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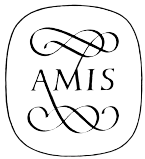

The Lodewyk Theewes Claviorganum and its Position in the History of Keyboard Instruments

WILSON BARRY

THE VICTORIA AND ALBERT MUSEUM, London, contains a one-manual claviorganum inscribed on the inner surface of the lockboard: *Ludowicus Theewes me fecit 1579* (see fig. 1).[1] This, the only surviving instrument by Theewes, is of immense importance in the history of the making of musical instruments, partly because it contains a rare example of a type of Northern harpsichord that preceded the Flemish type exemplified by the mature work of Hans Ruckers the Elder. Many parts of this instrument are now missing—the strings, the keys, all but one jack, all but one pipe, etc.—but recent analyses of the harpsichord portion, described by John Koster,[2] and of the organ portion, to be reported here, have determined its probable original disposition. From the remaining parts of the organ it has been possible, by a process of logical inference, to determine the probable nature of the missing parts. This, in turn, makes it possible to view the combined instrument as a whole, and to begin to inquire into its place in the history of musical instruments.

* * *

It was discovered some years ago that the name "Theewes" was rendered "Theeuwes" in the Antwerp archives, and this spelling became widely adopted. However, a systematic and thorough search of the Antwerp archives, now in progress, has revealed that the usual spelling in Flanders was "Theeus" and that "Theeuwes," together with "Teeus," were ex-

This article is a major revision of an article that was originally scheduled to appear in *The Organ Yearbook* 14 (1983). I am grateful to Peter Thornton, Keeper, Department of Furniture and Woodwork, Victoria and Albert Museum, London, for his kindness in allowing me to examine the Theewes claviorganum. Also of help in this study have been Howard Schott, Derek Adlam, and Michael Thomas. The photographs of the Theewes illustrating this article were taken by the author on 15 July, 1980, and are reproduced here by courtesy of the Victoria and Albert Museum.

1. Schott, 40–42; Mus. No. 125-1890.
2. Koster, 45–73.

FIGURE 1. Claviorganum built by Lodewyk Theewes, London, 1579. London, Victoria and Albert Museum 125-1890. Side elevation.

ceptional variants.[3] The instrument itself is signed with a Latinized given name and an Anglicized surname, which seems to conform to the convention of the time.[4] It seems that, in London, Theewes called himself "Lodewyk Theewes," and that therefore this is the name we ought to use.[5]

3. Private communication from Jeannine Lambrechts-Douillez, Museum Vleeshuis, Antwerp.

4. For example: Martinus van der Biest (Antwerp, 1580), Anthonius Meidting (Augsburg, 1587), Laurentius Hauslaib (Nuremberg, 1596), Mattheus Ringall (Augsburg, ca. 1600), Iohannes Hasard (London, 1622), Hermanus Tabel (London, 1721), etc. See Boalch, text and plates.

5. A similar instance is that of the name of Handel; at one time some scholars decided to put in an umlaut, but later other scholars decided to take it out again.

Theewes was born into a family of Antwerp harpsichord makers; he was admitted to the Guild of Saint Luke in 1561 as the son of a master.[6] The members of this guild included painters, carvers, framers, panel makers, bookbinders, printers, and harpsichord makers. Probably around 1565, Theewes emigrated to London; he was naturalized in 1567, according to the parish records of St. Martin's le Grand. The last date recorded for Theewes is 1585.

Frank Hubbard wrote that Theewes's "claviorganum is Flemish in every detail except in the choice of oak for the case work."[7] This statement might be difficult to defend, however, since no contemporary bentside harpsichord of either English or Flemish provenance survives to be compared with the Theewes. Koster described the Theewes claviorganum as a representative of "an international style practiced throughout most of Northern Europe."[8] This is a seminal idea and a healthy corrective to Hubbard's conjecture. Koster leaves us with the view that the Theewes harpsichord was to a degree both Flemish and English and, in a broader sense, Northern European.

* * *

The harpsichord portion, which is both the oldest extant keyboard chordophone of English provenance and "the earliest extant [bentside] harpsichord made by a Fleming,"[9] has a compass of $C–c^3$, 49 notes. Koster[10] argues persuasively that this full chromatic compass was peculiar to England in the second half of the sixteenth century; certainly Theewes's colleagues in Antwerp were building instruments with a compass of $C/E–c^3$, 45 notes. All the keys are now missing. Earlier accounts of this instrument refer to two remaining keys; the first of these was described by Raymond Russell:[11]

> Formerly one accidental key was preserved, and this was topped with small squares of ebony and boxwood, alternately placed. A similar decoration has been used on the virginal by Thomas White, 1653, at Hardwick Hall.

6. Hubbard, 46–47; 49–51.
7. Ibid., 133.
8. Koster, 66.
9. Hubbard, 49.
10. Koster, 45–47. Koster seems to have overlooked Caldwell's earlier discussion (133) of this issue, arriving at a similar conclusion.
11. Russell (1959), plate 54 (description).

The second key, a natural, was examined in January 1967 by Charles M. Mould,[12] who concluded that it was an original key from the upper manual of the ca. 1725 Thomas Hitchcock harpsichord (also in the museum)[13] that had been altered in the museum workshop to serve as a replacement in some unidentified spinet, and was lying around the museum until "some tidy warder dropped it through the rose" of the Theewes. Considering that both the Theewes and the Hitchcock came to the museum (in 1890) from the same place (Ightham Mote, Kent),[14] it seems more likely that the key was altered—considerably before 1890—by a workman cannibalizing the unplayable Hitchcock to repair a spinet at Ightham Mote. This spinet did not come to the museum with the Theewes and the Hitchcock,[15] and was probably disposed of prior to 1890.

The accidental key was described somewhat differently by Koster:[16]

> The keys are missing, but Hugh Gough tells me that one sharp which survived until about thirty years ago was made of about ten alternate vertical layers of ebony and boxwood.

Considerations of symmetry suggest an odd number of layers, probably seven ("triple skunktails"). In any event, this accidental key, which reminded Russell of those of a seventeenth-century English virginal,[17] was probably also never a part of the Theewes. Rather than ivory-covered naturals with arcaded ivory fronts, and checkered or striped ebony and boxwood accidentals, one might expect the Theewes to have had bone-covered naturals and accidentals of black-stained hardwood, like most surviving Northern harpsichords and claviorgana of the period.[18]

* * *

The Theewes had three choirs of strings: $2 \times 8'$, $1 \times 4'$. The front register controlled the shorter 8′ choir; the middle register controlled the 4′ choir, plucking to the right. The longer, back, 8′ choir was permanently

12. Charles M. Mould, "A Report on the Instruments by Thomas Hitchcock and Ludovic Theeuwes in the Victoria and Albert Museum," 2 pages, January, 1967 (unpublished report in the working catalogue of the museum).

13. Schott, 69–70, Mus. No. 126-1890; Russell (1959), plates 63–64; the keys of the Hitchcock are illustrated in Hubbard, plate 19, figure 7.

14. Schott, 42; 70.

15. Private communication from Howard Schott.

16. Koster, 52.

17. By Thomas White, London, 1653. See Boalch, 190; Boalch No. 5.

18. For example, instruments by: Martinus van der Biest (Antwerp, 1580), Hans Ruckers the Elder (Antwerp, 1581), Anthonius Meidting (Augsburg, 1587), Josua Pock (Innsbruck, 1591), Laurentius Hauslaib (Nuremberg, 1596), etc. See Boalch, text and plates.

provided with brays in the form of L-shaped brass pins screwed into the bridge about midway between the long and short unison strings. No other existing plucking keyboard chordophone seems to have been furnished with such brays, although some extant Flemish virginals of the *muselaar* type[19] are furnished with *arpichorda* consisting of metal hooks mounted on a batten, so that the accessory could be thrown on and off, like a buff stop. Because of the necessary shape of the virginal bridge, only about the lower two and one-half octaves could be brayed.

An extant example of a brayed harp is in the Germanisches Nationalmuseum, Nuremberg (see fig. 2),[20] and this is attributed to early sixteenth-century Germany, exactly the right period and provenance (Northern European) to be linked to the Theewes. The "ordinary harp" depicted by Michael Praetorius in 1620 also seems to be furnished with brays (see fig. 3).[21] One might speculate about practices and traditions that came from Cologne to Antwerp with Hans van Cuelen *et alii,* and then from Antwerp to London with Lodewyk Theewes *et alii.*

On the other hand, Sibyl Marcuse remarks: "Typically, the Renaissance harp was a bray harp."[22] It may be that we see in the brayed back choir of the Theewes the only surviving example of a quite usual variety of Renaissance harpsichord (and perhaps the variety most deserving of the name "harpsichord"). It may be that the *arpichordum* of the early Flemish virginals should be viewed, not as an innovation (or a "toy"), but rather as a lingering feature of the earlier days of the plucked-string keyboard instruments.

It seems that, once the notion of taking a chordophone, mechanizing it, and applying it to the finger-scale keyboard of the small organ, occurred to musicians and builders, no type of chordophone was exempt: the monochord engendered the clavichord, the psaltery the plucking clavicymbalum, the hammered dulcimer the dulce melos and the hammered clavicymbalum; various viols engendered the geigenwerk by way of the hurdy-gurdy, and the bray harp engendered the *arpichordum.*

19. *Muselaren* had their keyboards to the right, and plucked relatively far from the left-hand bridge (see Russell [1959], plate 26, which shows an *arpichordum* batten), in contrast to *Spinetten,* which had their keyboards to the left, and plucked close to the left-hand bridge (see Russell [1959], plate 25). The nomenclature derives from Douwes, 104; trans. in Hubbard, 233.

