. Sarti is mentioned by Ellis 1880:17: "his result is uncertain." See also Ellis 1880:42. The experiment was also reported in Gerber 1812:II:21. A complete report of the experiment can be found in Baroni and Tavoni 1983:223-9.
180. Probably Cavaillé-Coll.
181. See Ellis 1880:36 under 414.4. Chladni 1802:28 gave C-125, or the same as Euler's A-418.

182. The copy I examined was published in 1809; the pages in that edition were 28-30. Chladni had measured *C* at Wittenberg in 1802 as 128 (according to Kiesewetter 1827:148) and, sometime near 1827, Chladni informed Kiesewetter of pitches he had measured at C-136 to 138 (the latter about A+1). The musical world had thus already gone beyond Chladni's ideal "scientific pitch."
183. In addition to these, there are another 20 organs with pitches that were named and frequencies that can be deduced (2 English, 2 French, 12 German, and 4 Dutch); see Appendix 7.
184. This is with the exception of the earliest example (1606), still at A+1 (Praetorius's *CammerThon*; see 2-3b).

Chapter 2

Pitch before the Instrument Revolution of *ca.*1670

2-1 When Pitch Standards Became Necessary

In the early 16th century, church choirs usually sang alone; instruments were actually forbidden in the Sistine Chapel at Rome. Singers simply set their pitch for each piece so that its range matched comfortably their voices. And given the ranges of surviving pieces in the vocal repertoire, it is apparent that they could not all have been performed at the same pitch level. This means that the pitch reference for vocal groups performing without instruments was not permanently fixed in terms of any absolute frequency level.[1]

In 1765 Giuseppe Paolucci, with unusual historical insight for his time, wrote in his *Arte pratica di contrappunto* (III:173):

> Of composers even older than this [1584],[2] compositions can be seen in which the parts are higher, but it should first be said that these pieces were sung without organ or any other instrument, and the singers were consequently free to take a lower pitch if they wished, depending on whether the parts went higher or lower, exactly as present-day choirs do when they sing a Cantus Firmus, the pitch being chosen for each piece. It became the practice later for the organ and singers to answer each other, that is, the organ interjected now one, now another versetto, and thus being obliged to be at the organ's pitch, it was necessary that composers adapted to the pitch of the organs.

By the first decade of the 16th century, organs seem to have been used to accompany choirs at St. Peter's in Rome.[3] In this period, the organ alternated verses with the choir as Paolucci described. But for this function, it had no need to be calibrated to a standardized pitch; it had only to match the natural ranges of voices, and for the sake of practicality, the pipes needed to be connected to the keyboard in a way that allowed the organist to use simple tonalities. The "pitch" of the organ, that is, the frequency of the note sounded by the key A, was simply a function of vocal ranges.

An early indication of an appropriate pitch for church organs was given by Arnolt Schlick in 1511. In his book *Spiegel der Orgelmacher und Organisten*, Schlick printed lines in the margins to indicate the various pipe-lengths he recommended. He considered that

> The instrument has to be pitched for the choir [dem Chor gemeß] and be tuned suitably for playing with singers. . . . However, people sing higher or lower in one place than in another, according to whether they have small or large voices.[4]

Schlick's term "Chor gemeß" looks similar to the later terms "*Chormaß*" and "*Chormäßig/Cormesig*," and his phrase "suitable for playing with singers" sums up the meaning of these words. They appear to represent the same idea as the reference in 1507 cited in 2-2a3 to "coristo a voce de homo over da coro" ("*coristo*, at [the level of] a man's voice or that of a choir") and Barcotto's organ "in voce umana, e si chiamano corristi" ("corresponding to the human voice, which is called *corristi*").[5]

Schlick's concern was not specific pitch frequencies, since he added that voices varied in their range. The length of his lines was based on an estimate of the average range of choirs, a pitch that would *usually* be appropriate. The issue was still where to place the keyboard in relation to the sound of the pipes, and apparently had no relation to the pitches of other instruments; it was an extension of the singers's concern to match the range of the piece to the range of their voices.

It must have been in this way that the pitches of organs were decided in the generations before it became customary to use other instruments in church besides the organ. Whether this can be called a *pitch standard* is debatable, as 16th-century organs (all presumably "Chor gemeß" or *corristi*) varied in absolute pitch (compare Graph 4a, Italian organs built before 1670). Even into the 18th century, organs de-

scribed by contemporaries as at *Chormaß* could be a semitone apart.[6] *Chormaß* (and often *Chorton*, apparently) seems to have been used to describe an organ's relation to the voices who sang with it rather than a specific frequency. The need for a pitch *standard* in church did not arise until other kinds of instruments began to be used there.

Instrumental ensembles began to be commonly used in certain Italian churches in the early 1560s. "The regular use of [string] instruments in sacred music may have originated with Lassus in the Bavarian Court in Munich" by the 1560s or slightly earlier.[7] An account of church music in Rome in the 1570s mentions the use of organ, cornett, and sackbut, with the latter two used "among the quyre"[8] (thus not in *alternatim* passages). Gioseffo Zarlino wrote of combining other instruments with the organ in 1588 (IV:31:212).[9] Niemöller found records of the use of sackbuts in church services in Emden in the 1570s, and cornetts at the Catharinenkirche in Hamburg in 1592 (or earlier), Kiel in 1570, etc.[10] We may assume then that by the second half of the 16th century agreements on pitch standards had become necessary in church.

Writing in 1618, Praetorius tells us in *Syntagma musicum* that "First of all it should be said that pitch frequently varies in organs and other instruments. This is because playing together with all kinds of instruments was not a common practice among our ancestors."[11] The phrase "playing together with all kinds of instruments" evidently referred to a different practice from the usual one of playing in consorts of like instruments often made at the same time by a single maker.

A description in *ca.*1571 of an "instrument chest" of 45 winds, including large shawms, "Pfeiffen" (flutes), cornetts, a fife, and recorders made by members of the famous Bassano family included the remark "they are all tuned with one another at the standard organ pitch and are intended to be played together."[12] This appears to be an example of what Praetorius meant: diverse types of wind instruments ("all kinds of instruments") designed to play together at a single pitch standard. It seems that the fact that all the instruments were at the same pitch standard was unusual enough that it was worth noting; in other words, instruments were not always at the same pitch. The phrase "standard organ pitch" implies a generally recognized system by the 1570s, and perhaps also that organs and wind instruments were normally tuned to the same reference pitch in order to be able to perform together. This pitch may have been *mezzo punto*, the first pitch name I have seen mentioned (in 1559, see below).

2-2 Italy

2-2a Venice

Woodwind instruments, being less flexible, often turned out to be the decisive factor in agreements on pitch. For the whole of Europe in the 16th and 17th centuries, Venice was the most important source of the best woodwinds. Anthony Baines wrote,

> Among the [cornett] survivors in the big collections, those of Venetian manufacture predominate, which is appropriate, since Venice seems to have been the principal focus of design during the period. German courts, for instance, frequently bought their wooden wind instruments from Venice. . . . This, and the constant migration of players from one country to another, led to some degree of standardization in instrumental playing-pitch.[13]

Cornetts made in Venice were frequently exported to other parts of Europe: a contract with the Bassanos in 1559 speaks of customers "qui dela cita come de fora" ("here in Venice as well as abroad").[14] Vincenzo Galilei (1581:146) said in his *Dialogo della musica antica et della moderna* that the best cornetts of his day were made in Venice. After describing a standard set of recorders, Praetorius (1618:34) mentioned that "a whole consort of them can be bought in Venice for about 80 thalers." In 1596 Archduke Ferdinand of Schloss Ambras owned "4 curved cornetts bought in Venice . . . one new *doltana*, bought from Venice . . . one large consort recorder bought from Venice."[15] Thus (as it was to do again from the late 18th century up until the present moment) Venetian pitch set the standard in the countries of Europe.

2-2a1 Mezzo Punto (A+1)

In 1577 the Cathedral organ at Feltre was repaired by the Federici firm, in order "that the said organ be put in its regular pitch, that is, in the

cornett pitch of *mezo ponto*."[16] The term "*mezo ponto*" was also associated with cornetts in a contract drawn up in 1559 between three Venetian wind players in the service of the Doge of Venice and two instrument makers of the Bassano family:[17] "Loud [curved] cornetts, both at *mezo ponto* and *tuto ponto*, four *lire di piccoli* each, mute cornetts at all pitches [or sizes], 2 *lire* and 8 *soldi* each."

Mezzo punto and *tutto punto* were evidently widespread concepts in the north of Italy by at least the end of the 16th century, as a large order made by the city of Genoa in April 1592 shows. The order was for musical instruments from Venice, and the instruments were described as follows:

> First, six *mute* cornetts, together in a case, in the pitch of *tutto punto*, and made of boxwood; [then] six [non-mute] cornetts, whose pitch should if possible be precisely *mezzo punto*, together in a case[,] of boxwood, part for right-handed, part for left-handed players; [then] six *fiffari* [shawms?], the pitch of which should be precisely *mezzo punto*, in boxwood, in a common case; [then] eight recorders together in a case, they should consist of two small *sopranini*, four larger, and two tenors, lower than the four [previous] but without keys at their [bottom] ends, they should be at the pitch of *mezzo punto* and made of boxwood. All the above instruments should be of quartered, well-seasoned wood, and above all correctly pitched, and to obtain the best quality one should go straight to Gianetto da Bassano of Venice, or else "Instrument" Gerolamo, or Francesco Fabretti and brothers, because all of them are the most knowledgeable in these kinds of instruments.[18]

It appears from these references that *mezzo punto* was the most common pitch at the end of the 16th century and the one associated with most woodwind instruments, though not with mute cornetts.[19] If *mezzo punto* was the most common cornett pitch, its frequency can be determined from surviving instruments, of which there is a reasonable sample. Graph 1d shows the pitches of 101 16th- and 17th-century curved cornetts still in reasonable condition.[20] It is presently impossible to distinguish German from Italian instruments, or to date the instruments, but most of them were probably made in Venice between about 1570 and 1630, and used all over Europe.

Always bearing in mind that to reduce the pitch of a woodwind instrument to a single Hz value is a physical absurdity, and that margins are in order, the range of pitch shown in Graph 1d for curved cornetts is 415 to 504.

The central core ranges from 460 to 471, accounting for 52% of the total and averaging 466 = A+1. We assume this, or something close, was the principal cornett pitch. Graph 9 gives an idea of the pitches of the greatest number of curved cornetts. Graph 10 takes a sample of curved cornett pitches from all periods. Each column going to the right shows a greater incidence. The most common pitches are 464/465, the next most common are 463-467, etc.

Pitch estimates by Herbert W. Myers based on the dimensions of the cornett illustrations in Mersenne and Praetorius also shows a predominance of A+1 (see 1-3a and 2-3b). The same level (though centered a bit lower) is shown by contemporary recorders (cf. Graph 1a). Thus it is very probable that *mezzo punto* was A+1.[21]

Confirming this is Herbert W. Myers' observation that the finger-reach on cornetts at lower pitches, even a semitone lower at A+0, become noticeably more difficult. And people were generally smaller in the 16th century.

At a much later time, in 1765, Giuseppe Paolucci implied that most Venetian organs had been at A+1 when he wrote that "the already celebrated organ maker Master Pietro Nacchini was the first to lower organs in those countries by about a semitone . . ."[22] Organs by Nacchini for which original pitches are known are at A+0 (433, 436, and 437).[23] This would make earlier Venetian organ pitch, "about" a semitone higher, = 462 = A+1 (or again *mezzo punto*). This in turn clarifies a report from the end of the 17th century by Giovanni Andrea Bontempi, who had been employed as a singer at S Marco from 1643 to 1650. He reported in his *Historia musica* (1695:188), that the organs at S Marco "sono un tuono intero piu acuti degli altri dell'altre Chiese" ("are a whole-tone higher than the organs of the other churches"). Since we know that Nacchini lowered many organs a semitone to A+0 in the 18th century, most Venetian organs must have been at A+1 in Bontempi's time. "Un tuono intero piu acuti" than A+1 would have been A+3. This pitch may have been a relic of the past. The organ "in cornu Epistolae" at Bologna built by L. da Prato in 1475 was also apparently at A+3. In 1521 Giovanni Spataro, then *maestro di cappella*, complained

of its high pitch, and in 1531 it was lowered a whole-tone to A+1 by G.B. Fachetti.

Although he did not use the term *mezzo punto*, Antonio Barcotto in his manuscript *Regola e breve raccordo* of 1652 apparently regarded A+1 as typical not only for the cornett, but for the violin as well:

> [The organs] of Venice are among the highest used in that state, and must be tuned to the pitch of cornetts. Chamber organs, though, at Venice, Padua, Vicenza, and other cities, are a tone lower, [corresponding to] the human voice, which is called *corristi*. This difference of pitch is used to accommodate voices and instruments, since organs that are high work well with lower voices and violins, which are for this reason more spirited.[24]

Instrumental works like those by Fontana, Neri, Trabaci, Rossi, the *sonate* and *symphonie* of Marini, and the *canzoni* of Marini and Merula, all produced in Venice in the 17th century, were presumably played at *mezzo punto*, or A+1.

The other surviving cornett pitches are both above and below A+1, with peaks at 448-452 and 480-484; together these levels, which are the only other significant ones, make up some 20% of the known cornett pitches. Although neither of these levels is a complete semitone from 467 (A+1), they may have been regarded that way.[25]

A+2 may have represented an older pitch level that fell out of use by the 17th century. There are surviving organs at A+2, made in the 16th century: S Maurizio, Milan (1554) and the Silberne Kapelle, Innsbruck (16th century). In early Spanish sources, "*punto*" sometimes meant "pitch" and sometimes "tone."[26] Nassare wrote in his *Escuela música* "[it] is noticed in the musical chapels where dulcians, cornetts, and shawms are used, these are usually pitched a *punto* higher than natural pitch."[27] By "natural," Nassare meant a specific pitch level that was determined because it was comfortable for a man's voice. Since dulcians, shawms, and especially cornetts were normally at A+1, and ideal vocal pitch was generally considered *corista* at A-1, "*punto*" may well have been a whole-tone.

If *punto* originally meant "whole-tone," A+2 would be the level to which *mezzo punto* and *tutto punto* refer. *Mezzo punto* would then originally have meant "a half-tone below A+2" (A+1), and *tutto punto* "a whole-tone below A+2" (A+0). This might be checked by investigating the possible age of the few surviving instruments at A+2.

2-2a2 Tutto Punto (A+0)

A proposal submitted in 1582 for lowering the organ at Cremona produced an interesting discussion of pitch standards. In that year, the cathedral's organist, Camillo Mainerio, together with the *maestro di cappella* at Cremona, Marc'Antonio Ingegneri (who was also the music teacher of a 15-year-old named Claudio Monteverdi), recommended lowering the organ "approximately a semitone, so that the pitch of the organ in question will agree with the choir and the ensembles that perform both now and in the future with all kinds of musical instruments that play together in choirs and ensembles."[28]

An organist and builder, G.B. Morsolino, was consulted about this proposal. Morsolino (also Morsselino) had worked with Orlando di Lasso at Munich.[29] Part of his reply was the following:

> As for lowering [the organ], I see no advantage for playing with other instruments, since all the organs I have seen in my lifetime, either in Italy or elsewhere, that are normally used to perform with the greatest performers, are in the cornett pitch of *mezzo punto*, a note higher than ours that we are presently discussing at the cornett pitch called *tutto punto*, which is a note lower than the other that is called *mezzo punto*.[30] This situation obtains because, not wishing to hinder the organs when playing with the wind instruments, they leave them in the above-mentioned *mezzo punto* pitch, which is however too high for the chapel singers. Because of this practice, organists are always (or at least usually) compelled to play lower than the written key in order to accommodate the singers. This is what is done at St. Mark's in Venice; I do the same on mine [in Bergamo], as is done on most organs played by organists of any merit. For this reason it can be concluded that lowering [the Cremona organ] is not required for concerted playing, since organs used that way which are played by the best men in the profession are a note higher than ours at Cremona.[31]

A further opinion on the question was requested of the distinguished organ builder Graziadio Antegnati (who had built the organ at Santa Barbara in Mantua at A+1; see 2-2c). Antegnati sided with Ingegneri and Mainerio. He thought that lowering the pitch "renderà esso organo più comodo al choro et alla musica" ("would make this organ more practical for use with choir and mixed vocal-instrumental music").

