Directory of

Computer Assisted Research

in Musicology

1985

Walter B. Hewlett

Eleanor Selfridge-Field

Center for Computer Assisted Research in the Humanities

Menlo Park, CA

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Introduction

The use of computers in musical scholarship and college-level teaching can be divided into three general areas of activity--the acoustical, the graphic and the analytical. While specific projects may involve components in all three of these areas, it is more common for applications to center on one or possibly two areas. Thus electronic composers are concerned primarily with sound production; music editors work primarily with graphic material; and musicologists are interested in analysis as a component of musical scholarship. The purpose of this directory is to provide a common basis of information and a method of communication for those people whose efforts are academically focussed and who are working principally in the second and third areas listed above.

Bibliographies of literature on the use of computers in musicology have appeared infrequently. The première issue of *Computers and the Humanities* (1966) carried a three-page listing of such writings, while a fourteen-page addendum in the *College Music Symposium* (VI) of the same year provided a somewhat fuller listing. Subsequent early volumes of *CHum* gave additional bibliographical listings for music. A comprehensive *Bibliography of Computer Applications in Music* (Music Indexes and Bibliogaphies, 7) compiled by Stefan M. Kostka was published in 1974 by Joseph Boonin, Inc. It included 641 listings. The only generally accessible bibliography of a later date is that provided in the article on computers in the *New Grove Dictionary of Music* (1980).

This directory is distinct from the bibliographies listed above in two ways: (1) its emphasis is on work of relevance to historical and theoretical studies in music and does not extend to studies in sound synthesis except to the extent that these interests overlap, and (2) it is not based on smaller bibliographies culled from journals of recent publication but on information that has been offered by roughly 100 scholars who responded to a questionnaire distributed by the Center for Computer Assisted Research in the Humanities in the winter of 1985.

The information contained in this directory will inevitably give an incomplete sample of current and recent work in the field, but it is hoped that it will provide a base line of information on which others may build. In subsequent newsletters we will be happy to include any news that is received in writing. We wish here to acknowledge with gratitude the generous quantity of information that has been provided by so many respondents. We hope that this medium of exchange will be of some value to their future work.

Survey Results

While there is a certain overlap between the interests of scholars in identifying computer environments of practical benefit to their work and the interests of certain computer software and hardware specialists in developing products to meet this need, the orientation of these two groups is still somewhat different. In order to account for this difference, we created two versions of our questionnaire, one for each group. Both versions asked for information about projects currently underway, about general attitudes toward the future development of this field, and about what initiatives would be of greatest benefit in the near future. The scholars' version sought information about acedemic objectives and about hardware and software used in current applications, while the technical version asked more detailed questions about hardware devices, operating systems, and new software. There were also some questions about capabilities in the area of foreign language text handling, because this is so often a requisite of scholarly work in musicology. The questions were all open-ended and not geared toward any kind of statistical tabulation.

Communicating About Computer Research and Applications

A symptom of the degree of distance between those with common interests was the lack of any convergence on the question of the sources of information on which respondents presently rely. This seems to result primarily from practicality. Some scholars depend on the human expertise available to them within their universities. Single users of personal computers tend to rely on popular monthly computing magazines and on personal networks for information about hardware and software. Other scholars become tied into sales promotion programs for hardware and then design their "needs" to fit within the confines of specific equipment.

Among those who seek information from scholarly publications, the most commonly consulted journals are *Computers and the Humanities* (*CHum*), its associated bimonthly newsletter *Scholarly Communication: Online Publishing and Editing* (*SCOPE*), and the *Computer Music Journal*, but the range of other publications cited (from home computer monthlies through the newsletter of the International MIDI [synthesizer] Association to the proceedings of the Institute of Electrical and Electronic Engineers) and the small number of references to each suggest that there really is no appropriate forum for the regular exchange of information between developers and users in the field of music scholarship.

A number of respondents expressed the view that regular features on such work would be a welcome addition to the standard scholarly journals and that more effort should be made to provide information, discussion, and demonstrations at the national meetings of the major associations (notably the American Musicological Society and the College Music Society).

Overview of Current Needs

Assessments of current needs vary with the orientation of the respondent. Some scholars who have substantial projects that have been developed over several years on mainframe computers are concerned about the obsolesence of the hardware on which they depend, or about other obstacles to its use. Of this class of respondents, a significant number seem to have tranferred data input to microcomputers, using the host mainframe for storage and the processing of big jobs.

Those whose initial involvement has been with microcomputers tend to focus on different kinds of tasks, especially those associated with text processing. A large number of individual systems for the entry of musical data are in use on microcomputers.