20. Museum number MI 59.

21. Praetorius, plate 18, fig. 1.

22. Marcuse (*Survey*), 390; 283–285; and especially 296.

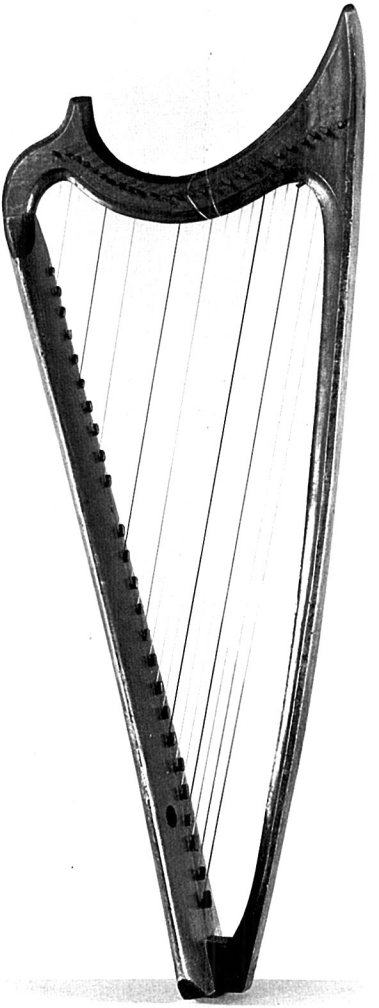

FIGURE 2. Early 16th-century bray harp. Nuremberg, Germanisches Nationalmuseum, MI 59.

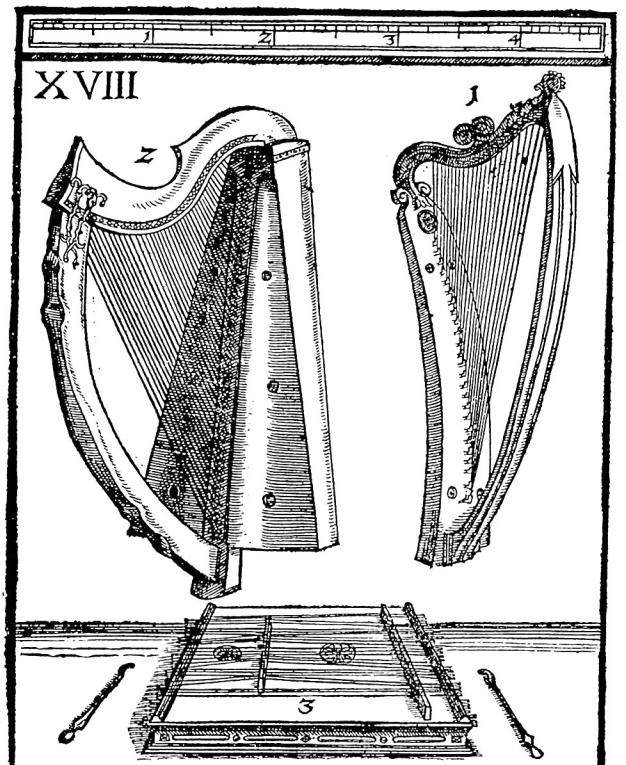

FIGURE 3. This "ordinary harp" depicted by Michael Praetorius in 1620 seems to be furnished with brays (from *Theatrum instrumentorum*, plate 18, fig. 1).

An early reference to the *arpichordum* (but called *Clavicimbalum*) was made by Sebastian Virdung in 1511 (see figs. 4–5):[23]

> Das ist eben als das virginale / allein es hat ander saiten von der dörmen [der] schaue und negel die es harpfen machen hat auch federkile als das virginale. ist neulich erfunden und ich hab ir nür eins gesehen.

23. Virdung, 9–10.

Se. Die musica hat vil auß teilung vnd der glider eines/ist vō der musica der instrument/darumb sowerden die selbē zū iren namen gemalet/vff das/das sye dester kentlicher einem jetlichen anschauwenden werden .A. wie vil synd dann der selben instrument .Se. Su můst das glid der musica von den instrumenten in dryerley geschlecht auß teylen/somagst du mich recht verstan .A. welichs synd die selben dry geschlecht Se. Das erst ist aller der instrument die mit seyten bezogen werden/vnd die heisset man alle seyten spill/Das ander geschlechtist aller der instrument die man durch den windt Lauten oder Pfeiffen machtDas dritt geschlecht ist aller ō instrumēt/die vō den metallē oder ander clingendē materien werden gemacht .A. Das kan ich nit wol verstan Bericht mich Das Se. Wol an ich will dir ein andere austeilung machen/ Des erstē geschlechtes der saitten spill/Etlich die haben schlüssel vnd nach dem selben mag man sye regulieren/vnd dañ nach der regeln vff den selben spilen lernen als zū gliche weyß die instrumenten mit den clauieren synd. Virginal B

Clauicordiū

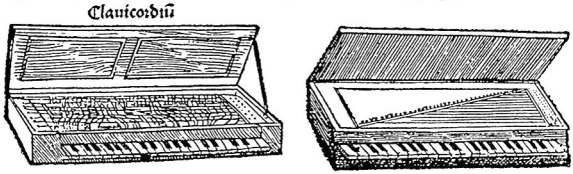

FIGURE 4. *Clavicordium* and *Virginal* depicted by Sebastian Virdung in 1511 (from *Musica getutscht und ausgezogen*, page 9).

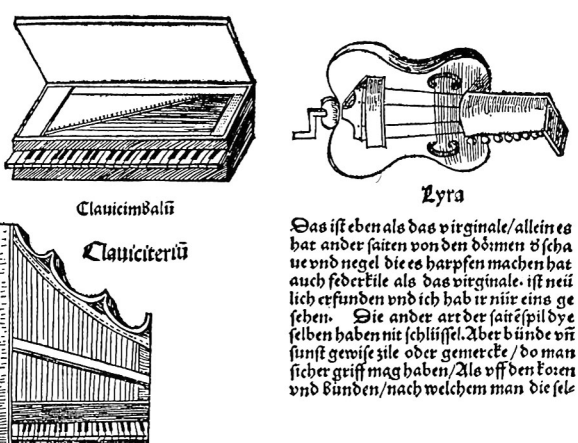

FIGURE 5. *Clavicordium* and *Claviciterium* depicted by Virdung (from page 10). The engraver of these woodblocks failed to reverse these drawings, so they appeared in the original as mirror images. Through the miracle of modern xerography, this is corrected here.

(This is exactly the same as the *Virginale* / the sole distinction being that it has different strings of the gut of sheep, and nails that make it harp. It also has quills like the *Virginale.* It is newly invented and I have seen it only once.)[24]

Virdung did not specify whether his description referred to his illustration of the *Clavicimbalum* or to that of the *Claviciterium,* and Hubbard chose to attribute it to the *Claviciterium* on the grounds that this was the instrument most likely to be described as "newly invented." However it seems from the illustrations that it was probably the *Clavicimbalum,* and not the *Claviciterium,* that was "like the *Virginale.*"

As Hubbard remarked,[25] Virdung's illustrations are extremely crude, and it is difficult to see a distinction between the *Virginale* and the *Clavicimbalum,* but it may be that the illustrator was supposed to show that the bridge of the *Clavicimbalum,* like that of the Theewes, was furnished with permanent brays.

The 1547 Inventory of the Musical Instruments of King Henry VIII[26] testifies that square or polygonal spinets were the rule, and that bentside instruments were rather exceptional; only two of seventeen "Virgynalles" at Westminster were bentside harpsichords, and these were of Italian, not Northern, provenance. It may be that the sixteenth-century Northern musicians and builders were in general quite content with the sound of rectangular and polygonal instruments, and resorted to the bentside configuration mainly to produce instruments with multiple choirs. There were, however, also single-strung bentside harpsichords;[27] these may be descendants of bentside psalteries. There is a Flemish painting of ca. 1430 in Madrid that shows a double bentside psaltery of perhaps 2′ pitch.[28]

By 1619 Praetorius[29] described the *Arpichordum* as follows:

Arpichordum. Da in[30] einer *Symphoney* oder *Virginall* durch sonderliche Züge von Messingshäcklin unter den Säitten ein Harffenirender Resonanz entstehet / und zuwege gebracht wird.

24. The expression "*eben als . . . allein*" is rendered "like . . . except" by Hubbard (p. 166, footnote 2), which does not seem to convey the force of the original text, which Marcuse (*Survey*) translates (283) "the same . . . only."

25. Hubbard, 165–166; trans. 327.

26. Barry (1982), 31–45.

27. Hellwig, 29–38; plates 35–40.

28. Madrid, Prado, no. 1511; illustrated in Wangermèe, plate 25.

29. Praetorius, 67. Commentary in Hubbard, 166–170. Little Michael Schultheiss, later known as Michael Praetorius, was eight years old when Theewes built his claviorganum.

30. Not *die*; see Praetorius' *errata,* 235.

(*Arpichordum.* There in a plucking keyboard chordophone or virginal through a special stop of little brass hooks under the strings a harplike resonance is created / and brought about.)[31]

Praetorius's definition of *Symphony*[32] is made obscure by his concern to forbid the use of *Instrument,*[33] then commonly used in Germany with the same meaning, but both expressions continued in use. Praetorius's definition of *Claviorganum*[34] is clearer:

Claviorganum ist ein Clavicymbel, oder ander Symphoni, da zugleich neben den Säitten etliche Stimmwerck von Pfeiffen / wie in eim Positiff / mit eingemenget senn . . .

(The Claviorganum is a bentside harpsichord, or other plucking keyboard chordophone, there at the same time besides the strings some stops of pipes / as in a Positive / are incorporated . . .)

A stop (*Zug*) can be a handstop (*Registerzug*) controlling a row of jacks, or a buff stop (*Lautenzug*) controlling a buff batten, or an *arpichordum* stop (*Harfenzug*) controlling an *arpichordum* batten. By extension, "stop" can even mean a choir of strings, or a rank of pipes. There is evidence that

31. Blumenfeld (67) unfortunately reads "metal jacks" for "Messingshäcklin." Blumenfeld's work is not without merit, but it consistently conceals real uncertainties and ambiguities in a deceptively polished translation. (See Blumenfeld's Preface, v–vi.) Hubbard (265) seems to have consulted Blumenfeld's translation, correcting certain details, but otherwise giving an identical reading:

The Arpichordum is a symphony [Hubbard: jack-action instrument] or virginal on which a harp-like sound is produced by means of a special stop which governs metal jacks [Hubbard: brass hooks] under the strings.