Morsolino placed *tutto punto* "un tuon" below *mezzo punto*. Since both a whole-tone and a semitone could be a "tuon,"[32] it is unclear from Morsolino's testimony whether he considered *tutto punto* A+0 or A-1 (and consequently whether the proposal was to lower the organ to A-1—two semitones below *mezzo punto*—or to A-3, which would have been two whole-tones below *mezzo punto*).

In order to answer this, it helps to consider why, in fact, Ingegneri and Mainerio would have made this proposal. Their stated purpose was to get the pitch of the organ in "correspondence" with the choir and ensembles of instruments. If *tutto punto* had been a whole-tone below *mezzo punto*, thus at A-1, lowering the organ further would not have been necessary, and A-3 would seem an absurdly low and impractical pitch. But if *tutto punto* was a half-tone below *mezzo punto*, at A+0, the organ might well have been considered too high for the choir. In addition, most of the instruments at *mezzo punto* would have had difficulty transposing down a semitone (transposing down a whole-tone is much easier). Thus we may safely assume Morsolino also equated A+0 with *tutto punto*.

Several sources indicate that *tutto punto* was sometimes a cornett pitch: Morsolino, the Bassano contract of 1559 cited previously, and the Genoa order of 1592 that relates *tutto punto* to cornetti *muti*. The most significant cluster of surviving *mute* cornett pitches is at 430-446 (see Graph 1c). The second most important cluster of surviving curved cornetts extends from 434 to 452 with an average of 444 (Graph 1d).[33] Original curved and mute cornetts also exist at A-1, but they are much fewer.[34]

There was a good reason for cornetts to be made at pitches a semitone apart: transposing a semitone would have been problematic. First, there is the difficulty of unequal temperaments and semitone transpositions (discussed in 0-3c). Besides this is the question of finger technique. Semitone transpositions were impractical because simple scales like C would turn into B and C# with a high percentage of cross-fingerings or half-holes. For both these reasons, whole-step and minor third transpositions were much easier and more practical on woodwinds without key systems. It is conceivable that players owned two or even three instruments pitched in consecutive semitones, allowing whole-step transpositions in various combinations to produce any required scale. While cornetts were predominantly at A+1, instruments a semitone lower would have been useful in Rome (where most organs starting about 1600 were tuned to A-2) and in the north where some organs were at A+2 (like the Antegnati at S Maurizio in Milan), since in both cases the necessary transposition would have been a simple whole-step.

Since transposition was common for organists, it seems the levels under discussion were at distances of integral semitones from each other. The relationship of these pitches would thus have been as follows:

A+1	*Mezzo punto*
A+0	*Tutto punto*; pitch of the Cremonese organ
A-1	The higher of two pitches for "choir and mixed vocal-instrumental music" (= *tuono corista*)
A-2	The lower of two pitches for "choir and mixed vocal-instrumental music" (= *tuono corista*)

Once it is apparent that clear and distinct pitch standards a semitone apart are involved, the seemingly apathetic wording of a number of authors from this period takes on a new significance. Costanzo Antegnati writes in his directions for tuning in *L'Arte organica* (Brescia 1608:72) that one may "stabilire la cordatura come si vuole Corista di tutto ponto, o di mezzo, o alta, o bassa come si vuole, & è commoda" ("fix the tuning as one wishes at *tutto ponto* or *mezzo* [*ponto*], higher or lower, as is wished and is comfortable"). Antegnati's phrase "corista di tutto ponto, o di mezzo" can thus be understood to offer a choice between two specific pitch standards; by "commoda" he would have meant the standard that was most appropriate for a specific church organ and choir. The same may be said of Bartolomeo Bismantova's comment on tuning keyboards in his *Compendio musicale*

(Ferrara, 1677): "You will need first to tune all the C's in perfect octaves, at the pitch standard you wish."[35]

At least one organ at A+0 is known to have been built at this time, though only one stop survives (Costanzo Antegnati, Cathedral of Verona, *ca.*1610).

2-2a3 Tuono Corista (*A-1*)

The first reference to the concept "*corista*" of which I am aware is from a contract for the organ at S Maria di Monteortone, Padua (1507), which specifies "Item sea coristo a voce de homo over da coro"[36] (at [the level of] a man's voice or that of a choir).

"*Corista*" quickly came to have a more general meaning, but it seems originally to have been associated with mixed groups of singers and instrumentalists. Its name makes its connection to choirs obvious. At first, it was probably produced by simply transposing downward, as Morsolino described; Zacconi noted in *Prattica di musica utile et necessaria* (1592:f218v):

> And observe, that just as the human voice can sing a piece a tone higher or a tone lower, depending on how well it works and is satisfying; so the instruments can play a composition sometimes in one key, sometimes in another because they are all without exception high compared to the voices. Thus, when it happens that instruments wish to accompany singers, most of the time, to oblige them, they play a 2d, 3d, 4th, etc. [lower].[37]

Although most sources put *tuono corista* a M2 below *mezzo punto*, it was sometimes lower, as Zacconi wrote. In 1609 Girolamo Diruta mentioned in *Il transilvano* "trasportationi . . . un Tuono, & una Terza bassa." At least part of the reason for this was that *tuono corista* at Rome was at A-2 (see 2-2b), a m3 below *mezzo punto*. Diruta distinguished between the common transpositions of *chiavette* (or clef-code) notation[38] and "another kind of transposition that allows a response in a comfortable pitch for the choir."[39]

The intervals between the organ's pitch and this chorus pitch, a whole-tone and a (minor) third, are smaller than those for *chiavette*, and are the same as those that would be made from most organs going down to the pitch Antegnati had said was "more practical for use with choir and mixed vocal-instrumental music." "And since most organs are pitched high, beyond *tuono corista*, the organist must accustom himself to playing otherwise, a whole-tone and a [minor] third lower."[40]

In the course of the 16th and 17th centuries, there are signs that organists in northern Italy were finding it increasingly impractical to be constantly transposing in order to match the compass of church choirs. There are indications that many organs were lowered in pitch, presumably to *tuono corista*. Some examples:

1546	Bergamo, S Maria Maggiore Lowered 2 semitones.[41]
1571	Ravenna Cathedral Put "in tono corista un tono piu basso del solito"[42] (in *tono corista*, a tone lower than normal).
1609	Reggio Emilia, Collegiata di S Prospero "di dieci piedi, un tuono più basso del cornetto"[43] (i.e., a tone lower than cornett-pitch).
1626	Saló, Duomo G.B. Facchetti, "arbasar uno tono lorgano."[44]
1628	Arezzo Originally at A+1; pitch lowered a semitone, and in 1723 a further semitone.
1645	Padua S Antonio Lowered a tone by Graziadio Antegnati.[45]

In the passage cited above, Costanzo Antegnati in 1608 was using the term "corista" not as a specific pitch level different from "*tutto punto*" and "*mezzo punto*," but with its modern meaning of "the general pitch standard."[46] The majority of sources in this period associated *tuono corista* with a specific frequency level, however. As quoted previously, in 1652 Barcotto wrote that chamber organs were pitched at "*corristi*," a tone lower than the pitch of cornetts; since the most common cornett pitch was *mezzo punto*, *corristi* would probably have been A-1 (depend-

ing on what Barcotto meant by "tone"). He went on to say that "The lower-pitched organs are much better at meeting the needs of choirs, as well as those of higher voices. But the lower and deeper voices have more trouble with them, and they do not work as well with violins as the high organs." This is reminiscent of Morsolino's argument for keeping the Cremona organ at A+0; organists were caught between the differing pitch demands of instruments and choirs.

Sabbatini (writing on keyboard tuning in 1657) also considered "corista" a specific frequency: "Next you will have to decide the position or pitch in which you wish to tune the instrument, whether in *corista* or something else."[47]

Barcotto in 1652 made another reference that might have been to *corista*:

> The Most Rev. Father Maestro Antonio Tavola, Maestro di Cappella at the hallowed Basilica of S Antonio in Padua, has had the organs of his church tuned to the most comfortable pitch that can exist for voices as well as instruments, having kept a limit neither too high nor too low, so that every voice and instrument can adjust comfortably.

Seven years earlier, in 1645, the organ in question at S Antonio had been lowered "a tone" (which could have been either a semitone or a whole-tone) by Graziadio Antegnati.[48]

Adriano Banchieri in *Conclusioni nel suono dell'organo* (Bologna, 1609:46,66) noted:

> [The note F2], called by instrumentalists and organists *corista*; it can be in the natural pitch of the instrument, *voce corista*, or alternately a tone lower or four higher, or lower.
>
> I would add that the organ is a keystone, since being tuned in *tuono corista*, every other musical instrument needs to take from it its proper pitch.

While Morsolino in 1582 had considered *tuono corista* a level achieved on the organ through transposition, here Banchieri a generation later appears to make it by definition the pitch of organs.[49]

2-2a4 *Instruments Pitched Lower Than* Mezzo Punto

The mute cornett was generally considered to be at a lower pitch than the curved cornett at A+1. How much lower is unclear, however. Most surviving mute cornetts are a semitone below most surviving curved cornetts; 57% of mute cornetts are at an average of 442 (A+0) and 25% average 420, a high A-1 (see Graph 1c and 1d).[50]

But there are indications that the mute cornett was normally thought of as a whole-tone lower than the curved cornett. Praetorius noted in two different plates (viii and xiii) that the mute cornett was in G (the cornett is normally thought of as in A). Myers calculated that Praetorius's mute cornett in Plate viii no.9 with a length of about 66 cm suggests a pitch of about 409.[51] A court inventory made at Stuttgart in 1589 indicated that while curved cornetts were at *CammerThon/Cornettenthon*, mute cornetts and flutes were at *ChorThon* (thus presumably a whole-step lower, as we will see in Section 2-3 on Germany).[52] One possible explanation for this discrepancy between A+0 and A-1 is that, just as curved cornetts were built a semitone apart at both *mezzo punto* and *tutto punto*, mute cornetts were also common at levels a semitone apart.

Surviving Renaissance flutes are also pitched about a semitone apart (Graph 1b). The majority (59%) are at 400, and the others cluster around 430.

Flutes were sometimes noted for their low pitch. The Stuttgart inventory of 1589 listed tenor and bass *Zwerchpfeiffen* "not agreeing with the *Chor* but a tone lower," and at Graz in 1577 there were "2 big *Zwerchpfeiffen* used in the *concert*."[53]

These instruments would have been used for different musical functions than those at *mezzo punto*. Prince Ferdinando de' Medici wrote in 1708 that "it does not appear possible to me that straight cornetts can produce the same effect as curved ones, because the curved ones . . . sound more like the trumpet, while the straight ones are softer, and are played at funerals and similar occasions, which is why we call them *cornimuti*."[54]

The order from Genoa to Venice in 1592 mentioned above specified that curved cornetti, shawms, and recorders were all to be at *mezzo punto*, while the mute cornetts were to be at *tutto punto*, so evidently they were not intended to be played together. Smith (1978:26) noticed

that mute cornetts and flutes were often scored together in 16th- and 17th-century music.[55]

Praetorius (1618:16) indicated that certain instruments were tuned a m3 lower than his standard *CammerThon* (which, as we will see, was equivalent to *mezzo punto* at A+1). He wrote that "Flutes and other instruments are also more beautiful when tuned at such a low pitch, and give quite another *timbre* to the listener."[56] There were certain other winds that Praetorius considered to be typically built at a lower standard.[57] These include the *gedact* dulcian[58] and *cornamuse*. Sackbuts could be crooked lower, and were also apparently made lower (cf. the *Secund-* and *Terz-Pusonen* in the Stuttgart inventory of 1589, presumably a M2 and m3 below the *gemeine* tenor).[59]

For strings, the pitch question is somewhat less rigid, since they can be retuned. When concerted pieces performed in church were tuned lower for the sake of the singers, it would have been absurd for the strings, playing in keys like G and D with all their open strings, to *transpose* down to F and C. In such cases they would presumably have *tuned* down a whole-step.[60] Praetorius advocated this practice:

> This pitch [*CammerThon*] is often found too high—and not only for singers, but also for string players. Violins, viols, lutes, pandoras, and so on require extraordinary strings to cope with such high tuning. Thus it happens that the top strings break in the middle of the performance, and one is left in the mire. Really, to let the strings hold their tuning better, stringed instruments like these must commonly be tuned about a tone deeper, with the other instruments also playing a second down. This does not come easily, by any means, to unskilled musicians; but it is a great relief for the singers to be able to sing at this pitch, a tone lower.[61]

When violins functioned as an accompanying orchestra rather than as soloists, being tuned "a tone lower" might also have been an advantage as they would have had a less individual and aggressive sound.

2-2b Rome

Barcotto wrote in 1652:

> The pitches of organs are very different from one city to another, since there are those who use very low organs, and others very high, such as those in Rome, which are among the lowest used in Italy.[62]

Roman pitch was often seen as a contrast to that of Venice. In 1640 (180-82), G.B. Doni devoted several pages in his *Annotazioni* to the notion that natural vocal ranges corresponded to latitude, and that northern people sang lower than southern. He therefore found it remarkable that the "Tuoni artificiali de gl'instrumenti" were just the reverse, at least in Italy: the organ pitches of Naples, Rome, Florence, Lombardy, and Venice, he said, formed a series of ascending semitones.

> Starting from Naples, it is known that organ pitch there is semitone lower than that in Rome; the latter is another semitone below that of Florence; that of Florence the same distance below that of Lombardy; and the latter equally a halftone lower than that of Venice. So that, adding these differences together, Venetian pitch is a ditone, or M3, higher than Neapolitan.[63]

Mendel called this description "suspiciously neat,"[64] but it is interesting to compare it to the 27 available Italian organ pitches prior to 1670 shown in Graph 4a. They break down into five distinct pitch levels at fairly precise semitones, averaging 387 (Rome or environs[65]), 415 (Tuscany, and south of Naples[66]), 435 (mostly in the North[67]), 464 (mostly the Veneto[68]), and (higher than anything Doni mentioned) 495 for Milan.[69]

In his *Compendio* of 1635, Doni mentioned this same relation but included only three of the five pitches; in describing a harpsichord by Iacopo Ramerino he wrote ". . . in which, ingeniously, just by moving the register the same strings will give you the pitch of Rome, that of Florence and that of Lombardy . . ."[70] Again, the implication is that these pitches were at equally spaced semitones.[71] If Rome was the lowest at A-2, the other pitches would have been A-1 and A+0. Doni thus associates "Lombardia" with A+0, and apparently leaves Venice to claim the pitch a semitone higher (A+1, which was in fact *mezzo punto*).

If organs at Rome were at A-2, according to Doni they would have been at A-3 at Naples. There is some support for this. Though made in the 18th century, there is one Neapolitan organ (Morano Calabro, Carmine) at 375. Barcotto (writing just 12 years after Doni) considered Roman organs among the lowest used in Italy. But he did not categorically rule out low organs at other places. The explanation may be that Naples, like many other places, used more than one pitch level.