Many projects in both categories appear to be somewhat hampered in efficiency by a lack of available expertise. Neither mainframe systems designers nor personal computer sales personnel on the whole are familiar with the various special needs of musical scholarship. Some personal computer users asked for information about "software packages for musical analysis." Except for a few basic utility programs for graphics or word processing, such software packages are not known currently to exist. Some users developing projects involving mainframe computers with a host of small peripheral devices imagine that their work could be expedited by being able to engage a full-time programmer whose focus would be exclusively on their needs. Integrated systems to provide even a reasonable fraction of all the capabilities that most users would like exist in only a few places as experimental prototypes.

All major brands of both mainframe and microcomputers and all major programming languages were represented in the survey responses. The most frequently mentioned mainframes were IBM, Amdahl, and Cyber; the most commonly mentioned micros were the IBM PC and the various versions of the Apple II, but a large number of other makers' hardware devices are also in use. Mainframe-based applications are being run on programs written principally in FORTRAN, PL/1, COBOL, and SNOBOL. Music programs for micros employ a host of different languages and operating systems. Only a handful of scholars have access to systems that permit screen display, editing and printing of musical data with sufficient ease to encourage large-scale projects, but some significant work is being done by independent researchers using very modest facilities.

In the area of foreign language text processing, roughly half the respondents seemed to be reasonably content with their current capabilities. The ability to handle foreign languages varied less with the kind of hardware used than with the software and the printers employed. In general, users of Wordstar requiring accents for French, Italian, and German appear to be content. The Epson FX-80 printer, which has a redefinable character set, is a special favorite of scholars.

The responses to questions about current needs were open-ended and have been grouped into the categories of hardware, standards, software, user support services, and future use of existing capabilities.

1. Hardware

There were relatively few expressions of need for improved hardware that were unrelated to software needs. These concerns are are listed in the software section. Some interest was expressed in the potential use of portable computers and optical discs in music-oriented systems.

2. Standards

Although there is much discussion among programmers and others involved in the software industry about the need for standardized formats for files and for the transportability of programs from one kind of computer to another, there was relatively little comment on this among our respondents.

3. Software

Suggestions for software improvement came mainly from systems developers and programmers. The following needs were identified:

(1) more software that is not machine specific (that is, more software that can be used interchangeably on computers of different makes)

(2) more software that can be modified by the user

(3) increased attention to algorithm design (affecting scope, efficiency, and accuracy of results)

(4) increased involvement of musicologists in design of software, since computer specialists do not always appreciate the elements that may determine the ultimate value of a program

Most responses concerning both hardware and software needs related specifically to the handling of musical notation. With regard to the input of musical data the following desires were expressed by multiple respondents:

(1) methods by which music can be input directly from a musical keyboard

(2) the development of optical scanning techniques able to read musical notation

(3) the acceptance of common encoding and query languages for music and the standardization of operating systems and file structures to handle these

There were also several expressions of interest in improved capability in the areas of screen display and editing of musical material. These focussed specifically on such things as:

(1) screen representation of musical notation

(2) higher resolution screen graphics for systems that already possess this capability

(3) interactive editing (the ability to change the results displayed on a screen through the use of a mouse, lightpen, or touch screen in conjunction with alphabetic commands)

(4) acoustical playback of musical data

A great deal of interest was expressed in improved methods of printing music for purposes of publishing, performance, and study. This includes the ability to create parts from a score and vice versa. A number of respondents expressed interest in the development of laser printers for musical output.

4. User Support Services

Many people who responded to the questionaire seem to feel they are working somewhat in isolation. Better communication between scholars in the field was identified as an important need. Among the suggestions received were the following:

(1) the publication of a newsletter of current information about developments over the range of subjects covered in the questionnaire

(2) more demonstrations of current capabilities and panel discussions of computer applications at meetings of the American Musicological Society and College Music Society

(3) access to information about encoding systems

(4) more and better documentation for existing software

(5) easier access to appropriate computer expertise

(6) establishment of user networks

(a) for scholars working independently on projects of mutual interest

(b) for scholars wishing to work in collaboration at diverse locations

(7) modem access to existing data bases

(8) on-line access to standard references works such as

(a) *Répertoire International des Sources Musicales*

(b) *The New Grove Dictionary of Music and Musicians*

(c) thematic indices of the works of major composers (*e.g.*, the Köchel catalogue of Mozart's works)

5. Future Use of Current Capabilities

For studies in which the data consists exclusively of text, there is significant interest in pursuing studies that involve such tasks as:

(1) creating bibliographical control over large repertories

(2) creating word concordances from on-line theoretical treatises

(3) creating databases providing uniform information about stylistic details of large repertories (instrumentation, tempo, key, length in measures. etc.)