32. Praetorius, 62. See Hubbard, 264, footnote 59; Russell (1959), 96. I agree with Hubbard that Praetorius meant to say that *Symphony* was a generic term for plucking keyboard chordophones, and disagree with Marcuse, *Dictionary,* 501 s.v. Symphonie (4) "German generic term for spinets and virginals [only] from the late 16th to the 18th century." In our day, a hopeless effort has been made to restrict the meaning of "harpsichord," e.g., by Hubbard (355): "To be distinguished from the spinet and the virginal. The harpsichord has a bentside. The strings are parallel to the key levers." But Hubbard's own title page—like Boalch's and Russell's—uses "harpsichord" meaning "plucking keyboard chordophone." See Barry (1984), 100. Two instruments by Valentin Zeiss, of 1639 and 1646 (see Boalch, 191; van der Meer), do not have bentsides, but who will say that they are not harpsichords?

33. According to Marcuse (*Dictionary,* 259): "*Instrument* (German), in seventeenth- and eighteenth-century a rectangular form of keyboard instrument, i.e., a clavichord, spinet, or virginal." However, if *Symphony* included bentside harpsichords, and *Instrument* was incorrectly used for *Symphony, Instrument* must also have (incorrectly) included bentside harpsichords.

34. Praetorius, 67.

some late German bentside harpsichords, at least, were furnished with *arpichordum* battens on the wrestplank; Jacob Adlung (Erfurt, 1758) writes of the *Harfenzuge*: "This is also found on the nut and is . . . a movable batten into which bent pins have been driven . . . When they are close to the string a harplike jarring will be perceived which detracts nothing from the clarity of the tone."[35] While all the evidence for this inference appears to be circumstantial, it seems likely that the Theewes was one of *many* Northern harpsichords from the period 1450–1600 that were furnished with permanent brays.

* * *

The spruce soundboard of the Theewes harpsichord extends beyond the upper belly rail, over the gap and the wrestplank, clear up to the back of the nameboard. The width of the wrestplank is only about 5 cm, but the width of the gap is about 25 cm. The 8′ and 4′ "front bridges,"[36] together with the three registers, stand over the gap on a freely vibrating soundboard. This soundboard is also about 8 cm wider on each side than it needs to be, so that the front bridges are exceptionally free at the bass and treble ends. The tonal effect must have been something like that of a *muselaar* or an Italian virginal.[37] The jacks were guided at the top by a leather register glued over mortises in the soundboard, and at the bottom by jack-slides controlled by three drawknobs in the front of the case.

There was formerly a rose about 10 cm in diameter.[38] The 4′ strings reached their wrestpins by passing through holes in the 8′ front bridge. The one remaining jack appears to have been an original 4′ jack lost inside the instrument when, perhaps, a new set of wider, but not thicker, 4′ jacks

35. Adlung, 557; trans. in Hubbard, 270.

36. Hubbard (358) defines "Nut" as follows: "The bridge in a [bentside] harpsichord or bentside spinet which is glued to the wrestplank." Well and good. Then he continues: "In a virginal or pentagonal spinet it is the left-hand bridge, nearest the line of the jacks." "Left-hand bridge" seems the preferable term for a bridge that is nowhere near the wrestplank. The left-hand bridges of sixteenth-century Flemish and Italian virginals (see Russell [1959], plates 25 and 26; Hubbard, plate 4) stood on freely vibrating soundboards, and by analogy to these, it seems useful to call the "nuts" of the Theewes "front bridges."

37. See Hubbard's description, 24–25. A "copy" of the Theewes harpsichord (without brays) was made in 1979 by Stephen Wessel, working under the direction of Michael Thomas (See Morgan, 114–115. Also ibid., 121). Its tone is described as possessing "the sharp, clear attack of Italian instruments, while having the longer sustaining power of Flemish ones."

38. According to Boalch (129), the roses of Hans Ruckers the Elder were usually about 6.5 cm in diameter, or occasionally 8.5 cm.

was installed.[39] Grant O'Brien discovered a jack tongue lodged in the instrument and observes that both this tongue and the complete jack have iron plectra which appear to be original.[40]

The dimensions of the harpsichord were measured by Koster.[41] Considering the observation of W. R. Thomas and J. J. K. Rhodes[42] that the dimensions of the Ruckers harpsichords are commensurable with an Antwerp *voet* of 283.8 mm, divided into 11 *duimen* of 25.8 mm, one might wonder whether Theewes adopted the English foot of 305 mm. It seems that Theewes did use the Flemish measures for the corpus of the harpsichord:

Dimension	Antwerp	Calculated	Measured
Length	7-1/2 *voeten*	2128.5 mm	2128 mm
Width	35 *duimen*	903.0	898.5
Height	9 *duimen*	232.2	230

The width seems to have shrunk 0.5 percent, and the height, including the thickness of the lid, 1.0 percent over four centuries. It is surprising that the shrinkage is not more; Theewes's work seems to be very accurate, and his lumber remarkably well-seasoned and stable.[43]

The *Stichmass*[44] of the keyboard is ca. 482 mm. Friedrich Ernst has written that the *Stichmass* of the Ruckers' keyboards is about 500 mm,[45] and Thomas and Rhodes have pointed out that this dimension amounts to 27 naturals in 25 Antwerp *duimen* (exactly $25/27 \times 25.8$ mm $\times 21 = 501.7$ mm).[46] The *Stichmass* of the Theewes may resonate to the English foot of 305 mm, with 21 naturals in 19 inches (exactly $19/21 \times 305/12 \times 21 = 482.9$ mm);[47] perhaps the octave span of the Theewes keys con-

39. Mould (see note 11) observes: "on fitting [this jack] into any of the remaining leather mortices in the jack guides, it was found that the width of the jack was such that there was up to 1/8" play, though the thickness was such as to be a correct fit."

40. Private communication, from a 1982 manuscript now published as *Ruckers: A Harpsichord and Virginal Building Tradition* (p. 28).

41. Koster, 48. Koster's determination of the height, 21.55 to 21.7 cm, does not include the thickness of the lid. Russell (1968) gives the height of the harpsichord as 23 cm.

42. See Thomas and Rhodes, 112–121, esp. 114. See also O'Brien, Table One (p. 49).

43. As we shall see, the interior parts of the organ do not exhibit the same accuracy.

44. *Stichmass*, or "standard measurement," is the width of twenty-one natural keys, a concept first proposed in Ernst, 63–75.

45. Ibid.

46. Thomas and Rhodes, 114.

47. One modern American standard is fourteen naturals in thirteen English inches, for a *Stichmass* of 495.6 mm. Dom Bédos (Paris, 1766–78) used fifteen naturals in thirteen *pouces* of 27.1 mm, for a *Stichmass* of 492.6 mm; see Bédos de Celles, vol. 1, p. 151; vol. 2, plate 58.

forms to a London fashion. On the other hand, the Victoria and Albert Museum has two sixteenth-century Italian spinets with the same *Stichmass*: "Queen Elizabeth's Virginals" (Venice?, ca. 1570), and one by Annibale dei Rossi (Milan, 1577).[48]

* * *

The approximate scaling of the back 8′ choir has been measured as follows:[49]

String	Length	Plucking Point	Percent
c^3	202 mm	134 mm	66%
c^2	350	144	41
c^1	620	152	25
c	~1100	163	15
C	~1530	177	12

The front 8′ choir plucks 53 mm (2 *duimen* = 51.6 mm?) closer. Since the front and back 4′ bridges are replacements, as is also the lower portion of the 8′ bridge, it is impossible to estimate the scaling of the 4′. These string lengths do not halve on the octave; consequently, the scaling is non-Pythagorean throughout. Two of these dimensions appear to be commensurable with the Flemish measurements; c^1 seems to be 24 *duimen* (619.2 mm), and c^3 seems to be 8 *duimen* (206.4 mm), in vibrating length.

Given that 8 *duimen* is one-third of 24 *duimen,* it seems that Theewes's octave scaling ratio was 1: $\sqrt{3}$. This is one of the ratios then in use by organ builders to establish the width of organ pipes,[50] and we recall that Theewes, like quite a few of his colleagues in the Guild of Saint Luke, was a skilled organ builder. The string lengths Theewes achieved, together with the lengths he seems to have been aiming for, may be compared as follows:

String	Formula	Antwerp	Calculated	Measured
c^3	$1/3 \times 24 =$	8.00 *duimen*	206.4 mm	202 mm
c^2	$\sqrt{3}/3 \times 24 =$	13.86	357.5	350
c^1	$1 \times 24 =$	24.00	619.2	620
c	$\sqrt{3} \times 24 =$	41.57	1072.5	~1100
C (Theoretical)	$3 \times 24 =$	72.00	1857.6	—
C (Actual)	$2\text{-}1/2 \times 24 =$	60.00	1548.0	~1530

48. Schott, 29–31; 36–39.
49. From Schott, 40; or Koster, 51.
50. See Mahrenholz, 41.

Only the bottom octave seems to be foreshortened with respect to the formula. Theewes did not need to use any of these numbers except 24 *duimen*; all the other dimensions can be derived by geometry, recorded on a scale stick, marked with the length of the C's, and used to locate the bridge on the soundboard.

A system of scaling something like Theewes's may be seen in some other early Northern instruments also, and it may be that one observes here the vestiges of an earlier "Renaissance" or "pre-Ruckers" practice. Koster [51] attempted to explain the scaling of the Theewes as a stage in a gradual transition from an early German practice of "rather slack iron strings" (pitch $c^2 = \sim 310$ mm) through that of "the early Flemish-type virginal to that of the mature Ruckers style," but this notion of a gradual transition presents some philosophical problems. An historical model of smooth and continuous change—evolution and progress—has its uses, but a more realistic image is often that of abrupt and discrete change—revolution.[52] The beginning and the end of the Renaissance were such revolutions, and one might say that, for the scaling of Northern harpsichords, the Baroque era began when Hans Ruckers the Elder, or one of his colleagues, woke up one morning and decided that henceforth he would use Pythagorean scaling for the top twenty strings of his 8′ choirs.