In 1618 (16), Praetorius reported a low Italian pitch:

> The lower pitch of which we have spoken (a minor 3d down) is used a great deal in different Catholic chapels in Germany, and in Italy. Some Italians quite rightly take no pleasure in high-pitched singing: they maintain that it is devoid of any beauty, that the text cannot be clearly understood, and that the singers have to chirp, squawk, and warble at the tops of their voices, for all the world like hedge-sparrows.[72]

Since (as we will see below) Praetorius's reference was *CammerThon-Cornettenthon* at A+1, the low level would have been A-2. He was thus probably referring to Roman pitch.

Mendel reported that three years previous to the appearance of Praetorius's book, the French theorist Salomon de Caus had recorded the dimensions of an organ pipe that (using the most likely standard of length measurement, the *pied de roi*) would produce A-2.[73] Athanasius Kircher published a translation of de Caus's text in 1650 "without any adjustment for the fact that Kircher lived and wrote in Rome,"[74] thus by implication confirming that Roman pitch was A-2.

Mendel (1978:77) cites a letter by G.B. Mocchi written in 1675 that also probably indicates this level. Mocchi wrote that German organs were tuned "fast zwei Töne höher" (= between a m3 and major third higher) than Roman ones. If Mocchi's German reference was standard *CammerThon/Cornettenthon* at A+1, a m3 lower would have been A-2; a little more would put Roman organs into the 380s, which is indeed the level of those that survive.

According to Doni, writing in 1640, the pitch of many Roman organs began to be lowered in about 1600:

having been lowered by a half-tone in the last 40 years (as people say, and demonstrate by a comparison with some old organs).[75]

I have heard these matters about the pitch of Rome discussed in diverse ways by the experts. For some, its lowness is to be attributed to the weakness and sloth of the singers; for others, to the many castrati who, once they are more advanced in years, are no longer able to sing with the same high-pitched voice as that of real boys; and finally for still others, to the large number of *bassi profondi* found here more than elsewhere.[76]

As for the castrati, it was indeed at the end of the 16th century that they became an important presence in the Sistine Chapel (they had been part of the choir from about 1565, and the Munich chapel under Orlando di Lasso had included them by at least 1574).[77]

That there was a Roman "*corista*" is reported by a number of sources dating from *ca.*1562 to 1702.[78] Since these dates are on both sides of the change in Roman organ pitch in about 1600 described by Doni, it is likely that "*corista*" in Rome was used as elsewhere to mean something similar to "*Chormäßig*," or "suitable for playing with singers," not a specific pitch frequency.

Barbieri (1991b:52-53) points out that the interval for downward transpositions as indicated by high-clef (*chiavette*) notation gradually diminished at Rome as a result of a general lowering of the pitches of organs. He cites a number of pieces to show that at the end of the 16th century the transposing interval was a 5th or 4th downward; at the beginning of the 17th century, it was only a 4th; at the end of the 17th, either a 4th or a 3d; and in the 18th century, only a 3d. The transposed interval in the north never got smaller than a 4th, probably because absolute pitch ended up a tone above Rome (1991b:55). Barbieri (1991b:54) cites three surviving versions of Palestrina's *Tu es Petrus*, written "per la basilica vaticana." The earliest, from the 17th century, is notated in high clefs, and requires a transposition "alla 4a bassa"; the second, from the 18th century, still in high clefs, requires "alla 3a"; a third copy is in *chiavi naturali* but is transposed downward by a 3d.

Palestrina was *maestro di cappella* of the Cappella Giulia at St Peter's from 1551. From 1555-1560 he was *maestro* at S Giovanni in Laterano, after which he moved to S Maria Maggiore. From 1571-1594 he was back at the Cappella Giulia. Barbieri (1980:22) cites a report in

1885 by Monsignor Bartolomeo Grassi-Landi[79] that states that the pitches of the organs at the Cappella Giulia, S Maria Maggiore, and S Giovanni in Laterano[80] were at A≈384, on the low side of A-2. Grassi-Landi called this pitch "*Corista di S Pietro*." If Doni's information is correct and Roman organs were lowered "per mezza voce, cioè mezzo tuono" in about 1600 (after Palestrina's time, in other words), Palestrina would have been performing his masses at a rather low A-1. The same pitch would presumably have applied to the masses and motets of Victoria, working in Rome in the 1570s and 80s. The composers active in Rome after 1600, like Landi (from 1620) and Carissimi (from about 1630) would probably have been working with the new, lower pitch of A-2.

By 1666, the castrato Antonio Cavagna, engaged for an opera performance at Venice, insisted that the orchestra tune to Roman pitch: "and I intend to sing accompanied with the instruments of the orchestra tuned to proper Roman pitch and not as I did in *Statira*, in *Teseo*, and in other works; this will be advantageous for my voice, and I bring up the subject now, so that no one will complain about it."[81]

2.2e Other Cities

The organ at the Basilica of Santa Barbara in Mantua was built in 1565 by Graziadio Antegnati. This instrument was recently restored to its original pitch, A+1, which suggests that this was also the pitch of the Mantuan court *cappella*. Mantua was very active musically. Palestrina wrote masses for S Barbara and it would be interesting to compare their ranges with those he wrote for Rome, a whole-tone lower in pitch. Salamone Rossi worked at the Mantuan court, and Lodovico Viadana was *maestro di cappella* from 1593 to 1597. Monteverdi held this post from 1601 to 1612. Presumably, both *L'Orfeo* of 1607 and the *Vespro della Beata Vergine* (1610) were originally performed at A+1.[82] Two parts of the *Vespers*, the "Lauda Jerusalem" and "Magnificat *a* 7," are among many late 16th- and early 17th-century vocal pieces that use *chiavette*, and are thus meant to be transposed downward, normally by a 4th.[83] When down a 4th and at A+1, these pieces are indeed placed in a proper range for both singers and instruments. Other theatrical works performed at court included Monteverdi's *Arianna* and *Il ballo delle ingrate*, and Marco da Gagliano's *Dafne*.

As Antonio Barcotto wrote from Padua in 1652, "Organs in Rome are also larger, unlike the church organs of this area, since they are three notes lower, for which reason they sound bigger."[84] Since it is unlikely that Padua's general pitch level was three whole-tones above *Corista di S Pietro* at A-2, we can assume Barcotto, like Morsolino speaking of the organ in Cremona, meant three *semitones*,[85] making Paduan pitch a plausible A+1.

There is a piece of evidence linking Naples to Ferrara (in the Veneto): in the late 16th century, when the Ferrarese court was interested in hiring a Neapolitan bass singer, they wanted to know "what is the lowest note he can sing, which can be measured by means of a flute. The note or number on the flute that corresponds to the deepest note of the voice should be written in the letter."[86] This method of communicating a note would have been accurate only if the pitch of flutes at Naples was the same as those in Ferrara. Thus at the end of the 16th century in these two cities in the north and south, instrumental pitch, or at least flute pitch, was assumed to have been equivalent.

The Cathedral at Milan has been called the "principal church of Lombardy."[87] Its organ, like a number of others in Milan, was made by Gian Giacomo Antegnati of Brescia. In Milan, however, the playing of instruments other than organ was forbidden in church, so the organs were not necessarily required to be tuned to match other pitch standards. Surviving pitches of organs by the Antegnati family are generally at A+1 and A+0 (a few are at A+2). Barbieri (1980:23n14) cites a chant manual published by G.M. Stella in Milan and Rome in 1665 that states "The pitch at Rome is about a tone and a half lower than that of Lombardy."[88] Stella uses the word "quasi," confirming other indications that the relation between the two pitches was not a pure interval.[89] Surviving organs from the Veneto in this period average 464; a tone and a half lower is 392, whereas surviving Roman organs are at about 384.

Although Crema and Cremona are in the Lombardy region, they were politically a part of the Venetian Republic until the 18th century. Cremonese violins were thus probably designed to be played at the prevailing Venetian pitch standards, anywhere from *mezzo punto* to *tuono corista* (A+1 to A-1 or A-2). It is well known that string instruments resonate best when they are tuned at certain pitches; as Harwood wrote (1981:470), "the pitch of a stringed instrument is perhaps the most important single factor in determining the way it sounds." Barcotto, who was a contemporary of Nicolo Amati and the young Antonio Stradivari, wrote in 1652 that the high organs tuned to "tuono dei Cornetti" (presumably A+1) "work well with lower voices and violins, which are for this reason more spirited." With the type of strings used at the time, violins could have been tuned at least as high as A+1, and possibly A+2.[90] Thus the most common pitch of Cremonese violins of the 17th century was probably *mezzo punto*, A+1.

In Bologna, the two organs at S Petronio "in Cornu Evangelli" and "in cornu Epistolae," as well as that of S Martino, were tuned at A+1, so the *sonate da chiesa* of Legrenzi and Vitali, written in the second half of the 17th century, were presumably conceived at that pitch, as indeed were the famous pieces for trumpet and strings by Cazzati, Perti, and Torelli.

In a letter from Florence dated 6 October 1612, Marco da Gagliano wrote that "in Roma si canta un tono più basso di quà" ("in Rome they sing a tone lower than here").[91] Since we do not know whether Roman pitch had descended from A-1 to A-2 by 1612, and whether by "tono" da Gagliano meant a whole-tone or semitone, the Florentine pitch could have been anywhere from A-1 to A+1. An organ that was built in Florence in 1571, SS Trinita, was preserved until 1939, at which time it was raised a half-step by shortening the upper ends of the pipes.[92] Since the rise was presumably to 435/440, the original pitch must have been approximately a ½-step lower. Doni had already associated Florence with A-1 in his writings of 1635 and 1640. There is thus reason to think that the *intermedi* and early operas of the 1590s by Cavalieri and Peri, as well as Caccini's *Nuove musiche*, were originally performed at A-1, and this pitch may also have been used in Cesti's Florentine productions of the late 1660s.

2-3 Germany

2-3a Praetorius's *ChorThon* (A-1)

In his *Syntagma musicum* (Part 1, 1618; Part 4, 1620), Praetorius provided a great deal of information on contemporary pitch levels both in Germany and in other parts of Europe. His comments are not always clear, but with the background of the situation in Italy, it is easier to understand them. Contrary to 18th-century custom, Praetorius often used the term *ChorThon* (choir-pitch) to mean a pitch a whole-tone below most instruments, which were at *CammerThon*. *ChorThon* used in that way was thus analogous to *tuono corista*, and a system that used two instrumental pitch standards a whole-tone apart was parallel to the one used in northern Italy.

Praetorius began by using the name *ChorThon* to designate a pitch a M2 lower than *CammerThon*, but halfway through his book his conception of *ChorThon* seems to have become ambiguous,[93] which has caused 20th-century readers major confusion. Fortunately, however, there was no doubt about *CammerThon*. He described *CammerThon* as "Our normal present-day pitch, to which nearly all our organs are tuned . . ."[94] The Schloß at Schmalkalden preserves an organ that was renovated in 1606 by Görge Weisslandt and was described as in "*rechten Zimberthon*" (i.e., presumably *Zimmer-* or *Cammer-thon*).[95] The original wooden pipes are pitched at 477. Since instrument making in the 16th and 17th centuries was concentrated in relatively few places, and the principal one for woodwinds was Venice, it can be assumed that Italian woodwinds were in regular use in Germany (as mentioned previously, Praetorius indicated Venice as a source of instruments). It is thus likely that *Cornettenthon* in Germany was similar to the most common Venetian cornett pitch, *mezzo punto* at A+1. And Praetorius explicitly equated his *CammerThon* with "*rechte Cornettenthon*."[96]

The reason for Praetorius's ambivalence about the meaning of *ChorThon* was that the term was in process of changing its meaning in north Germany in his day. He described how *ChorThon* was "earlier in the time of our elders a tone lower than it is now . . ."[97] From this we can take it that composers like Lasso at Munich were performing at that lower level, about A-1 (whatever its name). Praetorius described organs that had originally been at *ChorThon* but had been raised a step ("umb ein Thon") so that by his day they were mostly at *CammerThon*.

An example of this deliberate raising of pitch is the famous organ at St. Johannis, Lüneburg, originally built by Niehoff in 1553 at A-1, and described by Praetorius in 1618. The organ was rebuilt in 1652 by Stellwagen, who raised it a whole-tone to A+1, calling this pitch "*Chormässig*" (suitable for use with singers).[98]

In his own day, Praetorius considered that instruments were (as Zacconi had put it[99]) "tutti universalmente alti rispetto alle voci" ("all without exception high compared to the voices"). He did not approve of the rise in *ChorThon*, and considered the older, lower level better for voices and string instruments.[100] With prophetic insight (considering the situation in Germany a century later) he wrote that "it would not be a bad thing if all organs were tuned a tone [i.e., a second] lower: which is now, however, wholly impossible to change in our German lands, and so we shall have to keep to our usual *CammerThon* . . ."[101] As noted above, for the comfort of the choir, Italian organists transposed downward a whole-tone or m3 to *Tuono corista* in "ensembles that perform . . . with all kinds of musical instruments that play together in choirs and ensembles."[102] For the same purpose, Praetorius and other organists suggested adding low-pitch, transposing stops on high-pitched organs:

> Calvisius once wrote me (and I was already of the same opinion, for which reason I had wanted to have two separate stops in the organ of the Castle Chapel here tuned a half-tone lower) that he had often considered, since some organists would not be familiar with the new keys on the organs, whether it would not be better to have installed in organs . . . one or two soft stops, open or gedackt, of 8-foot pitch, tuned a whole tone or a minor third lower than the rest of the organ, to be used in concerted music.[103]

Praetorius, who was a frequent visitor to Prague, pointed with approval to the practice there "and certain other Catholic chapels" of pitching church music a tone lower than *CammerThon*.[104] This was apparently why he set out at the beginning of his book to call this lower church pitch *ChorThon*.

Nor apparently was he alone in using *ChorThon* to designate a lower pitch. The inventory of instruments at Cassel in 1638 listed "6 old flutes (*Zwerchpfeifen*) longer than the above ones and thus in *Chorton*."[105] The organ of St. Annen, Annaberg-Buchholz was tuned in 1652 "im ChorThon," but by use of a "*Kammerkoppel* can be put a M2 higher, or in other words, in *CammerThon*." Urban Vielhawer von Hohenhaw, writing in 1660 in Neisse, described a harpsichord also mentioned by Praetorius,[106] a "Clavicymbalum Universale, seu perfectum" with 19 keys to the octave. Hohenhaw implied that *ChorThon* was a M2 below *CammerThon* when he wrote that this instrument was capable of playing at three different pitches each separated by a whole-tone, "alß Chor-Cammer-vndt ein Thon, piu alto" (hence Chorton, CammerThon, and one tone higher).[107]

But in a book on organ building written in 1656, Werner Fabricius associated *ChorThon* with "Zinken, Posaunen, Dulcianen und andern chormäsischen Instrumenten":

> It would be reasonable to begin this chapter by considering *Chorton* or *Chormaß*, and if in tuning it has been determined whether the organ can be used together with cornetts, trombones, dulcians, and other instruments in *Chormaß* pitch. An organ maker must be able to determine this accurately with the aid of a pitch pipe that has been carefully tuned.

ChorThon remained an ambiguous word throughout the 17th century, sometimes referring to A-1, other times to A+1. In Germany it could still mean a pitch a whole-tone lower than *CammerThon* as late as the 1680s (cf. Haka in 3-3). This usage may seem strange to those familiar with the later 18th-century use of the terms, where their relationship is reversed. The switch in terminology was the result of a major instrument revolution in the 1680s and 90s, when the newly invented French woodwinds were adopted all over Europe (see 3-3b).