The lengths of the strings in the *Clavisimbalum* depicted by Henri Arnaut de Zwolle,[53] and dating from ca. 1440, are even less Pythagorean than those of the Theewes. It appears, therefore, that this type of scaling did not originate as a sixteenth-century transition from early German practice to the mature Flemish practice, but rather it appears full-blown in fifteenth-century Burgundy in the earliest harpsichord we know much about. It follows from such a system of scaling that, however taut the top string may be, most strings throughout the compass are considerably slacker than, it would appear, they need to be.

* * *

The exterior of the harpsichord is covered with leather: brown calf, blind tooled, with gilt stringing forming panels.[54] Hubbard observes that

51. Koster, 52.

52. As early as 1941, Paul Henry Lang (126) could write of ". . . the evolutionary conception, dear to the advocates of biological methods of historiography . . ." For a recent discussion of the notion of "Progress," see Leppard, particularly 7–21.

53. Wilson Barry, "Henri Arnaut de Zwolle on Small Keyboard Instruments," *The Historical Harpsichord*, Vol. 4 (Stuyvesant, NY: Pendragon Press, forthcoming).

54. According to Mr. Waterer of the Leather Museum, November, 1969 (unpublished report in the working catalogue of the Victoria and Albert Museum).

the harpsichord is similar in plan to those of the Ruckers family, except for its narrower tail.[55] The case walls are of oak, an "English" wood, and about 12 mm thick—a little lighter than the 14–16 mm usual in Flemish harpsichords. The Flemings usually built their cases of linden[56] however, a wood neither as dense nor as strong as oak, so that perhaps the scantlings and the case-material are interrelated and should be considered together. The front of the harpsichord is arranged like that of a Flemish virginal with its inset keyboard (figs. 6 and 7).[57] The front panels are about 12 cm in width, including the molding, and the keyboard is centered. The front panels and the keyboard surround are covered with gold-colored embossed paper.

FIGURE 6. Theewes claviorganum: Front elevation.

55. Hubbard, 50; also compare Russell (1959), plates 33 and 54.

56. See Hubbard, 56. Linden (*Tilia*) is also called lime. The American variety (*Tilia americana*) is usually called basswood or whitewood.

57. See Ripin, 67–76; plates 53–61.

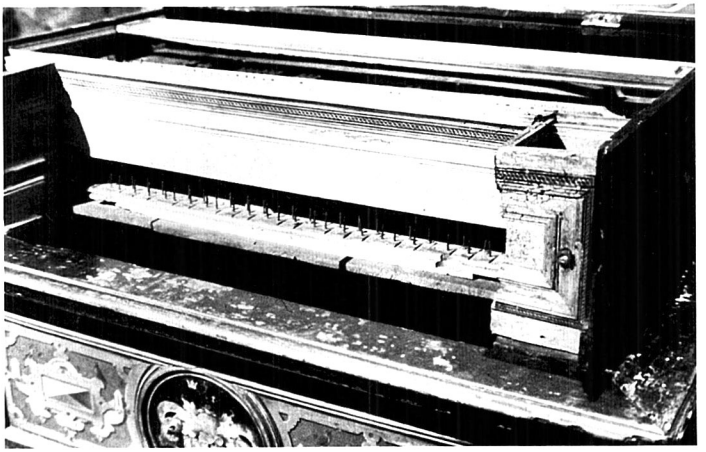

FIGURE 7. Theewes claviorganum: Keyboard surround.

This treatment of the front, and the moldings around the inside (rather than on the top) of the spine, tail, cheek, and bentside, indicate that this is a false inner-outer[58] instrument, and the *trompe l'oeil* is natural and convincing, unlike the conventionalized and unrealistic effects painted on some later Flemish instruments.[59] The resulting decor is rare, if not unique, among extant Northern instruments, but there is reason to believe that leather-covered false inner-outer Northern instruments were quite common in the sixteenth and seventeenth centuries.[60] Naturally, the illusion must be based upon the prior existence of *true* inner-outer Northern instruments.[61]

The interior of the lid-flap is painted blue, and the lid itself has two oval medallions, the larger depicting Orpheus charming the beasts, and the smaller perhaps a pastoral scene, all surrounded by strapwork on a wine-colored ground. The soundboard bears traces of painted flowers that appear to be original.

58. Hubbard, 20.

59. Germann, 54–105, esp. 65–67.

60. See Barry (1982), 31–45.

61. In 1564 Cornelis de Zeeuw represented a true inner-outer Flemish virginal in *Family Portrait.* Private collection. See Ripin, plate 57.

The casework of the organ is painted with strapwork in a style that derives from engravings that were being published in the 1540's and 1550's.[62] The pilasters, rails, and stiles, are black; the carvings and moldings are gilt. The ground of the panels is wine-colored, and these have, in addition to the strapwork, various badges and the arms of the Roper family. Prior to a cleaning of the casework in 1947, they were painted over with the arms of Sir Edward Hoby, of Bisham, Berkshire, and of his wife, Margaret. "This marriage took place in 1582, and Lady Hoby died in 1605; the overpainting must have occurred between those years."[63]

Stepping back to view the instrument as a whole (fig. 1), one sees that the casework of the organ is not a fantasy or a *trompe l'oeil,* but rather it has a form that arises entirely out of its function. The lower section, about 66 cm high, is ". . . a foote of wainscott and the Bellowes lyinge in the same," in the words of Philipp Van Wilder describing a similarly disposed instrument in 1547.[64] The upper section, about 38 cm high, has its own complete bottom, whose position is indicated by a molding in the casework, and is the organ proper. The structure of the lower case consists of a floor frame, indicated by a base molding, supporting stiles, indicated by pilasters, and supporting rails, indicated by a cornice. The floor frame is filled in by a solid panel—the bottom—and the pilasters have solid panels between them, totally enclosing the blowing compartment, or "foote," on five sides. A gilt line defines the boundary between the "foote" and the organ which are thereby separated visually even though they do not physically come apart.

The quality of the decoration is considered of the highest order, although it has been restored several times.[65] Recalling the skills of the members of the Guild of St. Luke: painting, carving, framing, paneling, bookbinding, and printing, as well as making harpsichords,[66] one recognizes that all of these crafts were called into play in producing this claviorganum of 1579.

* * *

There are ten holes in the front of the organ case—five on each side—which formerly contained drawknobs controlling five ranks of pipes divided into ten half stops (see fig. 6). Around the corner, in the vertical im-

62. Peter Thornton, private communication.

63. Schott, 42.

64. Barry (1982), 39.

65. Peter Thornton, private communication; also Sheridan Germann, private communication.

66. Hubbard, 46–47.

mediately beneath the cheek of the harpsichord, is a similar hole, 1.5 cm in diameter and 85 cm above the floor (see fig. 1), and there is another hole in the corresponding location on the spine side. These last two holes seem to have contained drawknobs controlling a coupler (organ to keyboard), also divided into bass and treble.

The organ must have had a fixed register, or upper guide, for the coupler stickers, and it seems that Theewes, with the example of the movable lower harpsichord registers before him, thought to have a movable lower sticker register, moving side to side one-half keyscale, or 6.8 mm, in addition to the necessary fixed upper sticker register. (It seems that, due to the geometry, the movable lower harpsichord jack registers also must travel about one-half keyscale.) The two drawknobs in the sides of the case were connected (via two horizontal trundles with a working length of about 9 cm) to the ends of the movable lower sticker registers, so that the coupler was divided into bass and treble. The trundles reversed the motion ("out" equalled "on" for both bass and treble) and increased the travel of the drawknobs to a respectable distance of perhaps 4 or 5 cm.

* * *

The upper front panel, immediately below the keyboard, is removable to reach the front two ranks (ahead of the stickers), especially the Regal, which would need frequent tuning. The top of the organ case is cut out to fit around the harpsichord bottom; this top is removable and is secured from the inside by wooden buttons. In order to tune the back three ranks (behind the stickers), it was necessary to remove the harpsichord and the top panel of the organ case. The harpsichord is provided with lid latches—apparently original—so that the harpsichord could be set on the floor on its spine while the organ was being tuned.

* * *

The various parts of the Theewes organ were examined and identified for Russell's 1968 *Catalogue*[67] by Austin Niland, who described the bellows as "2 diagonal feeders with four folds each (Italian style)." I did not examine them closely, but they seemed to be too small, and the wrong type, to be original; perhaps they are seventeenth- or eighteenth-century work. One would expect to find two identical wedge bellows, suitably weighted and as large as possible. There is a single hole in the tail end of the organ case, about 6 cm in diameter and some 50 cm above the floor, located so as to center on the treble bellows; through this hole passed the two ropes by which the pumper raised the feeders.

67. Russell (1968), 48–49.

The interior of the organ case contains a complete bottom of nominal 1″ softwood just above the floor. The space above this is devoted entirely to the wind system. Thus there is room for a pair of wedge bellows, side by side, each about 180 cm long and 45 cm wide, rising to a height of about 45 cm, allowing for the necessary clearances. The lower panel at the keyboard end locks into place with a key, and behind this panel was a space 20–30 cm deep, ahead of the wind trunk and the collector of the wind system, that might have been used as a storage closet.

* * *

The bottom of the organ (as distinguished from the "foote") is of softwood about 3 cm in thickness, and completely partitions off the interior of the case at the level indicated by the cornice, i.e., about 66 cm above the floor. Consequently the chest, mechanism, and pipes, of the organ are confined to a space that is a mere 36.3 cm in height. The bottom of the organ is also the bottom of the windchest; the exact location of the windchest may still be seen, outlined upon the bottom in packing leather. There is a rectangular wind inlet hole about 12 cm square, cut in the bottom and leading to the bass rear corner of the windchest; this opening constitutes the only communication between the organ and the "foote."

The low clearance under the top of the organ and the bottom of the harpsichord (which are in about the same plane) is a determining factor in the disposition of the pipes. Indeed the height of the chest is 14.4 cm, which leaves a clearance of only 21.8 cm above the chest. Allowing perhaps 7.5 cm for the length of the pipe feet and 2.5 cm for clearance at the top of the pipe, perhaps 12 cm is the speaking length of the longest metal or open wooden pipe that can stand on its own wind. (Stopped wooden pipes would need additional clearance for overlength and for the stopper handle.)

There is no sign that there were ever any rackboards. Short wooden pipes (less than 22 cm overall) with round tapered wooden feet perhaps 2.5 cm long, firmly inserted into tapered toe holes, would have required no additional support. It seems most likely that all the pipes of the Theewes, excepting the Cymbel, were of wood. The Cymbel, whose largest pipe was perhaps 15 cm in overall length and 1.0 cm in diameter, would also have been supported adequately by suitably tapered toe holes.

* * *

The compass of the organ is *C*, *D*–c^3 (no *C*♯), 48 notes. Looking at the bottom of the chest (fig. 8), one discovers thirty-nine pallets with glued-down tails remaining, and nine pallets missing. The bass end of the chest is detached, but remains intact. Even the spring rail remains, but is inserted

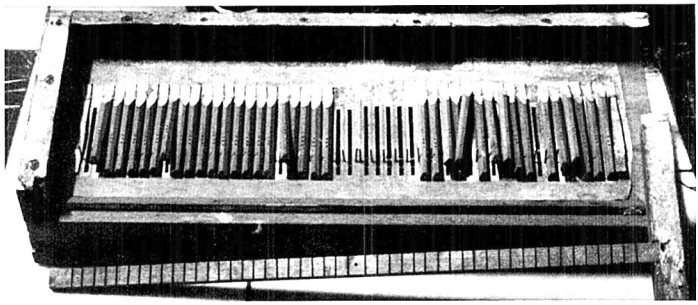

FIGURE 8. Theewes claviorganum: Bottom of windchest.

upside down (but not backwards) in its mortise in the bass endpiece. The bung is missing. Five screws in the back, and three on either end, fastened the chest to the bottom board.

The total width of the 49 keys was 666 mm, and the key scale is 482/36, or 13.4 mm. The scale of the chest is slightly larger than this: 666/47, or 14.2 mm. The center of the chest is between middle c^1 and $c\sharp^1$, and the bass pallet openings are actually a trifle narrower (if longer) than the treble pallet openings, in order to gain the space for the wide bar for screws in the middle of the grid. The slight difference between the scale of the keys and the scale of the chest was easily accommodated by skewing the stickers slightly.

In order to achieve a slider travel of one chest scale the toe holes in the chest are alternated in two rows, no matter how small the pipes are. Thus the widest pipe that can stand on its own wind is double chest scale, or 28.3 mm wide. The Regal is arranged in a single row, although its wind comes from alternating holes, so that its pipes can be no wider than chest scale.

* * *

Looking at the top of the chest from the front (fig. 9), one sees that the first toe board accommodated a very small rank of flues with the Regal behind it. The flue rank seems to have only two sizes of toe holes from bass to treble, apparently arranged in alternating half-octaves: 5, 6, 6, 6, 6, 6, 6, and 7 notes respectively. It is clear that this was a one-rank repeating Cymbal. Assuming it was a unison, a 29th would be a little too long to stand in the available height and a little too grave for a Cymbal; a 43rd would fit, but would be too acute. The middle ground, neither too long, too grave, nor

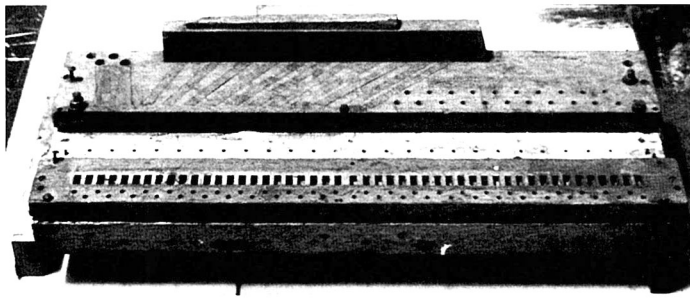

FIGURE 9. Theewes claviorganum: Top of windchest from front.

too acute, would be a 36th, 1/4′, breaking every octave. A reasonable scale at *C* would be about 10 mm.

Most of the first toe board shows the effects of four centuries of the exposure of the unfinished oak to air and dirt. The outline of the Regal boots can be seen, and it seems that the Regals were fully as wide as the chest scale, and that these pipes had a constant section over the full four octaves. The sites of the Regal boots exhibit three shades of color that can tell us about how long the boots have been missing from the toe board. The top seven pipes have been missing for nearly four hundred years, perhaps since the time between 1582 and 1605 when the claviorganum passed from the Roper family to the Hoby family. The b^2 boot seems to have remained in place at that time, but its pipe certainly did not play all by itself.

There seem to be twenty-one very clean sites (#1–8, #13–23, #28–29), and seventeen of these must have been covered by the boots removed during the cleaning of ca. 1966 and now exhibited elsewhere in the museum in a glass case known as "Cabinet A" (fig. 12). Four boots are missing, and these seem to have gone astray on the journey from the toe board to "Cabinet A."[68] There are in addition twenty-one moderately dark sites (#9–12, #24–27, #30–41, and #47) that have been exposed for perhaps two centuries. One might conclude that, whatever the state of the organ or the harpsichord at that time, the Regal was certainly out of service from that day to the present. The first toe board was held down by six screws, of which the two in the center are missing.

68. Perhaps they were taken as souvenirs by the four (?) persons responsible for the cleaning.

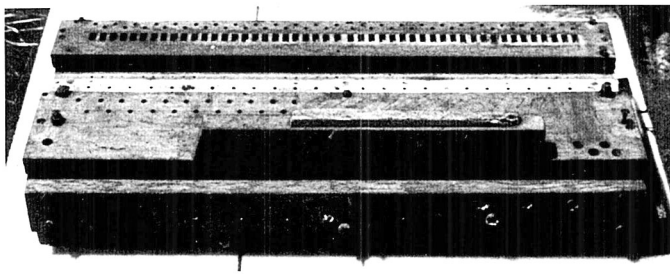

FIGURE 10. Theewes claviorganum: Top of windchest from back.

* * *

Behind the first toe board is a space for the stickers which, due to the angle of the photograph, shows in the view of the top of the chest from the rear (fig. 10). Behind the space for the stickers is the space for the second toe board, half of which, due to the angle, may be seen in each view. The toe board itself is missing, as are the six screws that held it down. The white leather that covers the table, suede side up, may be seen, and this leather is cleaner where it was under the toe board than it is in the sticker space, indicating that it has seen some service, although its condition is so good as to cause one to doubt that it is four hundred years old. This leather was carefully examined for signs of a break between the bass and treble sliders, and an indication was found between *a* and *a*♯. All ten of the sliders are missing; they were likely of quartersawn hardwood—oak or walnut—3–4 mm in thickness.

* * *

The third toe board is fastened down with five screws, none of which is missing. The view from the front (fig. 9) shows that the lowest four notes are channelled to holes in the rear of the toe board, to be conductored elsewhere. Thirteen routed channels, covered with veneer, may be seen, but the channelling is double-decked; there are fourteen additional channels in the bottom of the toe board. The view from the rear of the chest (fig. 10) shows that four notes, *C–E,* are conductored elsewhere, and twenty-three notes, $F–d\sharp^1$, are channelled to a vertical toe board, so that the pipes themselves can be installed horizontally. The remaining twenty-one pipes, $e^1–c^3$, stood on their own wind. The largest of these, e^1, must have had a speaking length not exceeding perhaps 12 cm, as we observed above (page 23), and a width not exceeding 28.3 mm (page 24).

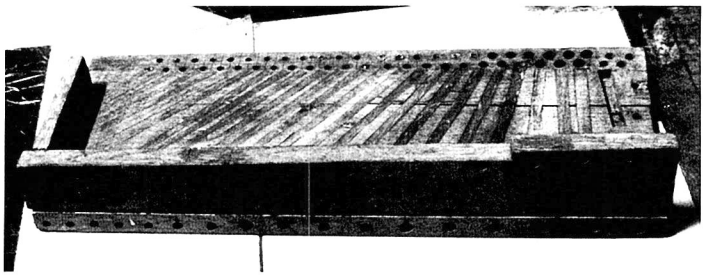

FIGURE 11. Theewes claviorganum: Channel board from back.

* * *

The fourth toe board is installed vertically on the rear of the grid, and exhibits the remains of at least eleven metal wind conductors, extending even into the extreme treble. It is evident that the pipes winded from this toe board were the largest in scale, required the most wind, and were in fact the 8′ Stopped Diapason, whatever it was called.

* * *

The channel board was found in three separate pieces and put together loosely for the photograph (fig. 11); the view is from the back, or tail end, of the instrument. Feeding this channel board were forty-eight metal conductors from the fourth toe board, plus four more from the third toe board. The lowest thirty-four Stopped Diapason pipes (C–$a^{\sharp}$) extended backwards from the vertical toe board in two layers. The little vertical toe board in the rear treble corner of the channel board winded the next six pipes (b^1–e^2) lying crosswise. There are eight toe holes in the front treble corner of the channel board for the remaining pipes (f^2–c^3), standing vertically. (These last toe holes, unfortunately, do not show in the photograph.)

The channel board, about 36.3 by 86.5 cm in size, lay on the bottom of the organ behind the chest, and its thickness is about 4 cm, so that the clearance above it is 32.3 cm. Allowing 7.5 cm for the foot and block, 2.5 cm for clearance at the top of the pipe, and an additional 2.5 cm for overlength and the stopper handle (assuming stopped wooden pipes), perhaps 20 cm is the speaking length of the longest pipe that can stand upright on the channel board. This longest pipe is f^2 of an 8′ stop, and there is plenty of height if it is stopped, but not quite enough if it were open.