2-3b A+1 Prior to 1670: Praetorius's "*CammerThon*"

Praetorius used other names for *CammerThon*, like *rechte Thon* (standard pitch) and *Cornettenthon* (cornet pitch). Despite the latter name,

which makes its pitch obvious, there has been recent debate about the level of *CammerThon*.

The source of confusion is the apparent discrepancy between the four different indications Praetorius provided for the value of *CammerThon*. The first of these is the synonym "*Cornettenthon*." The second is his "*Pfeifflin zur Chor-maß*," a scale diagram of a set of organ pipes provided in his book to indicate the absolute frequency of *CammerThon*. The third is the pitch of surviving original instruments that Praetorius said were pitched at *CammerThon*. And the fourth are the scale drawings of the same kinds of instruments, included in his book.

The first is straightforward, as we have seen: *CammerThon* and "*rechte Cornettenthon*" were identical.[108] As we have seen, the majority of cornetts, both Italian and German, were tuned at A+1.[109] *Cornettenthon* can be regarded as a constant, since cornetts had a single principal pitch center that did not change from the 16th to the 17th centuries, or even from the 17th to the 18th. They were thus an ideal reference for pitch frequency, and were commonly used that way in Italy, Germany, and Austria. In 1608 a project was undertaken to make the pitches of the organs in two churches in Nuremberg the same, for instance, and the reference was the pitch of "Cornet und Dulcian."[110] When Gottfried Silbermann's Jacobikirche organ at Freyberg was finished in 1717, one of the ways it was tested was described as follows: "to check if the organ was in normal *Cornet-ton* or *Chorton*, some of the municipal musicians played trumpets and cornetts with the organ as accompaniment, and found that they were well in tune together . . ."[111] The pitches of 12 German organs originally identified as in *Cornet-ton* survive, and are quite consistent at an average of 462 (see 1-8). *Cornet-ton* at A+1 emerges, in fact, as one of the two most reliable German pitch standards. Janowka wrote in 1701:43 "As a matter of fact, [recorders] match the German or Bohemian organs, tuned to the *Zinck* or cornetts at this pitch."[112]

As to the second of Praetorius's indications of the level of *CammerThon*, a number of reconstructions of the *Pfeifflin* diagram have produced results varying between about A-424 and 433; these are all a good semitone and a half below A+1.[113] The evidence appears therefore to be in conflict. Praetorius had described *CammerThon* as the pitch "to which nearly all of our organs are now tuned." If the reconstructions of the *Pfeifflin* diagram are valid, at least a few extant organs should therefore be in the area of 424 to 433. In fact, Graph 4c shows no organs near this pitch; there is a gap between 415 and 442, and the majority of organs are clearly at A+1.

Two recent articles have suggested explanations for this disparity. After examining the accuracy of the evidence based on the paper in original copies of the book, Karp (1989:156ff) concludes that Praetorius's performance pitch could have been in a range "anywhere between A-410 and about A-450 . . . The uncertainty of the paper dimensions would provide further room for arguing the pitch higher or lower, as one might prefer." More recently, John Koster has pointed out other factors that suggest that the diagram represents A+1.[114] Making his own reconstruction of the Pfeifflin pipe, Koster arrived at an A between and 454 and 468, depending on various factors. Previous trials using Praetorius's pipe measurements used lower wind pressure and smaller mouth dimensions, based on earlier 19th- and 20th-century assumptions (now disproved) about the nature of early organs. Koster's article plausibly resolves the conflict in the evidence.[115]

The third and fourth of Praetorius's pitch indications are in agreement with the first, and their evidence is consistent and abundant. Much of it is reviewed in Haynes 1995:157ff, and some of it will be noted here.

Graphs 1 and 4c show the pitches of surviving flutes, cornetts, and German organs of the period. Both curved cornetts and organs cluster at A+1. Renaissance flutes and mute cornetts are lower, and some of them do show a level in the low 430s, the pitch suggested by earlier reconstructions of the *Pfeifflin* diagram. But these instruments were apparently used for a different function and not normally expected to be at the usual high instrumental pitch. Weber (1975:8) wrote that "Transverse flutes and mute cornetts are . . . those wind instruments which appear together with strings in the so-called '*Stille*' or 'Broken' Consort," and (as noted previously) these instruments often appeared together.[116]

One surviving organ built by Esaias Compenius in 1616 is particularly relevant because Praetorius himself acted as the consultant in its building and was its first organist.[117] The instrument is unusual in being all of wood, which permits less leeway in voicing. It was originally built for Castle Hessen in Braunschweig, and survives in a more

or less unchanged state now at Frederiksborg Castle in Denmark. Its pitch is 470.[118]

A complete set of instruments, described in three separate inventories from the years 1658, *ca.*1720 and 1728, survives at the Musikinstrumentenmuseum in Berlin. These instruments were used at the St. Wenzel Stadtkirche in Naumburg. Krickeberg (1978:15) established that they probably originated in Leipzig, were collected from 1625 to 1630 onward, and were brought to Naumburg by the new Kantor in 1658. The present pitch of several of them (recorders and mute cornet) is 465.[119] This seems a good indication that as early as 1625 instrumental pitch at Leipzig was A+1.[120]

Herbert W. Myers recently did a thorough analysis of the dimensions of all of Praetorius's winds as depicted in the *Theatrum instrumentorum* (the pictorial supplement to the second volume of the *Syntagma musicum*, containing scale illustrations of instruments).[121] He reported that the dimensions of the alto and tenor sackbuts, the mute cornett (in G at A+1), the cornettino, the tenor cornett, most of the recorders (c2 sopranos, altos, and tenors), and the shawms indicated a pitch of A+1. This was a more careful backup study of conclusions he had already published in 1984, in which he wrote, "With very few exceptions (in particular, the transverse flutes) the lengths of the wind instruments depicted are very close to those of surviving examples that play at about a'=460 . . ."[122]

In addition, the combination cornett-sackbut is a time-honored one in both texts and music;[123] the two instruments must usually have been pitched identically. Praetorius used the sackbut as another check on the *Pfeifflin* diagram, writing "I also am personally of the opinion that no better instrument exists for representing *rechte Thon* [= *CammerThon*] than a sackbut, especially those made formerly and still presently at Nuremberg. If the slide is pulled out two finger's width from the end, it will produce A *lamire* in *rechte Chormasse* absolutely correctly and in tune." The reason Praetorius specified that the slide was not pushed in completely may have had to do with the original sackbut hand position;[124] it was also probably necessary to avoid sudden jolts to the embouchure. In this position, the sackbut gives its normal pitch for A. Myers (1984:370) writes

> Several [sackbuts such as those Praetorius indicates] are extant and playable, and they confirm a consistency of pitch on the part of Nuremberg makers of Praetorius's era. Completely closed, the majority produce a pitch slightly above modern *b* flat;[125] pulling out the slide the recommended distance (say, 45mm) thus gives a pitch slightly below that, equivalent to *a* at about a'=460.[126]

Myers also found that the sackbut dimensions in Mersenne were "very close to Praetorius's tenor (and to the length of most surviving Nuremberg examples)."[127]

The end result of the recent discussions about the level of Praetorius's reference pitch has been a clearer understanding and more certainty (at least among most of the people who have examined the question) that this pitch was A+1. Praetorius called this *Cammer-Thon/Cornettenthon*. As might be expected from a region that imported many of its instruments from Italy, *CammerThon* was equivalent to the analogous Italian pitch, *mezzo punto*.

Thus German music, especially instrumental music, written from Praetorius's time until the adoption of Lully's new instruments (roughly the first 80 years of the 17th century) was performed against a background of this reference pitch, A+1. There is no indication that instrumental pitch changed in Germany before the arrival of French instruments, nor would there have been any motivation for a change during those troubled times (which included the Thirty Years War). *CammerThon* was no doubt used by Rosenmüller in the 1640s and 50s, and by Biber for his violin music. Schein's collection of instrumental suites, the *Banchetto musicale*, published in 1617 (a year before Praetorius's book appeared) was probably conceived at *CammerThon*/A+1, as were his sacred concertos with continuo called *Opella nova* (1618 and 1626). Scheidt's *Tabulatura nova* for organ (1624) were likewise probably at this pitch. Scheidt worked with Praetorius at Halle in the 1610s, and was a friend of Compenius's.

Heinrich Schütz would also have used *CammerThon* at A+1 at Dresden from 1629.[128] There is indirect proof of this: the Fritzsche organ at the Schloßkirche, built in 1614, was lowered in 1737 a whole-step to "Cammer Ton" (by that time, A-1), so it must originally have been at A+1;[129] this is the organ shown in Conrad's well-known engraving (1676) of Schütz in the royal chapel (see Illustration 1, page 83).

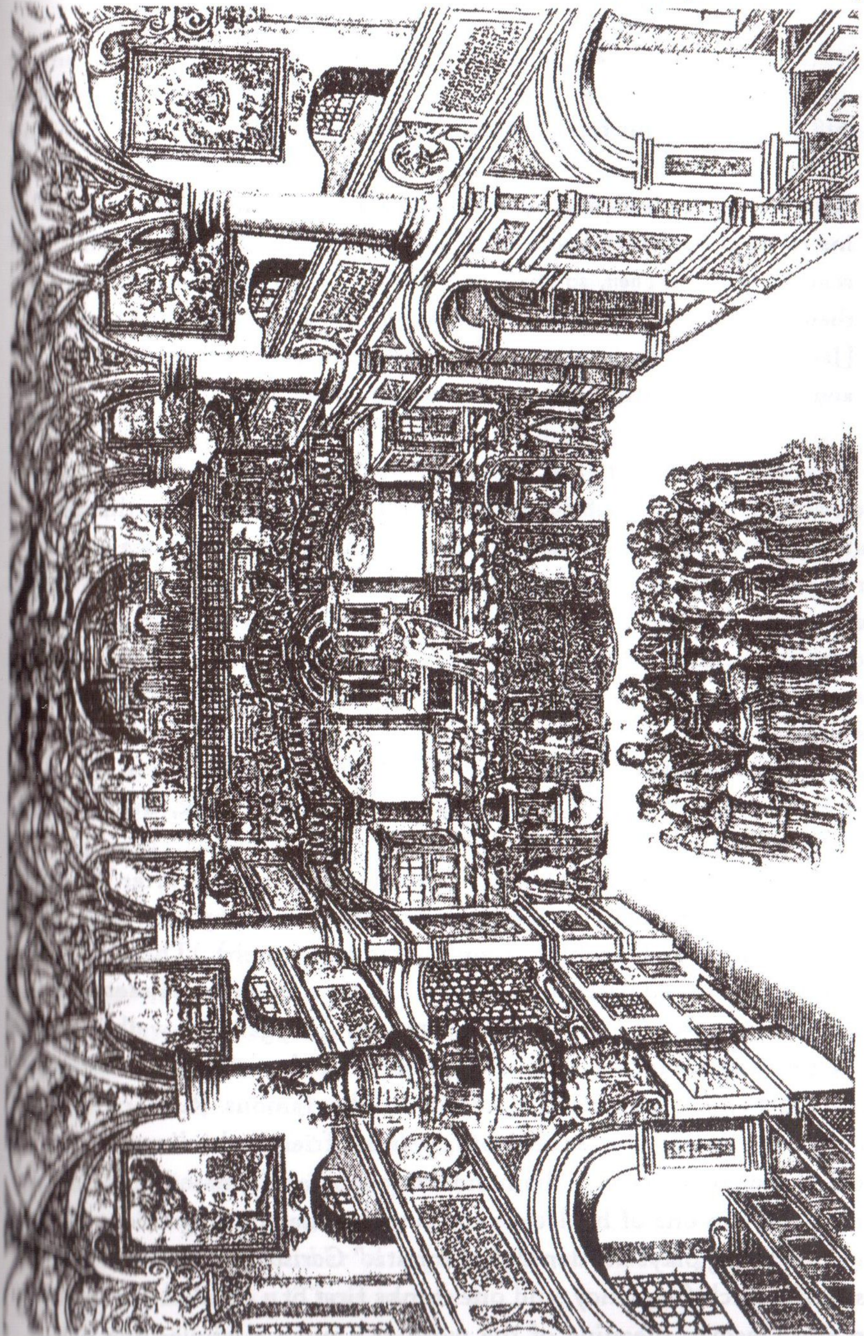

Illustration 1. Conrad, David. Frontispiece to *Geistreiche Gesangbuch*, a collection of music edited by Christoph Bernhard, Dresden, 1676.

2-4 The Low Countries

In 1618 (16), Praetorius reported that

> Formerly in England, and up to now in the Netherlands, most wind instruments have been made to sound a minor 3d lower than our present-day *CammerThon*, so that their *F* is in *CammerThon* our *D*, and their *G* our *E* . . . This is true of the excellent maker Johannes Bossus [Jan Bos] of Antwerp, who uses this pitch in most of his harpsichords and virginals, as well as the organs built into them.[130]

If Praetorius's *CammerThon* was A+1, these instruments would have been at A-2. Koster (1998:89) cites several clavecimbels from this generation, including one by Bos himself, that have an appropriate scaling for A-2. Van Biezen (1990:239) comments that organs made in the Netherlands in the 16th and early 17th centuries were often low, although closer to A-1 than A-2. Since Praetorius speaks of Antwerp, it may be that he was thinking of the pitch of the influential school of Flemish organ makers that included the Langheduls and Carlier, who built many important instruments in both Spain and France in the 16th and early 17th centuries. Of what survives of their work, the indications are that they normally worked at A-2.[131]

Pitch terminology in the Low Countries just 30 years after the appearance of Praetorius's book included words that are by now familiar: "corista" and "den reghten toon" (standard pitch). The Flemish *reghten toon* was apparently about a whole-step below Praetorius's *rechte Thon*, however. In 1648 Constantijn Huygens, a well-known Dutch musician and man of letters, ordered a clavecimbel from Joannes Couchet of Antwerp (successor to the famous Ruckers workshop).[132] Huygens was assisted by a mutual friend who lived in Antwerp, Gaspard Duarte, a diamond merchant and amateur musician. Duarte says in one of his letters to Huygens that an instrument "acht voet" (8') long plays at "den thoon corista." *Corista* was evidently thus a specific pitch frequency, and one thinks first of a parallel to the Italian and German meaning of the word as a pitch a whole-tone below instrumental pitch, i.e., A-1.[133]

Koster (1998:88-90) argues that the thicker strings used by the Ruckers led them to shorten their scalings while maintaining the pitch of the Antwerp makers of the generation before. This was the pitch described by Praetorius, apparently A-2. For lack of evidence, we are unable to consult other kinds of instruments,[134] so this question must remain open.