The purpose of the channel board is to receive the wind at chest scale

and to spread it out to pipe scale. Thus the channel board can tell us, within a few millimeters, the width of every pipe for which it was laid out. The holes in the lower row of seventeen holes in the rear of the channel board were aimed at the centers of the larger pipe of alternating pairs of the 8′ Stopped Diapason bass. Looking at the spacing, one can see that it steps down nicely in logarithmic proportions. Looking at either end of the channel board, one can see that the channel board continues about half a pipe-width beyond the last toe hole.

If these seventeen pipes were as large as possible (so as to touch on the sides), the sum of their widths was close to 86.5 cm. If these pipes were separated by (sixteen) spaces, the sum of these spaces would not have exceeded perhaps 8–10 cm (which defines the *minimum* width of the seventeen pipes); otherwise the vertical toe board could, and would, have been narrower, or else winded more than thirty-four pipes. These seventeen pipes in the lower row were *C* plus the even-numbered pipes from *D*♯ through a^1.

The photographs of the Theewes that illustrate this article were originally taken in the form of color transparencies. It was possible, therefore, to study the various parts of the organ by projecting the appropriate slide on a screen, life-size, or even larger. Examining the projection of the slide corresponding to fig. 11, it was determined, using proportional dividers, that, for example, the distance between the centers of the toe holes for *D*♯ and *F* (which is a good approximation of the width of *E*) was twice the distance between the centers of the toe holes for $d♯^1$ and f^1 (which is a good approximation of the width of e^1). Thus the maximum width of the pipes seemed to halve on the double octave, or twenty-fifth chromatic pipe. There is plenty of evidence[69] that this system of scaling was frequently used in the early days and, as a practical matter, in its modern form (called the 24th step ratio), would be a reasonable scaling for small-scaled wood pipes today.

The width of any pipe in a rank that halves on the twenty-fifth note can be expressed in terms of the width of the first pipe, *C* (1), and the number of the pipe, *n*, as follows:

$$W_n = W_1 \cdot (2)^{(1-n)/24}$$

In order to write an expression for the sum of the maximum widths of the seventeen pipes represented by $n = 1, 4, 6, 8, \ldots 30, 32, 34$, let $k = n/2$.

69. See Mahrenholz, 39–40.

Then:

$$W_T = W_1 \left(1 + \sum_{k=2}^{k=17} (2)^{(1-2k)/24} \right)$$

Evaluating the series:

$$W_T = W_1 \cdot 10.85450 \ldots$$

Whence: since $W_T = 86.5$ cm, $W_1 = 7.97$ cm.

A table of values could now be constructed, giving the estimated maximum width of every pipe in the rank. Of course it was not until the middle of the eighteenth century, notably in the work of Georg Andreas Sorge,[70] that the use of logarithms was introduced into the scaling of organ pipes. The scaling used by Theewes proceeded discretely from pipe to pipe by steps ultimately derived from Pythagorean theory, so that his "curve" was probably composed of short line-segments that varied a little in some places, both plus and minus, from our curve. But our curve is based upon both the height and the slope of Theewes's "curve," so that one can be certain that some points will diverge a trifle, other points will coincide, and the differences will average out.

The minimum values are also of interest; if one supposes sixteen spaces of about 5 mm each between the seventeen pipes, the sum of the spaces would be 8–10 cm, or, say, ten percent, making the minimum pipe-width about ninety percent of the maximum. The estimated outside widths of the C's work out as follows:

Pipe	Maximum	Minimum
C	80 mm	72 mm
c	57	51
c^1	40	36
c^2	28	25
c^3	20	18

In 1959 only three wooden pipes of the Theewes organ were still in existence and by 1968 only one pipe ("part of one wooden stopped pipe, about four feet long") remained.[71] This single remaining pipe of the

70. See Sorge.
71. Russell (1959), plate 53 (description); Russell (1968), 49.

Theewes was measured by Koster and identified as $D\sharp$.[72] The maximum theoretical width of this pipe would be:

$$79.7 \times (1/2)^{(1/8)} = 73 \text{ mm}$$

and the minimum would be ninety percent of this, or 66 mm. The dimensions of this pipe were measured as follows:[73]

		Width	Depth
	Outside	66.5 mm	76.0 mm
minus	Inside	50.7	63.5
equals	Double Wall	15.8	12.5
× 1/2	Single Wall	7.9	6.3

The smallness of this measured width with respect to the maximum width may be assessed as follows:

$$73 \times (1/2)^{(x/24)} = 66.5 \qquad \text{or,}$$

$$x = \frac{24\log(66.5/73)}{\log(1/2)} = 3.23$$

This means that the actual pipes seem to have been about 3-1/4 scales smaller than the maximum scale the channel board could accommodate with no spaces between the pipes. The difference in the wall thickness of a single pipe seems extreme, although I have noticed a difference of fourteen percent in the thickness of two toe boards.

The width of the mouth of a cylindrical metal pipe is most commonly 1/4 of the circumference, especially in early work. In such a pipe the width of the mouth, multiplied by the diameter, equals the cross-sectional area. For a rectangular wooden pipe to have the same ratio between the mouth-width and the cross-sectional area, the inside width of the pipe should be pi/4 times the inside depth of the pipe. The determination of pi by Archimedes (d212 B.C.) was 22/7, and this value seems to have been still in use in Theewes's time.[74] Testing the $D\sharp$ pipe by this ratio, 63.5 mm × 11/

72. Koster, 53.

73. John Koster, private communication.

74. A better approximation of 355/113 was proposed by Adriaan Metius (1571–1635). Dom Bédos gives an account of these approximations and chooses to use 314/100, which is about as small to the true value as Archimedes' value is large. (Metius' approximation is good enough for most practical purposes today.) See Bédos de Celles, Part I, Chapter II, Section One, Para. 46 (p. 8).

14 = 49.9 mm, or 0.8 mm small, easily within the margin of error of this particular pipemaker.

Working backwards from this very credible $D\sharp$ pipe, if its inside depth is 63.5 mm, the inside depth of C would be:[75]

$$63.5 \times (2)^{(1/8)} = 69 \text{ mm}$$

and the inside width of C would be 11/14th (Archimedes' pi/4) of this, or 54 mm.

The estimated inside dimensions of all the C's may now be determined as follows:

Pipe	Ratio	Width	Ratio	Depth
C	11/14	54 mm	1/1	69 mm
c	$11\sqrt{2}/28$	38	$\sqrt{2}/2$	49
c^1	11/28	27	1/2	35
c^2	$11\sqrt{2}/56$	19	$\sqrt{2}/4$	24
c^3	11/56	14	1/4	17

The channel board holds, in addition to the forty-eight pipes of the 8′ Stopped Diapason, the first four pipes of the rank on the third toe board, and these must be the stopped wooden pipes of a 4′ Flute, lying crosswise, mouths up (since open 4′ pipes would be too long to fit in the available space). Knowing the length of the vertical portion of the third toe board (782 mm), one can project the slide corresponding to figure 10 on a screen and measure the spacing of the toe holes exactly, to determine the maximum width of pipe the toe board will accept. The first pipe of this rank that stands on its own wind (e^1) also has a known maximum width (double chest scale).

It turns out that the scale of the 4′ Flute may be no greater than the scale of the 8′, and, in the absence of any reason to believe otherwise (this scale is already very small in absolute terms), one might conclude that the scale of the 4′ was probably as large as possible, or the same as that of the 8′. The longest pipe on its own wind (e^1), with a nominal length of 2/5′ + 12.5 cm, which works out to 24.7 cm, actually fits into a clearance of 21.8 cm, so that one is convinced that this is the longest pipe that can stand on its own wind. Indeed the first open pipe short enough to stand on the chest would be about d^2, and if the first thirty-eight pipes of this 4′ rank are stopped wood,

75. This logarithmic calculation is unhistorical and not exactly correct, but will not vary from the true dimension by more than about one percent, or 1 mm, no matter how Theewes calculated his stepwise scaling.

the balance must be also. It is perfectly feasible, with a four-octave compass, to carry stopped wooden pipes to the top of a 4′.

Taking a final look at the channel board (fig. 11), one notices a substantial crack down the middle. Both the top and the bottom of the channel board have twenty-six pieces of veneer inlaid in them, whose grain runs counter to the grain in the board, especially in the bass, and the crack is widest in the bass. Knowing that the width of the channel board is about 363 mm, and estimating the greatest width of the crack at 9 mm, one concludes that the board would have shrunk 2-1/2 percent in width, if it had not been restrained by the veneer. One might think that this crack did not occur until after 1890, when the claviorganum was first brought into the museum and subjected to central heating, but on the contrary the color of the wood, and the accumulated dirt, inside the crack suggest that the crack occurred well before, say, 1700. The remaining Regal boots also show signs of early shrinkage of about 2-1/2 percent, as will appear below.

* * *

The second toe board is missing, but its pipes are subject to the same limitations of height as are those on the third toe board. One naturally expects a 2′ stop, and obviously *e* of a stopped 2′ rank is the longest pipe that can stand in the available height. This pipe could be as wide as double chest scale, or 2.83 cm. This width may be compared with the maximum width of the 8′ Stopped Diapason as follows:

$$79.7 \times (1/2)^{(x/24)} = 28.3 \qquad \text{or,}$$

$$x = \frac{24\log(28.3/79.7)}{\log(1/2)} = 35.85$$

This means that *e* of the 2′ can be no wider than c^2 of the estimated maximum Stopped Diapason, or a^1 of the estimated actual scale of the 8′. The scale of the 2′, then, might have been anything from 0–7 scales larger than the 8′ (and 4′)—smaller seems unlikely. Suppose one chooses a moderate path and estimates the 2′ to have been 2 scales larger, making the inside dimensions of *C*:

$$69 \times (1/2)^{(22/24)} = 37 \text{ mm (depth)} \qquad \text{and}$$

$$37 \times (11/14) = 29 \text{ mm (width)}$$

The difference of two scales amounts to only 2.5 mm at *C*, or about 7 percent throughout the compass, so that it seems that one may grind this grist rather small.