Duarte mentioned smaller instruments that played "gemeynelick eenen thoon hooger" ("generally one tone higher"). Huygens had proposed a clavecimbel two tones lower than "Mevrouwe Swan's;"[135] Duarte advised Huygens,

> That could be bad and quite out of style, and unsuitable for playing with voices; [I would rather advise] the natural pitch of this country, which is called *corista*, exactly one tone lower than that of Madam Swan, [a pitch that] serves well for normal voice [ranges]. The pitch of the said Madam [i.e., a tone higher than *corista*] is suitable for extraordinarily good voices that sing high, and for playing *allemanden* and *courranten* [i.e., solo music]. At this same [higher] pitch I have four or five [instruments?], unlike my clavecimbel and organ (which are at *rechten thoon*), the one I would recommend to Your Honor.[136]

It is surprising that Madam Swan's instrument is taken as a reference pitch, as if a harpsichord remained at a constant level;[137] perhaps it too was regularly tuned from a "*fluijtien*" (pitchpipe) like the one Couchet provided to Huygens (see 1-4a). In a letter dated 19 July of the same year, Duarte indicated that the clavecimbel was to be made "in unisono van den leegsten ordinarisen thoon chorista" ("in unison with the lowest normal pitch, or *corista*"), presumably the one he had earlier recommended. Couchet himself called the pitch of this instrument "den reghten toon" (standard pitch). As to whether this would have been A-1, A-1½, or A-2, we saw in 1-7 that, in about 1682, Huygens' son Christiaan developed a method of measuring pitch, and reported that his harpsichord (which may have been this same Couchet that his father had bought in 1648) was at A-409, or A-1½.[138]

In the North, a number of organs built in the early 17th century were apparently at A-1. These included:

Haarlem, St. Bavo, small organ (J. van Covelens, *a*1629)
Wijk bij Duurstede, St.-Jan Baptist (A. Kiespenning, *ca.*1615?)
Leiden, St. Pieter (Jacobs, 1628, recently restored)

Rotterdam, St. Laurents (H. Goldfuss, 1641)
Maastricht, O.L. Vrouwekerk (1652).[139]

In Groningen, Schnitger's contract made up in 1692 for the rebuilding of the organ in the Martinikerk stated that the organ at that time was "1½ toon te hooch" ("1½ steps too high") in relation to the pitch he eventually gave it (A+1).[140] The organ had existed from 1479. Other organs from this period were at A+1, including most of the important organs in Amsterdam.[141]

Bouterse (1995:81-85, 2001:195) reported the pitches of five small one-piece recorders of Dutch provenance from the 16th and 17th centuries. The fact that all of them are close to A+0 suggests that in the Low Countries at least, this pitch level may have been quite ancient. It is difficult to know how far to generalize from these "hand-fluytjes" to other kinds of music-making on other instruments, however. The one-piece keyless traverso left on the island of Nova-Zembla by a Dutch expedition in 1596 and rediscovered in 1871 is also at A+0.[142] A+0 continues to be seen on a few Dutch woodwinds and organs in Holland through the 18th century (Graphs 16 and 24).

2-5 England

Much of the pitch evidence from the 16th and 17th centuries that might have come from English organs was erased by two widespread annihilations of existing instruments. The first of these disasters was the result of Henry VIII's break with Rome and the so-called "English Reformation:"

> For the period between 1526 and 1600 no [organ] contracts have yet come to light; by the fourth quarter of the century it is clear that organs had been removed or destroyed across large parts of the country.[143]

Many organs were taken from churches after 1547, and others ceased to be used. "No new organs are known to have been built in London churches during Elizabeth's reign (1558-1603)."[144]

After a brief but impressive flowering of organ building in the 1630s, the Civil War of 1642 to 1649 and the subsequent Commonwealth systematically abolished musical activities in churches and at court. Hopkins & Rimbault (1855:190) wrote, "In 1644 church organs were ordered to be demolished by Act of Parliament, and so implicitly was the nonsensical decree obeyed that very few organs escaped the general destruction." By the time of the order of parliament, in fact, few church organs remained. Even later, after the Restoration in 1660 and the Great Fire of 1666, organs "were rarely purchased out of parish expenses, as they were not considered necessary for worship."[145]

All that remains of the pitches of organs made before 1660 are a few pipes from Thomas Dallam's instrument for King's College Chapel, Cambridge, 1606; the largest sounds about G2 at 433-440, making A = 487-494.[146] Another Dallam organ at Christ Church, Oxford, was probably at 484 (see 3-4). There are also early pipes at about 473 from a Robert Dallam instrument originally built *ca.*1632 for Magdalen College, Oxford.[147]

By the mid-19th century, organ experts had already surmised that organs had been pitched higher in the past. Hopkins & Rimbault (1855:189) wrote,

> If we read the notation of the old services *a tone higher*, the average compass of the treble parts will then be made to the extent from middle b or c¹ up to e² or f²; and the bass parts, as a rule, not lower than Gamut G or FF; precisely the ranges which are known to be the best for the corresponding voices in church music.

Ellis (1880:35) measured the fork used by Hopkins & Rimbault as their reference "Philharmonic" pitch; it was 433.2. Thus "*a tone higher*" would have been about 484. E.H. Fellowes (1921:71ff) estimated, mainly on the basis of voice ranges, that sacred vocal music in England in the early 17th century was "more than a tone higher than modern pitch" ("modern pitch" equaling 435).

None of these figures is very specific, but they are probably indicating a level known as *Quire-pitch*.

2-5a Church Music and the *Quire-pitch* Grid

English church organs from the Tudor period through the late 17th century were normally built from a bottom pipe of five- or ten-foot length, which the organist called a C. Based on this length, with a diameter given by Nathaniel Tomkins in 1665 (7½ inches, see quotation below), such a pipe has been calculated to play at about 50.1 Hz,[148] or midway between modern G and Ab. On this basis, a1 would have been at about 508 Hz. For some time, it was widely accepted that that was the pitch implied by a 10-foot pipe. But Goetze (1994:61) reports recent measurements of unaltered early English organ pipes generally called "10-foot," and finds that in reality they are consistently somewhat longer and yield a lower pitch than A-508. They are, in fact, at what works out to be about A-473, sharp to A+1 by about 32c.[149] A pitch at somewhere between A+1 and A+2 is therefore the most likely frequency for the 10-foot organs of this period.

To match this pitch to the ranges of choirs, organists evidently found it necessary to use a transposing scheme that involved shifting the names of the keys on the keyboard. The note that was normally *C* was transformed into an *F*. Thus when playing alone, an organist considered his bottom note a *C*, but when he accompanied a choir, he customarily changed it to an *F*, thereby effectively performing a transposition. The untransposed system (where the key *C* was called *C*) is now sometimes called "*Organ-pitch.*" The other system, where the key *C* became *F*, was called "*Quire-pitch.*" As it was expressed at the time, an organ was in "Gamut in Dsolre," which meant that when the organ key *D* (Dsolre) was played, it would produce *G* (Gamut) in *Quire-pitch.*[150] Because the keys were nominally a 4th lower than *Quire-pitch*, *Organ-pitch* sounded a 4th higher than *Quire-pitch* (or a 5th lower).

Thus in discussing the organ at Worcester Cathedral, Nathaniel Tomkins in 1665 equated the pitch of a 10-foot pipe (activated from the "key" on the keyboard that we would call C) with two different notes in different nominal pitches:

> The great Organ wch was built at Worcr consisted of 2 open diapasons of pure and massy metall double F fa ut of the quire pitch & according to Guido Aretines scale (or as some term it double C fa ut according to ye keys & musiks) an open pipe of ten foot long ye diameter 7 inches & an half. (at St. Pauls Lond. ye diameter was 8 inches).

The difference between these "pitches," *Quire-pitch* and *Organ-pitch* ("according to ye keys & musiks"[151]), was not one of frequency (since they were produced by one and the same pipe) but of nominal pitch, since the key on the organ keyboard had two different names.[152]

It is logical that this kind of organ is now known as the "transposing organ." It was apparently common in the 16th and early 17th centuries, and may be a remnant of a tradition that was widespread in Europe; 16th-century organs on the continent were sometimes in C/F (cf. Schlick). The ramifications of the system are explained in detail in Clark (1974:25-37).

If *Quire-pitch* was A≈473, *Organ-pitch* a fifth lower[153] (or fourth higher) would have been A≈317/634. The approximate frequencies of note names in these two pitches would be:

Quire-pitch	Hz	*Organ-pitch*
A	473	D
G#	448	C#
G	423	C
F#	400	B
F	377	A#

The four highest of these frequencies are remarkable. Instrument for instrument, they reflect almost exactly the pattern of pitches of surviving English church organs from as far back as there are records up until the 19th century (Graph 22). The same is true of chamber organs (Graph 23).

As we will see below, the most common 17th- and 18th-century frequency for A was ±423, a M2 below *Quire-pitch* and a fourth above *Organ-pitch*. The two semitones immediately above 423 were also common: A≈448 and A≈473. Such a consistent relation is unlikely to have been a matter of chance.

Although original organs are pitched at what appear to be integral intervals to both *Quire-pitch* and *Organ-pitch*, the relation to *Quire-pitch* is more practical for transposition (a semitone, M2 and m3) than that of *Organ-pitch* (an augmented fourth, perfect fourth and major third).

It would seem, then, that *Quire-pitch* was the reference point, and survived (sometimes in transposed forms) on organs right through to the 19th century.[154] The consistency of these levels is a retrospective confirmation of the original frequency of *Quire-pitch.*

It is possible, then, to construct a transposition grid based on *Quire-pitch*, and identify its pitches as follows:

Pitch symbol	Approximate value	Interval from *Quire-pitch*
Q-0	473	(*Quire-pitch*)
Q-1	448	Semitone below
Q-2	423	M2 below
Q-3	400	m3 below (= A-1½)

Q-1 is a semitone below *Quire-pitch*, Q-2 is two semitones below, etc. In what follows, I will use these symbols to indicate approximate pitch frequencies.[155] It will be noticed that they fall between the normal grid encountered on the Continent (A+1, A-2, etc.). This suggests an independent English pitch system. There are other indications of this difference that will be discussed below: Robert Dallam's "quarter of a note" for the organ at New College, Oxford; Praetorius's (1618:15) English wind instruments "umb etwas, doch ein gar geringes, niedriger" ("somewhat, but only a little, lower"); Rousselet's hautboys and bassoons for the Queen's Theatre "environ d'un Car de Ton plus haut."[156] The inventory from Kremsmünster Abbey of 1739 also mentions "1 Paar [Flautten] englischen Tons"[157] (one pair [of recorders] at English pitch), as if their pitch was unusual.

An apparent confirmation of these levels is an analysis by Darryl Martin of the pitches of 17th-century English virginals. As mentioned in 1-4a, Martin has found that virginals built between 1638 and 1684 fall into four pitch groups at his reference pitch (*pitch V*), V-1s, V-2s, and V-3s (i.e., in descending semitones). Most instruments are at *pitch* V. Martin believes that if these virginals were strung in iron, and based on the string lengths of other keyboard instruments outside of England, *pitch* V would have been between 459 to 497 Hz. The center of these numbers is 478.[158] This may well be an indication that *Quire-pitch*, centered on 473, was already established by the 1630s, along with its derivatives Q-1, Q-2, and Q-3.

Quire-pitch can be observed on organs from 1660 to 1730, but disappears after that (see Graph 22); Q-1 persisted until at least the mid-18th century but is absent after 1770. Q-2 was regularly used by Renatus Harris and was to become the dominant organ pitch in England in the 18th century and into the 19th, identified at least once as *Chappell-pitch* (see 3-2b3); when it was later adopted by orchestral instruments it was called "*new Consort-pitch*."[159]

Among the memoranda of Dr. Woodward, Warden of New College, Oxford, under the date "March 10th, 1661," occurs the following:[160]

> Some discourse was then had with one Mr. Dalham, an organ maker [presumably Robert Dallam], concerning a new fair organ to be made for our college chapel. The stops of the intended organ were shown unto myself and the thirteen seniors, set down in a paper and named by the organist of Christ Church, who would have had them *half a note lower* than Christ Church organ, but Mr. Dalham supposed that a quarter of a note would be sufficient.

As it happens, the original pitch of the new organ (made by Robert Dallam in 1665) can be calculated from surviving pipes at the College: it is A=470, which is of course *Quire-pitch.*[161] With this information we can deduce that the older Christ Church organ (presumably a ¼-step above Dallam's organ) would have been at about 484.

This compares interestingly with the "trebill cornets for the quire," two exceptionally fine instruments still preserved in the Christ Church Library, which are pitched "a little higher than [A-440]."[162] This may thus have been Q-1 (448). The cornetts were "bought for the choir of Christ Church Cathedral in preparation for the visit of James I and his Queen to the House on 27 August 1605. The King and Queen heard *excellent voices mixt with instruments* at a service in the Cathedral."[163] The cornetts have silver mounts that fit over their upper ends, and lower the pitch to somewhat below 440.[164] These mounts may have lowered the cornetts to a whole-step below the organ, thus allowing the instruments to play together through transposition.

Dr. Woodward's memorandum gives evidence that organs could be only a ¼-step apart; since transpositions must necessarily be based on integral semitones, these two instruments could not have been part of the same transposition system. Christ Church's organ had been built by Dallam's father. By building at *Quire-pitch*, Dallam must have been doing so purposefully, as it was necessary to overrule the suggestion of the organist of Christ Church, who wanted it lower. Dallam was thus deliberately choosing the *Quire-pitch* system, which he used (as far as we know) for all his other English organs.[165] He had built organs in Brittany, however, in another grid (cf. Ergué-Gabéric at 389).[166]

2-5a1 *Religious Vocal Music in the 16th Century*

Lacking the evidence of organs, determining the pitch standards of religious vocal music in England before the 17th century can be only speculative. Wulstan (1966) combined the notion of *Quire-pitch*[167] with "clef codes" (in which clef choice was used to indicate specific transpositions), and extrapolated backwards from the *Quire-pitch* evidence of the early 17th century. While reasonable, the question is how far back the principle can be applied. It is now generally believed on the basis of a number of surviving fragments of organs as well as contracts (e.g., Duddyngton) that the 10-foot pipe represented the normal church organ pitch at the time.[168] Other bits of evidence presented in Caldwell 1970 and Bray 1980 (the ones not based on vocal ranges and voice types) indicate that the system of transposing from *Organ-pitch* to *Quire-pitch* was in use by 1519, and perhaps earlier.[169]

Bowers's competing argument, which implies that Tudor music was at 440, is less convincing because it is based exclusively on vocal ranges.[170] Ravens' suggestion that "the average human voice would have had a higher natural pitch in the 16th century than today" was mentioned in 1-5c, and underlines the problems of using vocal ranges and voice types to determine historical pitch levels.

2-5b Instruments Other Than the Organ before 1642

2-5b1 *The Court and Church Music*

Henry VIII maintained several "consorts" of foreign musicians. Of the two groups of shawms and sackbuts at court, the first he inherited

from his father and the second was imported from Italy in the 1520s. The two groups were kept distinct, possibly because the Italians played at a different pitch level than the older group.[171] At the end of the 1530s, Henry also engaged a recorder consort from Venice consisting of five brothers of the famous Bassano family. He also imported a consort of six French musicians associated with his private chamber, who in 1543 were described as "the flutes." By 1561, this group probably included cornetts (the instrument was to have an important place in the ensemble).[172]

Originally these court groups played in closed consorts. There is no record of the use of instruments in church services at court until the 1590s.[173] Agreement with organ pitch was therefore not necessary until then.

The foreign consorts either came from Venice or very likely got their instruments from there. The Bassanos arrived in London from Venice "with all their instruments."[174] Since wind instruments are not easily altered in pitch, it is probable that the pitch or pitches these consorts used (at least at first) were standard in Venice. As mentioned in 2-2a, there is documentation of members of the Venetian side of the Bassano family using "*mezo ponto*" and "*tuto ponto*," pitches with levels we determined to be A+1 and A+0. *Strumenti coristi* also existed at *tuono corista* (A-1 or 1½), used both with voices and in small broken consorts. The "instrument chest" mentioned in 2-1 was made by the London Bassanos and described in *ca.*1571 as including 45 winds all tuned to "den gemeinen Tonum der Orgel" ("the standard organ pitch"). There are records of other instruments the Bassanos made for musicians on the Continent, presumably at the appropriate pitches.[175] The large recorders Mersenne depicts (1636:III:239) "sent from England" may have been made by Anthony II Bassano;[176] they form only part of a set, the others presumably made in France or Italy; all were probably at the same pitch. Thus the Bassanos almost certainly continued to make and play instruments at Continental pitch levels (of which the most common was A+1) when they moved to England.

But there are indications that, early on, they were also able to accommodate the English system. In the larger cathedral and collegiate choirs, wind instruments regularly played with choirs from as early as 1525.[177] References to the use of wind instruments in church become frequent from about 1600. The cornett is often mentioned in these performances, and while we would normally expect the formances, and while we would normally expect the Continental cornett pitch at A+1 to apply, it is likely that the English instruments were pitched a little lower, for several reasons. The first is of course the *Quire-pitch* system, suggesting that organs in English cathedrals would have been at pitches a little above or below Continental cornett pitch: either *Quire-pitch* (473) or Q-1 (448). Praetorius (1618:15) tells us which:

> *ChorThon* among our ancestors was about a tone lower than it is today. (The examination of early organs and different wind instruments confirms this.) Over the years it was raised to its present level in Italy and England, as well as in the princely chapels of Germany. The English pitch, however, is a very little lower, as the instruments made in that country show, for instance cornetts and shawms (or 'hoboys', as they call them there).[178]

As Myers (1983:3) observes, "'a very little bit lower' must be taken to mean lower by rather less than a semitone, since the rest of his discussion relates pitches by semitones and larger intervals."

It was also true that the Bassanos were fine makers and could easily have adapted their instrument designs to the English pitch grid. It has been suggested that the "rabbit's feet" or "silkworm moth" mark (!! in various multiples) found on many renaissance woodwinds was the Bassano's workshop mark.[179] While this cannot be proven, it appears probable.[180] In her careful study of the general !! mark, Maggie Lyndon-Jones has distinguished nearly 20 forms, with the implication that they represent individual makers. Since the Bassanos worked in both Venice and London, if the mark was theirs, the pitches of surviving instruments under each mark type could indicate a relationship between makers and locations. Some of these mark types (Lyndon-Jones's Type C and Type K) include cornetts at both *mezzo punto* (A+1) and *Quire-pitch*, suggesting they were made by individuals working in both Continental and English systems (see Graph 11). Type B, on the other hand, shows curved and mute cornetts at only *mezzo punto* and *tutto punto*, despite the clear association of some Type B cornetts with England.[181] Types A and G recorders at Verona are at 450 and 452,[182] thus most likely Q-1 and suggesting English provenance.

From this, then, it would seem that *Quire-pitch* or one of its derivatives (most likely Q-1) was an available level for wind instruments as far back as the 1520s when wind instruments began to be played with choirs. The instruments that frequently played together were cornetts, sackbuts, shawms, and recorders. There is no reason to think that this wind-instrument pitch was abandoned in the course of the 16^{th} century and up through the time of the Civil War in 1642 (or even at the Restoration in 1660). Talbot gave measurements for the cornetts of "Mr. Shore" in the 1690s that would theoretically produce pitches[183] of A≈451 and A≈467 (which are Q-1 and A+1).

Q-1 may also have been the level of secular vocal music in England in the early 17^{th} century. Based mainly on voice ranges, both Fellowes (1921:71ff) and Wulstan (1966:105) suggested that secular vocal music would have been performed at about A+0. This falls between two levels of the *Quire-pitch* grid, Q-1 and Q-2, and being only a quarter step from either one, could as well line up with either (cf. also the pitches of the earliest chamber organs that survive in Graph 23a). Without further evidence, this is only speculation.

2-5b2 Consort-Pitch

Praetorius's wistful discussion of A-2 (1618:16, quoted in 2-4 above) ascribed it to the Netherlands, some Catholic chapels in Germany, and Italy (meaning, presumably, Rome). He also said it was used for wind instruments in England "formerly," which would probably have meant in the 16^{th} century. "Formerly in England . . . most wind instruments have been made to sound a minor 3d lower than our present-day "*CammerThon*," so that their *F* is in *CammerThon* our *D*, and their *G* our *E* . . ."[184] It is surprising that he said it was used on "most wind instruments," since no other evidence from that period has so far turned up to indicate such a pitch, either A-2 (392) or Q-3 (400).

Q-3 was probably the pitch Thomas Mace identified as "*Consort-pitch*" in 1676 (pages 207, 216-7), and it may have had a long and venerable history, especially in secular music. Mace's clearly conservative bent and dislike of the new French ideas that were becoming popular in the late 17^{th} century suggest he was referring to an English standard long established. We may be justified in extending *Consort-pitch* backwards into the 16th century through the history of the paramount English consort instrument, the viola da gamba. Peter Holman writes (1993:265):

> It used to be thought that the destruction of England's main musical institutions, the royal music, the cathedral choirs, and the collegiate foundations, together with the disruption of the [Civil War] and the establishment of Parliamentary government, produced conditions that were wholly detrimental to its musical life. But Percy Scholes pointed out in the 1930s that the Puritans were not against music as such, only against elaborate church music, and the public exhibition of plays and dancing. Some types of music, notably those that could be cultivated at home, actually flourished.

Viol playing, then, may well have continued through the 17th century virtually without disturbance.[185] In that case, presumably, so would have its pitch. Pitch has a natural tendency to stay where it is unless it has a reason to alter; it is in everyone's interest that it remain stable. As Segerman observed (1985b:60), a prime factor in establishing a string pitch standard is top-string breaking point,[186] and since that depends on the size of the instrument, and viols did not change in design from the 16th to the 17th centuries, the standard probably remained approximately the same. Evidence of the level of *Consort-pitch* in the later 17th century, in other words, would probably be indicative of what had been practiced before.

That *Consort-pitch* probably had an interface with the *Quire-pitch* grid is likely. Current information on viol strings at the time (which should be taken as approximate, since our knowledge of the subject is still relatively limited) suggest that Mace's viol pitch was about 382-392.[187] By that indication, *Consort-pitch* could have been Q-3 at 400 or Q-4 (if it existed) at about 377. Q-3 is clearly the more likely, since its vigor in the late 17th century (see 3-4) and its persistence into the 18th suggests it had an established history extending back earlier.[188]

2-6 France

2-6a *Ton de Chapelle* at A-2

Since pitch evidence for this period in France is not plentiful, the question to ask is if there are any indications that the situation was different from the rest of the continent. For wind instruments, the short answer is "no;" the woodwinds shown in Mersenne's books published in 1635-37 are similar in dimensions to those in Praetorius a half-generation earlier. All of them were at A+1, the normal pitch of Venetian woodwinds used all over Europe at the time.

But the normal organ pitch in France and Flanders was indeed unusual; in the mid-16th century it was considerably lower than in Italy and Germany. This difference was to become an issue of importance by the late 17th century, because by then it had been transmitted to other instruments, the designs of which France began exporting to the rest of Europe.

The classical French organ seems to have appeared in about the middle of the 16th century, in the general area of the Low Countries, Normandy, and the Ile de France;[189] by that time, the concept of "ton du choeur" was already in existence.[190] As mentioned in 2-2b, Salomon de Caus recorded the dimensions of an organ pipe in 1615 that (using the *pied de roi*) would have produced A-2. A number of original organ pitches are known from the 17th century, all in the region of A-2:

395	Paris, St. Gervais, 1601
395	Soissons, Cathedral, 1621
392	Meaux, Cathedral, 1627
396	Rodez, Cathedral, 1629
388	Lanvellec (Bretagne), 1647
395	L'Isle-sur-la-Sorgue, 1648
395	Orléans, Cathedral, 1657
395	Bourges, Cathedral, 1663
385	Lille, St. Sauveur

This was the principal pitch associated with organs in France right into the 19th century (see Graph 19). It was presumably the one Mersenne in the 1630s called "*Ton de Chapelle*."[191]

There may have been other organ standards, as implied by a minute dated 17 August 1612 from the organ builder Pierre Marchant. He requested the Chapter of the Cathedral at Aix to inform him "en quel ton ils désirent que le grand orgue soit mis" ("at which pitch they wish to have the large organ tuned") in order "that it be tuned at the most comfortable and appropriate pitch for the music of this church. The question was duly debated and after all arguments and opinions were heard by the gentlemen, it was resolved and commanded to the said Master Pierre that it be put in *Ton de Chapelle* . . ."[192]

A confirmation of the connection between A-2 and *Ton de Chapelle* is Mersenne's description of cornetts, instruments he said were used "together with voices in churches, cathedrals, and chapels" and "in vocal concerts and with the organ."[193] In his musical example he calls the cornett's lowest note a0, which was the lowest note of the instrument at its normal pitch, A+1. But in the text and in his range chart, Mersenne starts the instrument on c1 instead of a0. As Herbert W. Myers points out (*), a0 at A+1 (say, *mezzo punto*) is the same sounding pitch as c1 at A-2 (the level of French organs). Thus if Mersenne had been using A-2 as a standard, he might have considered the cornett as in c1.

2-6b *Ton d'Écurie*

While the cornett may have been used in church, and could be transposed in order to plug into the *Ton de Chapelle* grid, most of the instruments depicted in Mersenne's books were never heard in ecclesiastical settings. They were the woodwinds current at the French court, and had no need to be in a pitch relation to church organs. Many of them, particularly the "*haut*" instruments, were at a level similar to Italian *mezzo punto* and Praetorius's *CammerThon/Cornettenthon*, A+1.[194] Indeed, considering the connections between the French court and northern Italy at the time, the woodwinds described in Mersenne might have been made there. The story (perhaps apocryphal) of the famous shawm player from Siena named Filidori comes to mind, who in about 1620 had impressed Louis XIII with his playing.[195] In any case, Myers writes that "certainly Mersenne's dimensions for woodwinds of Renaissance type do not differ significantly from those of surviving examples from elsewhere."[196] Myers calculated that Mersenne's treble cornett was 56.8 cm long, for instance, which (compared to extant early cornetts) should yield A≈469 (A+1). The cornett is still present in French artistic representations of wind instruments in the late 1660s,[197] although the instrument was soon to disappear from most musical contexts. Mersenne gave the treble shawm an acoustic length[198] of 241.2 mm, and its total length was 2 pieds = 649.7 mm, not significantly different from the total length of the treble shawm Praetorius depicted (at 653 mm), as well as extant museum instruments.[199]

The court's wind players were part of the *Grande Écurie* (or Royal Equerry), and a group like the *Douze grands hautbois* probably performed at A+1. There is in fact a later mention of a standard called *Ton d'Écurie* that was probably A+1. It appears in an inventory drawn up on October 17, 1708, at the death of Jacques Danican Philidor (a court musician who joined the "*Chambre du roi*" in 1690). It lists a number of instruments, including "2 hautbois dont l'un vieux et l'autre d'un tond descurie"[200] ("two hautboys, one old and the other in *Ton d'Écurie*"). On the death of Philidor's wife Elisabeth Hanicque a few months later, a second inventory of the estate mentions instruments (presumably the same) as "2 hautbois, dont l'un vieux et l'autre de ton différent"[201] ("two hautboys, one old and the other in a different pitch"). Taken together, these statements imply that "tond descurie" (= "*Ton d'Écurie*") was different from the pitch of most of Philidor's instruments (which would presumably have been at lower pitches).

Wind-band instruments, often used for ceremonial and outdoor occasions, have a tradition of being in higher keys, which sound more exciting ("son timbre a plus d'éclat")[202] and carry further. Hautboys, like trumpets, were sometimes used on the battlefield and on parade. A pitch associated with the *Écurie* would for these reasons probably have been high.

It is possible, then, that *Ton d'Écurie* was the pitch standard at A+1 that existed in Mersenne's time and was associated with wind instruments. The well-known maker Jean-Jacques Rippert is survived by a number of recorders at this level. We have no means of making a direct link between A+1 and *Ton d'Écurie*, but by default it seems probable. That A+1 existed is certain, however (whatever its name), and it is probably the reason the woodwinds underwent radical changes in the mid-17th century that made them suitable for use in the Opéra (see 3-1).

In comparing the fife and the traverso, Mersenne (1636-37:243) implied a difference in pitch between wind ensembles and "*concerts*:" "mais l'on ne fait pas ordinairement toutes les parties de Musique avec les Fifres, comme avec les Flustes d'Allemande, que l'on met au ton de chapelle pour faire des concerts" ("but it is not usual to put fifes on all the parts of an ensemble, as is done for German flutes, which are made at *Ton de chapelle* so they can be played with other instruments"). It would be very interesting to know the circumstances and instrumentation of these *concerts* in which German flutes played.[203] In any case, fifes would probably have been pitched at *Ton d'Écurie* (the *Fifres et Tambours* was one of the official groups in the royal Écurie).

2-6c Lully's Pitch (*Ton d'Opéra*)

Lully's major opera productions, begun in 1672, were performed at a pitch that came to be called *Ton d'Opéra*. By the 1690s (when Lully was no longer alive), it was at A-2 (see 3-1a). It is unlikely to have changed; Lully's influence remained strong and his works continued to be regularly performed for nearly a century after his death. To have altered the pitch level of performances of his works would have disturbed the ranges of the vocal parts, and since it was the singers who had the upper hand at the Opéra,[204] pitch there showed no sign of change from the 1690s until at least 1750.[205] Indeed, *Ton d'Opéra* was so stable that it became the common reference pitch in France.

Although it is not enough evidence on which to base a conclusion, there is an indication of the respective pitch levels of the *Grande Bande* (the *Vingt-Quatre Violons*) and *Petite Bande* (the "*petits violons*") in the early 1660s.

Cavalli's opera *Ercole amante* was commissioned by Cardinal Mazarin to celebrate the marriage of Louis XIV and Maria Theresia of Spain, and Cavalli wrote it in Paris, probably in 1660 or 1661. Lully wrote instrumental ballets, or *entractes*[206] that were interspersed throughout the opera and danced by the king, queen, and other members of the court. It is curious that Lully's *entractes* were systematically

and consistently notated a m3 below each of the pieces they followed in Cavalli's opera (C-A, g-e, etc.). The logical explanation for this difference in key is that Lully's pieces were played by another ensemble, pitched a m3 above the opera orchestra. The only plausible combination of pitches would have been A-2 and A+1.

Ercole Amante was performed from February to May 1662. Lully at this point had the *petits violons* (an orchestra created for him), but had not yet consolidated his power at court and had not begun working with the *Vingt-Quatre Violons*, the established orchestra of the court. That would not happen until two years later in 1664.[207]

Thus it seems Lully performed these *entractes* (and the *Ballet des sept Planètes* that followed the opera) with the *petits violons*, while the opera itself was played by the *Vingt-Quatre*, probably conducted by Cavalli. There was certainly space enough for the two bands in the cavernous theater built by Vigarani in the Tuileries, and money was no object for this performance (Mazarin had spoken of "jetter l'argent par les fenêtres" to astound all of Europe with the wedding celebrations). Indeed, several later pieces included the two ensembles playing in conjunction (one on the stage, the other in the pit, for example).[208]

This could explain the difference in pitch: the *Vingt-Quatre Violons* would have been at A-2 for the sake of the singers; the fact that organs (used to accompany voices in church) were already at A-2 indicates that it was considered a singer's pitch. Georg Muffat's association of A-2 and "Teatralischen Sachen" (see 0-1c) may well have been referring back to the years 1663 to 1669, which he had spent in Paris studying music: "The pitch to which the French usually tune their instruments is a whole-tone lower than our German one (called *Cornet-ton*) and in operas, even one and a half-tones lower." Muffat's reference, *Cornet-ton*, was A+1.[209] Thus pitch "pour les *Operas*" would have been A-2.