It is necessary at this point to go back and observe a detail in the construction of the toe boards that was previously passed over. Referring to figure 11, one can see that the vertical toe board on the channel board is notched out in the center for a distance of about 42 cm. This notch matches the lower row of toe holes in the vertical portion of the third toe board in both height and extent, and it is clear that the purpose of the notch was to provide a support for the extreme ends of the 4′ Flute pipes in the lower row (the even-numbered pipes F–d^1).

Now looking at the vertical portion of the third toe board (fig. 10), one finds a batten fastened to its top, about 30 cm in length, and extending about from B to $d\sharp^1$ on the chest. The conclusion is inescapable that the missing toe board for the 2′ rank also had a vertical section, and that the only purpose of the batten could have been to support horizontal 2′ pipes at the proper level. Reconstructing this toe board from the evidence, the first ten pipes (C–$A\sharp$) lay crosswise, mouths up, in two layers over the channels in the third toe board. The next five pipes (B–$d\sharp$) extended over the batten and were winded from the vertical toe board. The next six pipes (e–a) were short enough to stand on their own wind, and probably did. Now, if the break between the bass and the treble was at a–$a\sharp$, and if the 2′ treble half-stop were open pipes, the six pipes ($a\sharp$–$d\sharp^1$) would be too long to stand on their own wind, and would need to be disposed horizontally. Obligingly, the batten extends just far enough to accommodate these pipes. (And above $d\sharp^1$ the vertical 4′ pipes on the third toe board would have interfered in any event.) If on the other hand the 2′ treble had been of stopped pipes, the batten extended exactly an octave higher than necessary.

* * *

The stoplist of the Theewes organ can now be stated with some assurance:

Five ranks and a coupler (organ to keyboard), drawing in twelve half stops, divided at a–$a\sharp$.

Compass: Four octaves, C, D–c^3 (omitting $C\sharp$), 48 notes.

				Approximate Inside Dimensions:
1.	Stopped Diapason 8′		wood	C: 54 mm × 69 mm
2.	Flute 4′		stopped wood	C: 38 mm × 49 mm
3.	Principal 2′	Bass:	stopped wood	C: 29 mm × 37 mm
		Treble:	open wood	

4.	Cymbel I rank	1/4′ repeating, metal	*C*: 10 mm diameter
5.	Regal 8′	wood	
6.	Coupler	(Organ to Keyboard)	

Of the two hundred forty pipes in this organ, one hundred forty-four were shorter than 22 cm, and stood vertically on their own wind. In addition, eight pipes shorter than 22 cm stood vertically on the channel board. The pipes longer than 22 cm, eighty-eight in number, lay horizontally and were winded via channels and conductors.

* * *

A number of odds and ends discovered in the course of cleaning the interior of the organ ca. 1966 are displayed in Cabinet A (fig. 12). A list of these, together with any comments, follows:

1. A piece of a jack.

2. Part of jack #22.

3. Most of jack #33.

4. A fragment of tooled leather from the harpsichord case exterior.

5. Two pieces, totalling about one-half of a leather guide. This may be the original guide, discarded long ago, but saved for use as a templet. One piece has thirteen notes and the other twelve, so that these pieces are no part of the guide now in the instrument, which is missing five pieces containing respectively four, three, eight, seven, and nine notes.[76]

6. Two short wooden battens, each with a steel pin in one end, and to each side of which is glued one edge of a strip of soft leather, suede side out, so that one edge of the batten has a soft leather purse. These seem to be the ends of a buff batten that lowered (by rotating) onto the strings from above. These are old, but there is no evidence that they were ever a part of the Theewes, which seems to have served as a storage closet (see page 23) for various bits and pieces of musical instruments at Ightham Mote, particularly those of the mysterious spinet, for which the Hitchcock key was altered (but never installed), and to which perhaps both the strange accidental key and the two pieces of a buff batten originally belonged.

7. Two pallet springs, about 15 cm long, and about the right size. These are clean and bright, while other ironwork, particularly the balance pins of the keyboard, is distinctly corroded. These springs may be later replace-

76. See Russell (1959), plate 54.

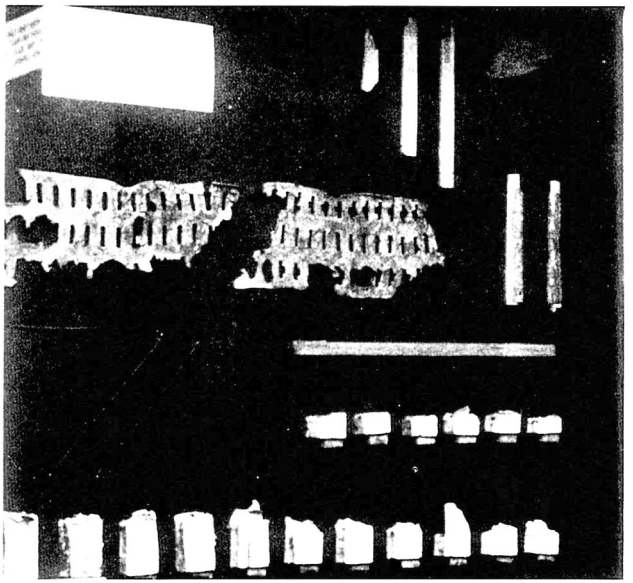

FIGURE 12. Theewes claviorganum: Cabinet A, containing miscellaneous parts.

ments. On the other hand, within the pallet box and inside the organ case, the pallet springs were better protected from dampness and air pollution than were the balance pins.

8. One coupler sticker about 3 mm × 10 mm × 22.5 cm in length. This seems a little too clean and bright to be four hundred years old; perhaps it is a later replacement.

9. Seventeen wooden Regal boots. These are covered with about two layers of paper, wrapped tightly and glued. The letter of the note, written in ink, may still be seen on the paper. In the course of time, perhaps rather early, the wooden blocks had shrunk, like the channel board, so that they no longer fit tightly in the boots. Moreover the boots and resonators themselves had shrunk, so that the Regals no longer fit tightly side to side. Variable leakage, as the pipes shifted in the boots, especially during tuning, affected the pitch and made the pipes unstable in pitch and dif-

ficult to tune. The purpose of the paper was to reduce the leakage and prevent the pipes from shifting around so much. The wooden Regal boots are not very heavy, so that gravity alone would not keep them in place during tuning.

Ordinary paper is about 0.1 mm in thickness, and two layers, or four thicknesses, restored the width of the boots to full chest scale. Consequently the shrinkage had been about 0.4 mm in 14.2 mm, or 2.8 percent.

* * *

Confronted with an artifact as marvelous as the Theewes claviorganum, one cannot help but wonder how it came into existence; what was in the mind of the maker as he began his work? Of course, one might measure all the dimensions of all the pieces in millimeters, and try to make a perfect copy of the model, mistakes and all, without understanding anything of the principles that Theewes followed. But, since the length, width, and height of the harpsichord seem to be commensurable with the Flemish measures, further study would probably reveal that other dimensions are commensurable as well. Knowing all the nominal dimensions of the instrument in *duimen* would give us some understanding of what Theewes had in mind, and the difference between the nominal and the measured dimensions would tell us how carefully he seems to have worked.

One might lay down as a working hypothesis the notion that, in the absence of any reason to the contrary, all the dimensions of any early keyboard instrument are probably commensurable with the prevailing standard of measurement. For instance, Werner Walcker-Mayer reported in 1970 that the dimensions of the 228 A.D. Roman organ of Aquincum seem to have been commensurable with the Roman foot.[77] I reported in 1985 that the dimensions of the keys of the 1361 Halberstadt Cathedral organ, and all the dimensions of the small keyboard instruments described and illustrated by Henri Arnaut de Zwolle ca. 1440 were commensurable with the same standard.[78] Thomas and Rhodes pointed out in 1973 that both the case dimensions and the *Stichmass* of the Ruckers instruments are commensurable with the Antwerp *duim*.[79] Undoubtedly, the use of the English foot, the French *Pied du Roi,* and various Italian and German standards of measurement could be discovered in the various appropriate instruments.

77. Walcker-Mayer, 37–38.
78. Barry, *The Tracker* (1985): 16; Barry, this *Journal* (1985): p. 7, footnote 11.
79. Thomas and Rhodes, 114.

It seems that it has been possible to recover the scaling formula of the back 8′ choir of the Theewes harpsichord, and the intended length of the strings. It would be fascinating to study other early Northern harpsichords with non-Pythagorean scaling to see if they exhibit a definite scaling formula—not necessarily that of the Theewes.

The full chromatic bass and the *Stichmass* of the Theewes seem to be in accordance with a London tradition different from that of Antwerp. This London *Stichmass* may be in imitation of instruments imported from Northern Italy, like "Queen Elizabeth's Virginals" and many other documented examples, since lost. Kevin Coates[80] has demonstrated that the dimensions of many Northern Italian viols are commensurable with a Brunswick *Zoll* of about 23.78 mm.[81] Examples range from a bass viol by Battista Ciciliano, Venice, ca. 1590,[82] to a violin by Antonio Stradivari, Cremona, 1703.[83] This seems to suggest that a school of Italian lutherie may have been founded ca. 1500(?) by immigrant German luthiers.[84] The *Stichmass* of the Theewes, therefore, may amount to thirty-one naturals in thirty Brunswick *Zollen* (exactly $30/31 \times 23.78 \times 21 = 483.3$ mm). If this were true, the *Stichmass* of the Theewes arrived in London by a long roundabout route.