The *petits violons* on the other hand, playing instrumental dances without voice, would still have tuned to the traditional *Ton d'Écurie* (A+1; see 2-6b). Later, when the two ensembles began to merge in 1664, the *petits violons* would have had some major refitting to do to come down to the low pitch; the string instruments (which might well have been Italian, where pitch was high) would probably have been replaced, and the pitch change affected the design of the winds so fundamentally that it may have precipitated the process of developing the new models that appears to have taken place between 1664 and about 1670.[210]

2-7 The Habsburg Lands

A dual pitch system was practiced in the Habsburg Lands as early as 1513. Mendel (1949:178) describes a contract made in that year for an additional small organ at the St. Jacob Pfarrkirche in Innsbruck with a G that was to be the same pitch as the large organ's F (in other words, it was an organ pitched a whole-tone below the large organ).

> The reason given is: "in order that when His Imperial Majesty's choir sings in the said church, they shall have in the two organs two different pitches [chormass] side by side . . ." i.e., in order that the organist may have two manuals at different pitches at his disposal, and avoid difficulties of transposing.

The use of pitches a whole-tone apart was of course parallel to the system outlined by Morsolino in 1582 for northern Italy, in which the organist transposed down a whole-step for the sake of the singers (to "*Tuono chorista*," called "*ChorThon*" in Prague) from a high instrumental pitch (called "*mezzo punto*" in Italy and "*Cornet-ton*" in the Habsburg Lands). Praetorius, as we have seen, would have liked to see the same relationship adopted in northern Germany. He cited Prague as an example (1618:15):

> Thus I find very appealing the distinction drawn between *ChorThon* and *CammerThon* employed at Prague and at a number of Catholic chapels elsewhere. Our normal modern pitch, to which nearly all of our organs are now tuned, is there called "*CammerThon*" . . . "*ChorThon*," however, which is a whole-tone lower, is used only in the churches, primarily for the sake of the singers, on whose shoulders rests the greatest responsibility in church . . . it allows their voices to hold out better, and saves them from becoming hoarse through operating at high pitch.[211]

Vienna also used this system, regarding *ChorThon* as a tone below *Cornet-ton* (i.e., the general instrumental pitch).[212] Poglietti's instructions for tuning the harpsichord, published in Vienna in 1676 (p.100) include the comment "Cornetton ist umb ein Ton höcher, als Chorton" ("*Cornetton* is a tone higher than *ChorThon*").[213]

The same terminology is found in other places in Austria. A contract dated 7 May 1621 for the organ in Brixen called for an organ in *ChorThon* with a movable keyboard that "auf Cornetthon zu rucken ist" ("can be shifted to *CornetThon*").[214] An inventory of instruments at Kremsmünster Abbey made in 1606 lists "2 Fleuttl die Cornetthöch" made that year by Hans Feichtinger of Gmunden.[215]

ChorThon was evidently a low pitch in at least some parts of southern Germany. An inventory from Stuttgart, 1589, listed curved cornetts at *CammerThon/Cornettenthon* and mute cornetts and flutes at *ChorThon* (presumably a whole-step lower).[216] "A.S.," the writer of the *Instrumentälischer Bettlermantl* (p1633), spoke of "gerechter" *Cornet-ton* as the pitch of most instruments, including the trumpet, while *Chorton*, evidently lower, was used for certain others like the clavichord "or similar instrument."[217] A clockwork organ survives, built by Langenbucher in Augsburg in about 1620; it is at A-418.[218]

Thus in the south (Austria, Bohemia, and southern Germany), the term *ChorThon* was used to mean a vocally-oriented *lower* pitch than instrumental pitch. It was also called "französisch Ton" and "Tono Gallico." As we will see in 3-6, this terminology was common until well into the 18th century, and was in direct opposition to the usage in northern Germany at the same time.

Notes

1. Cf. Jander, Harris, and Fallows 2001:430-31.
2. Paolucci is speaking of a motet by Andrea Rota, probably from his collection published in 1584.
3. O'Regan 1995:124. The first indication in an Italian treatise of the liturgical use of organs dates from 1529, according to Barbieri 1994:587.
4. Schlick 1511, "Das Ander Capittel." Tr. based on Barber 1980.

5. See 2-2a1 below.
6. For instance: Hamburg, Jacobikirche and Freyberg, Dom, at 489 and 467, respectively.
7. Bonta 1990:520ff.
8. Sherr 1994:607 (quoting Gregory Martin [Rome, 1969, written in 1581], *Roma sancta*, ed. G.B. Parks, p.96). Cf. also O'Regan 1995:108ff.
9. Quoted in Ratte 1991:332.
10. Niemöller 1969:206ff.
11. Praetorius 1618:14.
12. Inventory made by J.J. Fugger. Quoted in Lasocki 1983:633n70.
13. Baines 1957:241.
14. Ongaro 1985:393.
15. See Lyndon-Jones (1996a:10) for other documentation of the purchase of Venetian instruments in Italy, Germany, and the Habsburg Lands.
16. Cited in Mischiati 1981:74.
17. Ongaro 1985:396.
18. Quoted in Moretti 1992:20 from Ferretto.
19. This observation is thus in disagreement with Mitchell 2001:100, who suggested (citing Haynes 1995, for an unclear reason) that *tutto punto* was more common than *mezzo punto*.
20. Tarr's categories 1-3 (see Tarr 1981).
21. This level was posited some time ago by Anthony Baines, and reported by Mendel (1955/1968:222).
22. Paolucci 1765:174 note (d).
23. See Haynes 1995, Appendix 7-9a.
24. It is true that for 17th-century instrumental music, violins tuned lower than A+0 are less effective and have less bite and character than wind instruments of the same period (small recorders and cornetts).
25. The Cassel inventory of 1613 described by Baines (1951:32) lists one case of curved cornetts *im thon* (at pitch, presumably *Cornet-ton*) and another "nearly [*sic*] a tone higher than the above." Roland Wilson* suggests that some of the lower instruments were alto (G-) cornetts at A+2.
26. Beryl Kenyon de Pasqual* and Nelson 1994:255n3 and 254.
27. Nassare 1723:IV:455.
28. The text is cited in Cesari & Pannain 1939:xvi. This organ (made by G.B. Facchetti, 1546) was replaced in 1937 (Lunelli 1956:38ff) and again in 1985.
29. See Haar 1989:249. (I am grateful to Douglas Kirk for this reference.) According to NG2 (17:150), a player named Morsolino became organist at Cremona in 1591.
30. I have been advised by Douglas Kirk on information from Andrew Parrott that the "non" found at this point in the text as transcribed in Cesari & Pannain (and which renders the sentence nonsensical) does not exist in the original document. Morsolino used "tuon" to mean both "pitch" and "tone" when he described *mezzo punto* immediately above; the "tuon" that he used here could thus be either. The present phrase might also have meant "which is a lower pitch than the other, *mezzo punto*."

31. Quoted in full in Cesari & Pannain 1939:xvi-xvii. A more literal translation into English appears in Herbert Myers, "To the editor," GSJ LV (2002, forthcoming).
32. At least two other authors use "tuon" to mean "half-step." Cf. Barcotto 1652 § 13 on Paduan organs in 2-2c. G.B. Facchetti II (a descendent of the builder of the organ in question) wrote, in 1626, in a proposal for the organ at Salò: "Item ancora come obligo a riazonzer bisognando una cana mazor che non sono quele che sono in opera ziove di stagno e questo si fara per arbasar uno tono lorgano per far chel sia conformo come lo coro de li preti" (quoted in Podavini 1973:18-20). "Una cana" (one pipe) implies a semitone.
33. As Graph 1d shows, Mitchell 2001:101 is in error when he states that "Practising players have searched in vain for such an instrument [a cornett at A+0] amongst European collections."
34. Six of the seven stamp-type "B" !! cornetts, dated by Lyndon-Jones (1999:246) to c1559-1608, are at 430-443, averaging 438.
35. Quoted in Barbieri 1987:247.
36. (Mendel 1978:37n35 citing R. Lunelli, *Studi e documenti di storia organaria Veneta* [Florence, 1973], 37).
37. This is paraphrased in Spanish by Cerone (Naples, 1613:1064).
38. Many interesting articles deal with the origins and use of *chiavette*. Cf. for instance, van Heyghen 1995:21ff, Kurtzman 1994, McGowan 1994, Kreitner 1992:179, Barbieri 1991b, Kurtzman 1985:75, and Parrott 1984. The latest is by Barbieri in NG2 (5:597-600).
39. Cf. Barbieri 1991b:56. Virgiliano (c1600) categorized transpositions of a third or less as associated with *chiavi naturali* rather than *chiavette*.
40. Page 4.
41. Originally built 1498; see Lunelli 1956 cited in Mendel 1978:37.
42. Jeppesen 1960:31.
43. Mischiati 1981:9.
44. Podavini 1973:18.
45. Lunelli 1956:112-13.
46. In modern Italian, *corista* has also come to mean a tuning fork.
47. Galeazzo Sabbatini, *Regola secura per accordare a orecchio conforme l'uso moderno, gl'organi, cembali, o altri simili instromenti da tasti* (Pesaro, 1657), quoted in Barbieri 1987:243.
48. See Lunelli 1956:112-13. The pitch of this organ was measured by the physicist Giordano Riccati in 1742 as A-493, but it had been virtually replaced twice between Antegnati's work and Riccati's measurement.
49. Banchieri was from Bologna, where organs were generally tuned at A+1; at S Petronio from 1531.
50. 1496 average 470 (A+1). The Cassel inventory of 1613 described by Baines (1951:32) lists mute cornetts at three different pitches: the 2d pitch a tone higher than the first, the 3d a fourth higher than the 2d. Four of these instru-

ments have apparently survived at Leipzig (see Heyde 1982:51-55); two are pitched at A-2 and two at A+0.

51. This is of course if it is considered to be in A. Praetorius's depiction of the mute is more than 13% longer than the curved cornett; a whole-tone is about 12%. It is also about 5.6% longer than a good modern cornett that plays at 440 (Herbert W. Myers*). See also Myers 1997a.

52. Ardal Powell (*).

53. Baines 1951:35.

54. Ferrari 1994:207.

55. Listed on pp.56-57. Among other examples, she indicated works by Schütz and Schein. Myers (*) points out that there are other pieces that mix flutes with instruments characteristically at high pitch, such as Schein's *Vater Unser*, which has "Violino, cornetto, voce" on the top part, "Traversa, cornetto, voce" on the second, and violone+trombone on the other three lines. It is thus possible that flutes at higher pitches did once exist; indeed, a tenor survives at Vienna at A+1 (museum no. 185).

56. Original text quoted in 0-1c.

57. Myers 1997a:44.

58. Cf. the Cassel inventory of 1613, which includes "Ein großer Fagott ins C. octaf, Ein großer Fagott ins B. octaf" (one large dulcian in low C, one large dulcian in low B♭). Lyndon-Jones 1996a:16. These instruments were often used to accompany choirs and help keep the pitch level, and would have been useful pitched at the low *ChorThon*.

59. Baines 1951:34.

60. *Pace* Barcotto 1652; see above.

61. Praetorius 1618:15. Tr. based on Crookes 1986:31.

62. Barcotto 1652, §16.

63. Doni 1640:181; text and translation from Mendel 1955/1968:236. A certain A.D.V. (see Bibliography; quoted in Barbieri 1980:24n14) paraphrased this passage in 1702: "En Italie [les Orgues] varient suivant les Villes. Celles de Florence sont plus hautes d'un Demi-ton que celles de Rome, qui de leur coté sont plus basses d'un Ton qu'a Venise . . . De sorte que les Orgues de Venise sont plus hautes de deux Tons entiers que celles de Naples." According to Scharlau 1969:149, Kircher left notes in a Ms (MU B 370) that indicate a similar series of pitches, but in reverse, so that Naples was a major third above Venice (*sic*).

64 . Mendel 1978:75.

65. This is the average pitch of Rome: St. Peter's (Cappella gregoriana and Cappella giulia), S Maria Maggiore, S Giovanni in Laterano, Orvieto.

66. This is the average pitch of Montepulciano: S Maria delle Grazie; Firenze: SS Trinità; Nicastro: S Domenico.

67. This is the average pitch of Casalmaggiore: Chiesa di S Chiara; Verona: Cathedral, L'Aquila; Piacenza: Chiesa abbaziale di San Sisto; Fanano: S Giuseppe.

68. This is the average pitch of Carpi: S Bernardino; Brescia: S Giuseppe, S Carlo; Bologna: S Petronio "in Cornu Evangelli," "in cornu Epistolae," S Martino; Arezzo: Cattedrale, Colognole; Bolzano: Castel Coira.

69. This is the average pitch of Milan: S Maurizio and Innsbruck: Silberne Kapelle.

70. Doni 1635:70. Thomas and Rhodes 1980:14:783 state that Doni gave this same information in a Ms at F-Pn (fonds fr.19065) entitled *Nouvelle introduction de musique*. Walther (1732:511, citing Kircher VI:461) also refers to Ramerino (although he calls him "N. Ramarinus"), mentioning his harpsichord with 9 [sic] manuals, the first of which he says is "nach der Römischen Music eingerichtet, und wird insgemein *Tonus chorista*, oder der chor-Ton genennet."

71. The 1537 Müller harpsichord at Rome transposes one whole-tone.

72. Tr. based on Crookes.

73. Caus, *Les raisons des forces mouvantes*.

74. Mendel 1978:43. Kircher's book was *Musurgia universalis* (Rome, 1650).

75. Tr. Mendel 1968:236. There is a surviving record that in 1627 the pipes of a portable organ at the Cappella Giulia were lengthened "per abbassarlo mezzo tono ò poco meno" (cited in Hammond 1983:110,365). Barbieri 1980:24n15 notes numerous records of a sudden lowering of organs in the region of Rome in subsequent years.

76. Tr. Barbieri 1991b:54.

77. Barbieri (1991b:38) reports that "In the Cappella sistina, castrati began to be regularly engaged only from the year 1599 for soprano parts and from the end of the seventeenth century for alto parts."

78. According to Mendel (1955/R 1968:192), Athanasius Kircher wrote in 1650 that "Roman music" was at "tonus Chorista." The Chiesa della Minerva (c1562) was at "tono choristo," and S Maria in Aracoeli (1586) was "in tono choristo, come quello della chiesa della Minerva" (Cametti 1919:449-50). Lunelli (1956:95ff) also reports a contract for the Cathedral at Anagni (1702) specifying "von 7 Fuß und im römischen Chorton." The organ at San Luigi dei Francesi was lowered a semitone to "tono choristo" in 1617 (Barbieri 1991b:54).

79. *L'armonia dei suoni col vero corista o diapason normale* (Rome, 1885), p.19.

80. A curious aspect of the history of the pitch of the organ at S Giovanni in Laterano is the existence of organ parts notated a semitone below the other parts in certain works by Girolamo Chiti, who was *maestro di cappella* there from 1726 to 1759. The *Dixit Dominus*, CHWV 678, for instance, is in Bb except for the organ in A. That would imply that the organ sounded a semitone above the other parts, which is difficult to explain if it was indeed pitched at A=384. Cf. Gmeinwieser 1968:161.

81. Letter 17 Oct 1665. Quoted in Rosand 1991:238.

82. A contemporary letter includes the statement "Mr Graciadio ha fornito l'organo di tutto ponto, con gli 12 registri . . . l'organo è riuscito tanto buono che io non saprei dimandar meglio" (quoted in Fenlon 1980:188). "*Di tutto*

ponto" does not here refer to the organ's pitch but means rather "completely, thoroughly," as in "Mr. Graciadio has quite finished the job of supplying the organ." I am grateful to Herbert W. Myers (*) for help in understanding this passage.
83. See Parrott 1984:490-516, Kurtzman 1985:75, and van Heyghen 1995:19ff.
84. Translation adapted from Picerno.
85. "Tono" was also used to mean semitone in a proposal for the organ at Saló written in 1626 by G.B. Facchetti II quoted above.
86. Quoted in Wistreich 1994:9.
87. Lunelli 1956:74ff.
88. *Breue istrutione alli giovani per imparare con ogni facilità il canto fermo*, pp.126 and 124, respectively. Margaret Murata* writes that on p.48 Stella also wrote "voce Chorista di Lombardia, ch'è una voce [e] mezza quasi più alta di questa di Roma."
89. Margaret Murata* notes further "That the practical differences [between the pitches of Milan and Rome] are ingrained and entrenched, see p.140ff where tables of modes for ordinary chants are re-given to accomodate Lombard use, and p.149, which discusses reconciling local organ pitch to the chants." She also points out a passage in Giulio Cesare Marinelli's *Via retta della voce corale* (Bologna, 1671) that cites Stella on *organi Lombardi* and states that Roman organs are pitched "quasi, o senza quasi" a m3 below others (presumably *organi Lombardi*).
90. Segerman 1983a:28.
91. Quoted in Vogel 1889:103-4.
92. Lunelli 1956:58.
93. As Herbert W. Myers put it (*), this was "from p.121 onwards." Cf. Myers 1998:260.
94. Tr. Crookes 1986.
95. Hart 1977:125-28.
96. Praetorius 1618:41.
97. Praetorius 1618:14.
98. The instrument was subsequently lowered a half-step in the 19th century. Cf. van Biezen 1990:671.
99. 1592, quoted above.
100. The organ at the Martinikirche, Braunschweig (where Praetorius lived) was lowered about two semitones in 1630 (Mendel 1978:37). Praetorius's lower *ChorThon* had apparently been preceded by organs often tuned higher. Fock (1939:313) writes "In der Zeit zwischen 1540 und 1600 findet sich in den Kirchenrechnungen sehr oft der Ver-merk, daß die Orgel "ummegestemmet" ist, das heißt: die früher in höherem Tone stehende Orgel wurde auf eine niedrigere Stimmung, eben den Chorton, gebracht."
101. Praetorius 1618:16.
102. Ingegneri and Mainerio 1582 (see 2-2a2).
103. *Syntagma* III:81-82. Translation from Mendel 1948:183.
104. Praetorius 1618:15.

105. Baines 1951:36.
106. Praetorius 1618:63f.
107. Quoted in Ratte 1991:380ff.
108. Praetorius 1618:41. The specification in the contract for the organ at Mainz Cathedral, finished in 1627, was for "Cornett Thon" (Bösken 1967:80).
109. Cornetts did of course exist at lower pitches but were less common. Cornetts made in Venice were frequently exported to other parts of Europe (cf. the Bassano contract cited in 2-2a1), and since the pitches are similar to German instruments, a national distinction is unnecessary.
110. Harrassowitz 1973:21.
111. Quoted in Müller 1982:428.
112. See also Janowka 1701:93, quoted in 3-6. I am indebted to Jean-Pierre Couturier for help in translating the passages in Janowka used in this study.
113. Ellis 1880, Bunjes 1966, Thomas & Rhodes 1971, Gwynn 1981, and Karp 1989. These conclusions have been the base of a series of articles on Praetorius's pitch by Ephraim Segerman starting in 1983 (see Bibliography). Despite arguments from various quarters, Segerman has remained loyal to the ±430 level. The question was further discussed in Myers 1998 (which points out numerous errors in Segerman's use and understanding of the relevant evidence) and Koster (1999, see below).
114. In a paper presented at the Symposium "Stimmton und Transposition im 16.-18. Jahrhundert," Hochschule für Künste, Bremen, 9 October 1999. Proceedings are in press.
115. An article and related responses by Segerman, Myers, and Koster appeared in *GSJ* 2001 (200-18, 420-24), none of which alters their former positions. Segerman's general survey of pitch history in that issue is fundamentally flawed by using as a general reference ("P") a value for Praetorius's pitch at A=430 that is no longer credible.
116. Smith 1978:56-57.
117. Cf. Vogel 1986:34.
118. Mendel 1948:123 suggests that the additions of Cavaillé-Coll in 1896 could have lowered the pitch a small amount. See also Williams 1980:101; Mendel 1978:30; T. Schneider 1937:32; Lottermoser 1983:70.
119. According to Krickeberg. Tarr 1981:58 gives cornett #662 as at 470, and a mute cornett, #661 as at 409.
120. There is also a connection between Naumburg and Heinrich Schütz, who was honorary court Capellmeister at Zeitz, a city closely connected with Naumburg.
121. Myers 1997a.
122. The unsupported statement in Thomas & Rhodes (1980:782) that the woodcut illustrations in *De Organographia* generally depict instruments "a significant portion of a semitone lower than a'=440 Hz" seems to have been based on their conclusions about the Pfeifflin diagram rather than on any real comparison or measurement.

123. Cf. Galilei 1581:142, Baines 1983:501.
124. McGowan 1994:457.
125. Segerman 1993 confirms this pitch with careful measurements of the sackbut illustrations.
126. Segerman (1985:262) suggested that a shank could have been added to this sackbut, lowering it a semitone to about 435 and thus reconciling the pitches (this is repeated in Segerman 1993, although he seems now to have retracted it). It is difficult to imagine that Praetorius, attempting to be quite specific about the pitch frequency he wished to convey, would not have mentioned an added shank, since its role would have been critical in fixing that pitch. Both the shank and crook illustrated with the *Posaun* could have been used, of course, to lower the instrument to accompany choirs (cf. 2-2a3). The standard crooks were used "to create two principal new pitch levels: a single coil to play a tone lower, or two to play a major 3rd below" (McGowan 1994:459). Praetorius included with his tenor sackbut a "Krumbbügel auff ein ganz Thon," probably for playing a tone below *CammerThon*. Shanks were used for smaller adjustments of tuning within a standard, much like the cornett's "Giunte," as described by Bismantova (see 0-2a). The *Instrumentälischer Bettlermantl* (p1633) also mentions crooks for sackbuts (see Kite-Powell 1997:7).
127. Herbert W. Myers*.
128. Cf. Moser 1959:316, 521.
129. Flade 1931:114-15; Wolf 1738:69 (orig. p.178).
130. Praetorius appears to be indicating claviorgana here.
131. Pierre Hardouin*.
132. See Worp 1915:IV:465,477,486,489 and O'Brien 1990:180,197,225. See also 1-4a.
133. Van Biezen 1990:240 suggests the same thing, since this pitch favored singers. O'Brien (1990:62) tentatively suggested that Ruckers and Couchet worked at a reference pitch (which he calls "R") of 413-419 (A-1). He based this on a similarity of scaling and a link to Taskin's 1783 tuning fork at 409. How consistently, and when Taskin used his tuning fork, and whether he had others now lost, are all open questions, and O'Brien's suggestion for the frequency of "R" was not meant to be proven (nor could it be, based solely on scaling).
134. The nearest we can come are recorders made in Brussels in the early 18th century, which are relatively consistent at an average of A-1½ (406).
135. Lady Utricia Swan, née Ogle, wife of Sir William Swan, who corresponded with Huygens. Howard Schott*, O'Brien 1990:305.
136. 3 May 1648. Quoted in Worp 1915:IV:477.
137. Cf. Wraight's comment quoted in 1-4a that "scales were considered to have a well-defined relationship to the intended pitch and that the safety factor was sufficiently narrow to make it imprudent simply to tune a harpsichord a semitone higher."

138. Christiaan Huygens inherited his father's musical compositions, and had apparently visited Duarte and possibly Couchet in Antwerp when the harpsichord was being made (see Worp 1915:486).
139. Cf. van Biezen 1990:290.
140. Dorgelo 1985:67,71.
141. Van Biezen 1990:380n61. Cf. also Peize, NHK (A. Verbeeck, 1631), and Zeerijp, Jacobskerk (T. Faber, 1645).
142. Bouterse 2001:197, 295.
143. Bicknell 1996:43.
144. Temperley 11:147.
145. Temperley 11:147.
146. This pipe was probably intended to be at nominal *Quire-pitch* F2. See Clark 1974:36. Ellis's evidence (1880:42) on the Worcester Cathedral organ (T. Dallam, 1613) and that at St. John's College, Oxford (T. Dallam, c1619) is too vague to be usable.
147. Now at Tewkesbury Abbey and Stanford-on-Avon (Bicknell 1996:80). For this pitch, see Goetze 1994:61.
148. See Mendel 1978:65n66.
149. Cf. Ellis 1880:48 under 474.1.
150. Bicknell (1996:82) expressed this idea, but got the relation between the two backward. If a keyboard *C* produces a *Quire-pitch F*, it is a keyboard *D* that will produce a *Quire-pitch G*. A keyboard *G* will produce a *Quire-pitch C*.
151. "Keys and musiks" probably means "white and black keys" (Clark 1974:27). Cf. Mendel 1978:64 and Wulstan 1966:107-08. Gwynn (1992:57) states "The solo pieces were played on 'the keys', and the ranges indicate that they were played untransposed."
152. Gwynn 1985:67 reports that there are 17th-century organ pipes marked with both names.
153. See Mendel 1978:64-65.
154. Cf. for example the chamber organ at Canons Ashby, Lowered in 1851 to about 425.
155. This system of notating English pitches is different from the one I used in my dissertation.
156. See 4-5a.
157. Kellner 1956:357.
158. Brass stringing would produce pitches of about 389, 367, 346, and 327. Evidence supports the use of iron, however (p.39ff).
159. The transposition system used by organists seems no longer to have been used by the end of the 17th century (Clark 1974:48; Bicknell 1985:80). An analogous move to a non-transposing organ keyboard was made on the continent during the 17th century (van Biezen 1990:286).
160. Quoted in Hopkins & Rimbault 1855:190.
161. The organ was lowered a whole-tone by R. Harris in (? 1713) to ±425 (Gwynn 1985:68-69; Goetze 1995:62). A chamber organ survives at Bethnal Green that was formerly also at New College, made in about 1680. It was dis-

covered in the mid-19th century by Sir John Sutton and was "originally below concert pitch" (the latter being in the low 450s; see 10-1d). The wooden pipes had been cut, however, and the pitch is presently 1½ semitones above 440 (John Pike Mander*).

162. Drake 1981:44. The cornetts may have been made by Arthur or Anthony II Bassano. They are shown in Parrott 1978:183.

163. Quoted in Drake 1981:44.

164. The mounts "slightly worsen the intonation, which is otherwise excellent." Drake 1981:44-45.

165. Dallam built Prestbury, St. Peter (1663) at *Quire-pitch*; Oxford, Magdalen College (1630s) was at Q-1 and Cambridge, St. John's (1635) was apparently Q-2.

166. Lanvellec, 1647, at 388, may have originally been built higher than it now sounds and had its pipes shifted. Ton Koopman* noted in playing it that the semitone tuning suggests this.

167. Which he thought at that time was about 503; it can be corrected downward to 473 without affecting his argument.

168. Cf. Goetze 1994:60, 1995:61. Goetze makes clear here he is speaking of "church organs (as opposed to the few extant chamber instruments)."

169. See Mendel 1978:65 and Gwynn 1985:66-67.

170. Bowers 1995:10-15, 43ff. Bowers also questions the clef code theory when applied to that period.

171. Lasocki 1995b:174.

172. Lasocki 1995b:175-76.

173. Parrott 1978:183.

174. Lasocki 1995b:9.

175. Lasocki 1995b:216.

176. Lasocki 1995b:221.

177. Parrott 1978:183.

178. Tr. based on Crookes 1986.

179. See Kirk 1989:19-20, Waterhouse 1993:20-21, and Lasocki 1995b:223-28.

180. Lyndon-Jones 1999:243, 261-62.

181. Lyndon-Jones 1999:246-47.

182. Weber 1975:7-8.

183. Following the method described in Haynes 1994.

184. Original text quoted in 2-4.

185. Praetorius (1618:44) mentioned a practice among English viol consorts of transposing the music down a fifth by pretending to play different sizes. His wording suggests a pitch change, but like the transposing organ, the actual sounding pitch did not change, merely the nominal pitches of the strings. Cf. Myers 2001:6.

186 . Although the breaking point is a useful reference, there are indications that strings were not always tuned up to it; see Myers 2001:14-15.

187. Segerman 1991:14.

188. Jones (1989:157-69) uses lutes to propose pitches for the period 1610-70. On the basis of string length and composition, he suggests "Consort-Pitch" was "between a semitone and a tone below modern standard pitch." This is Q-3, which is quite plausible.

189. Dufourcq 1957:70.

190. Rokseth 1930:353.

191. Mersenne 1636:I:iii:§VI, p.169.

192. Dufourcq 1971:I:202.

193. Mersenne Proposition XXII.

194. See 2-2a1 and 2-3.

195. Thoinan 1867:398.

196. Myers 1989:3.

197. Gobelins tapestries *L'Air* and *Printemps*, which probably depict the instruments used in the Écurie. See Haynes 1988b and Haynes 2001:30.

198. The distance from the top of the instrument to the middle of hole 6.

199. Myers 1997a. Mersenne's shawm played a six-finger d1, whereas Praetorius's was at e1 for the same fingering and (apparently) pitch frequency. This suggests there was a pitch standard for French shawms that sounded a whole-step higher than the one used in Germany.

200. Dufourcq and Benoit 1963:195. I am indebted to Marc Ecochard for pointing this passage out to me.

201. 7 February 1709. Benoit and Dufourcq 1966:206.

202. Cf. this mid-19th-century advertisement (Verroust 1857:[last page]): "Au point de vue du progrès des musiques militaires . . . notre nouveau hautbois en Ré ♭ est incontestablement préférable à celui en Ut; son timbre a plus d'éclat, et il permet d'exécuter dans les tons les plus favorables les passages les moins accessibles à ce dernier."

203. Mersenne included detailed dimensions of a traverso that he called "one of the best flutes in the world," but there are serious questions about the placement of the tone-holes and the total length of the instrument. Trevor Robinson's reconstruction of it (reported in Robinson 1973:84-85) plays close to "modern," i.e., A+0. But, as Powell comments (2002:58), Robinson was obliged to interpret Mersenne's dimensions too freely to be sure they accurately represent the instrument he described.

204. Rousseau 1768, s.v. "Orchestre" observed that in French music "c'est toujours l'acteur qui règle l'orchestre tandis que l'orchestre devrait règler l'acteur."

205. This is when major reworkings and additions began to appear in productions of Lully's works. Before then, alterations "tended to be relatively small in number and modest in scope." See Rosow 1989:217, 228.

206. LWV 17/1-12.

207. He had been appointed *surintendant de la musique et compositeur de la musique de la chambre* in May 1661 and was naturalized in December of that year. He added the title of *maître de la musique de la famille royale* and married Lambert's daughter in July 1662.

208. Beaussant 1992:128.
209. Cf. the next section, 2-7.
210. See Haynes 2001:56-59.
211. Tr. based on Crookes 1986.
212. Vienna and Prague were connected both politically and culturally as parts of the Habsburg sphere. Antonicek (1980:19:716) wrote "Ferdinand II made Vienna his capital and place of residence, although neither he nor later monarchs liked to reside there permanently; other towns such as Prague, Regensburg . . . and Graz shared Vienna's reputation as one of the places where the imperial Kapelle gave outstanding performances."
213. To distinguish this pitch from the northern *Chorton* at A+1, I will write this southern name for the lower pitch as "*ChorThon.*"
214. Senn 1974:39.
215. Mandorfer 1977:29.
216. Ardal Powell (*).
217. Kite-Powell 1997:5. See also Campbell 1995 (who believes the dialect used in the text indicates a south-German or Austrian provenance).
218. Haspels 1987:123.