* * *

With fifteen drawknobs, the Theewes was capable of an astonishing variety of combinations: theoretically, $2^{15} - 1 = 32{,}767$. The organ half stops made two-manual effects possible: for *Growndes,* duos, and accompanied treble solos. The organ is completely enclosed on all sides, like the later *Echoes* organs,[85] but the upper front panel of the organ was removable, if it were desired to let out the sound. By the same token, the harpsichord could have been played with the lid down, if it were desired to keep in the sound. The Elizabethan and Jacobean keyboard music, contemporary with the Theewes, that has survived to our time, has been described by John Caldwell.[86] Perhaps some of this music was intended for the organ, and some for the harpsichord ("virginalles"), but much of it would go equally

80. Coates, 22. Coates does not mention that a few of the instruments he analyzes seem to have dimensions that resonate to the Roman foot.

81. This was also the measurement used by Praetorius. See Barry, *The Tracker* (1985): 16.

82. Coates, 39.

83. Coates, 76.

84. See Lang, 239–240.

85. Beginning with Father Smith: Temple Church, London, 1688. See Clutton and Niland, 59–69.

86. Caldwell, 52–156.

well on either instrument.[87] The Theewes claviorganum would seem to be an ideal vehicle for realizing all of this literature.[88]

There is mention of several sixteenth-century English claviorgana which would be collateral to the Theewes: in 1530 William Lewes, of London, delivered two claviorgana to King Henry VIII, who, at his death in 1547, owned four claviorgana.[89] In 1583 Robert Dudley, Earl of Leicester, possessed at Kenilworth ". . . an instrumente of organs, regalles, and virginalles covered withe crimson velvett and garnished withe golde lace . . ."[90] There are in existence at least five other sixteenth-century claviorgana, in whole or in part, all originating in South Germany or Austria.[91] It may be that a comparative study of these instruments collateral to the Theewes would yield some interesting results.

One concludes this tour through the 1579 claviorganum by Lodewyk Theewes of London with a feeling of immense respect for the craftsmanship and ingenuity of its builder. Much has been discovered and some interesting speculations have been raised. These in turn suggest further investigations and raise further questions. The special problems posed by the Theewes required a special way of proceeding, so the methods of this present study are probably not directly applicable to many other investigations. Still, to some minds, the methodology of this present study may be as interesting as the findings.

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87. See Caldwell, 63.

88. Specialists in performance practice may begin working out the correct, or authentic, registration for all these pieces on the Theewes.

89. Barry (1982), 39–40.

90. Russell (1959), 68.

91. Briefly described in Wilson Barry, "Claviorganum," *Encyclopedia of Keyboard Instruments*, gen. ed. Robert Palmieri: Vol. 2 *The Clavichord and Harpsichord* eds. Igor and Judith Kipnis (New York: Garland Publishing Inc., forthcoming).

Bibliography

Adlung, Jacob, *Anleitung zu der musikalischen Gelahrheit* (Erfurt, 1758); facsimile reprint ed. Hans J. Mooser (Kassel: Bärenreiter, 1931).

Barry, Wilson, "The Keyboard Instruments of King Henry VIII," *The Organ Yearbook* 13 (1982), 31–45.

———, "Preliminary Guidelines for a Classification of Claviorgana," *The Organ Yearbook* 15 (1984), 98–107.

———, "The Gothic Organ at Halberstadt, Revisited," *The Tracker* Vol. 29 No. 2 (1985), 12–18.

———, "Henri Arnaut de Zwolle's *Clavicordium* and the Origin of the Chekker," this *Journal* 11 (1985), 5–13.

Bédos de Celles, François, *L'Art du facteur d'orgues,* 4 vols. (Paris, 1766–78); trans. by Charles Ferguson under the title *The Organ Builder,* 2 vols. (Raleigh: The Sunbury Press, 1977).

Blumenfeld, Harold, trans., *The Syntagma Musicum of Michael Praetorius: Volume Two, De Organographia, First and Second Parts, Plus All Forty-two Original Woodcut Illustrations from* Theatrum Instrumentorum (New York: Bärenreiter, 1962; New York: Da Capo Press, 1980).

Boalch, Donald H., *Makers of the Harpsichord and Clavichord 1440–1840* (London: George Ronald, 1956); 2nd ed. (Oxford: Oxford University Press, 1974); 3rd ed., ed. Charles Mould (Oxford: Oxford University Press, forthcoming).

Caldwell, John, *English keyboard Music before the Nineteenth Century* (New York: Frederick A. Praeger, Inc., 1973; New York: Dover Publications, 1985).

Clutton, Cecil, and Niland, Austin, *The British Organ* (London: Batsford, 1963); 2nd ed., revised and enlarged (London: Eyre Methuen Ltd., 1982).

Coates, Kevin, *Geometry, Proportion and the Art of Lutherie: A study of the use and aesthetic significance of geometry and numerical proportion in the design of European bowed and plucked string instruments in the sixteenth, seventeenth, and eighteenth centuries* (Oxford: at the Clarendon Press, 1985).

Douwes, Klaas, *Grondig ondersoek van de toonen der musiik . . . Met een tweede deel, handelende van versoheidene musikinstrumenten . . .* (Franeker [Friesland]: Adriaan Heins, 1699); facsimile (Amsterdam: Frits Knuf, 1970).

Ernst, Friedrich, "Four Ruckers Harpsichords in Berlin," *Galpin Society Journal* 20 (1967), 63–75.

Germann, Sheridan, "Regional Schools of Harpsichord Decoration," this *Journal* 4 (1978), 54–105.

Hellwig, Friedemann, "The Single-strung Italian Harpsichord," *Keyboard Instruments: Studies in Keyboard Organology 1500–1800,* Edwin M. Ripin, ed. (Edinburgh: Edinburgh University Press, 1971; New York: Dover Publications, Inc., 1977), 29–38; plates 35–40.

Hubbard, Frank, *Three centuries of Harpsichord Making* (Cambridge: Harvard University Press, 1965; 1967).

Koster, John, "The Importance of the Early English Harpsichord," *Galpin Society Journal* 33 (1980), 45–73.

Lang, Paul Henry, *Music in Western Civilization* (New York: W. W. Norton & Company, Inc., 1941; 1969).

Leppard, Raymond, *Authenticity in Music* (London: Faber Music Ltd., 1988; Portland: Amadeus Press, 1988).

Mahrenholz, Christhard, *Die Berechnung der Orgelpfeifen-Mensuren vom Mittelalter bis zur Mitte des 19. Jahrhunderts* (Kassel, Basel, Paris, London, New York: Bärenreiter-Verlag, 1968); trans. by Andrew H. Williams under the title *The Calculation of Organ Pipe Scales from the Middle Ages to the Mid-nineteenth Century* (Oxford: Positif Press, 1975).

Marcuse, Sibyl, *Musical Instruments: A Comprehensive Dictionary* (New York: Doubleday, 1964); corrected ed. (New York: W. W. Norton & Company, 1975).

———, *A Survey of Musical Instruments* (New York, Evanston, San Francisco, London: Harper & Row, 1975).

Meer, John Henry van der, "Die Orgelklaviere von Valentin Zeiss, Linz," *Kunstjahrbuch der Stadt Linz* (Vienna and Munich: Anton Schroll, 1967), 154–163.

Morgan, Brian, "Master Brian his Virginall," *The English Harpsichord Magazine* Vol. 2 No. 5 [Oct., 1979], 114–115.

O'Brien, G. Grant, "The Stringing and Pitches of Ruckers Instruments," *Colloquium. Ruckers klavicimbels en copieën: Universele instrumenten voor de interpretie van de muziek uit Rubens tijd* (Antwerp, Museum Vleeshuis, September 30–October 2, 1977), ed. J. Lambrechts-Douillez (Antwerp: Ruckers Genootschap, 1977; The Brussels Museum of Musical Instruments, *Bulletin,* vol. VII-12-1977 [reprint, 1978]), 48–71.

———, *Ruckers: A Harpsichord and Virginal Building Tradition* (Cambridge: Cambridge University Press, 1990).

Praetorius, Michael, *Syntagma musicum II De Organographia* (Wolfenbüttel, 1619); ———, *Theatrum instrumentorum* (Wolfenbüttel, 1620); facsim-

ile, ed. Wilibald Gurlitt (Kassel, London, Basel, New York: Bärenreiter, 1958).

Ripin, Edwin M., "On Joes Karest's Virginal and the Origins of the Flemish Tradition," *Keyboard Instruments: Studies in Keyboard Organology 1500–1800,* Edwin M. Ripin, ed. (Edinburgh: Edinburgh University Press, 1971; New York: Dover Publications, Inc., 1977), 67–76; plates 53–61.

Russell, Raymond, *The Harpsichord and Clavichord: An Introductory Study* (London: Faber and Faber Limited, 1959); 2nd ed., revised by Howard Schott (New York: W. W. Norton, Inc., 1973).

———, *Catalogue of Musical Instruments, Victoria and Albert Museum: Vol. I. Keyboard Instruments* (London: Her Majesty's Stationary Office, 1968).

Schott, Howard, *Victoria and Albert Museum Catalogue of Musical Instruments, Volume I: Keyboard Instruments,* 2nd ed. (London: Her Majesty's Stationary Office, 1985).

Sorge, Georg Andreas, *The Secretly Kept Art of the Scaling of Organ Pipes,* unpublished manuscript, 1764; facsimile and Eng. trans. by Carl O. Bleyle, (Buren: Frits Knuf, 1978).

Thomas, W. R., and Rhodes, J. J. K., "Harpsichord Strings, Organ Pipes and the Dutch Foot," *The Organ Yearbook* 4 (1973), 112–121.

Virdung, Sebastian, *Musica getutscht und ausgezogen* (Basel, 1511); facsimile (Kassel, Basel, London: Bärenreiter: 1970).

Walcker-Mayer, Werner, *Die römische Orgel von Aquincum* (Stuttgart: Musikwissenschaftliche Verlaggesellschaft, 1970); trans. by Joscelyn Godwin under the title *The Roman Organ of Aquincum* (Ludwigsburg: Musikwissenschaftliche Verlaggesellschaft, 1972).

Wangermée, Robert, *Flemish Music and Society in the Fifteenth and Sixteenth Centuries,* Eng. trans. by Robert Erich Wolf (New York, Washington, London: Frederick A. Praeger, Inc., 1968).