(4) creating specialized bibliographical databases

For studies dependent on musical data or on a combination of musical and text data, these areas of interest predominate:

(1) thematic indexing projects of many kinds, with capabilities for cross-references and concordances between them

(2) the scoring and editing of unedited music

(3) collation of variants and borrowings

(4) resolution of questions of attribution

(5) studies of chronology based on elements of style and/or diplomatic studies

(6) comparative studies

Technical obstacles to present work were cited only once as a serious problem. Those respondents who referred to obstacles otherwise identified them as human ones: time, money, prejudice against the use of computers, and bureaucratic and financial barriers.

Handling Musical Data

Background

Although much important work in musicology depends entirely on text material that can be handled by any computer, it has been recognized since the early 1960's that in order for musicology to benefit from advanced technology to the same degree as other humanistic disciplines, some method of representing musical data directly would need to be found.

Musical notation is both enormously sophisticated and frustratingly erratic. In contrast to the precise and consistent form that computer data normally takes, musical notation combines information about rhythm, pitch, and other aspects of sound into single symbols. Because the potential number of data elements generated by a single note may number into the dozens, the task of converting musical data to a computer-digestible alphabetical or numerical code can require significant amounts of data entry time and computer storage. This in turn can make the task of data retrieval long and complicated.

There are two philosophical approaches to encoding musical data for computer use. One is the universal approach that attempts to anticipate all possible notational and symbolic requirements. The other approach is to develop only those elements of notation that are required for a particular task. In this section we have attempted to provide current information on approaches of the first type. Approaches of the second type are indicated in the Applications section.

There are also two practical approaches to entering musical data into a computer. One is to devise letter and/or number codes (alphanumeric notation, in computer parlance) to represent notes with their various attributes. The other is to play single lines of music on an electronic keyboard. This latter method does not eliminate the need to devise special codes. Special sets of instructions need to be provided for the computer to interpret the music that has been entered. Data entry systems of recent invention tend to favor the electronic keyboard as an input device because of its familiarity as a musical instrument.

After some representation of musical notes has been stored in the computer, a means of proofreading the entry, editing what is stored, and fixing a format for output are required. Those systems that have an interactive editing and/or print capability have distinct advantages over systems in which the data is proofread or printed in its alphanumeric form.

In the following listing we identify first those encoding systems that are based on terminal input of alphanumeric codes for data entry, and then those that use an electronic keyboard for musical data entry. Although most encoding systems designed originally for mainframe computers have been adapted to some extent for microcomputers, we have put systems devised initially for microcomputers in a separate category. The reason for this is that at present the amount of data that can be stored on a floppy disc is limited.

Terminal Entry Systems--Mainframe-Based

DARMS

DARMS (Digital Alternate Representation of Musical Scores) is the encoding system that has been sustained by the largest number of contributors for the longest time. It was conceived in its initial form by Stefan Bauer-Mengelberg in 1964 and its early development was fostered by IBM's Systems Research Institute. Both in 1966 and in 1976 introductory summer seminars for music faculty were given at the State University of New York at Binghamton, which remains the focus of DARMS development today.

During the intervening decade, a significant amount of development was done on IBM mainframe equipment. Notable among these intermediate achievements were the syntax checkers written by by Raymond Erickson for PL/1 and by Bo Alphonce for SNOBOL, both in *c.*1973-74. At roughly the same time, Anthony B. Wolff and others became interested in the prospect of developing a second version of DARMS that would be useful in moving encoded data from one device or system to another.

This expanded version, or "canonizer," as it has subsequently come to be named, has been under development by Bruce McLean, a Ph.D. candidate at SUNY Binghamton, for a number of years. The target date for completion is 1986. McLean's current work is being carried out on a Sage II microcomputer, which uses the P operating system and Pascal (version IV.1) as a programming language. It can alternatively use CP/M and the programming language C.

Concurrent with McLean's effort is that of Stephen Page, a D.Phil. candidate at Oxford University, to develop a query language, or in other words a method of interrogating musical data, stored in DARMS code. Page's work is in the design stage and it is anticipated that it will employ Pascal or Modula-2 programs to run on a DEC VAX or a Victor 9000 (an IBM PC compatible) computer. The aim of his work is "to attempt to bridge the gap between a musicologist's 'description' of a musical unit and the computer's view of the score."

Several principles of the original conception differentiate DARMS from other encoding languages. One is inclusiveness. It was intended that any notational feature found in common musical notation of the period *c.*1650-1950, including signs relevant only to performance (such as fingering numbers), should be encodable. Another goal was objectivity. It was intended that no feature of the music should be interpreted at the time of input. For example, in phrase repetitions each note is described fully at each occurrence; opportunities for shorthand representations are ignored out of respect for objectivity. Finally, DARMS was intended to facilitate multiple avenues of output, such as Braille editions, in addition to those in conventional notation.

DARMS does not include an online music editing capability or screen display at the present time. Acoustical playback of encoded data was effected in 1982 at Colgate University by translating material entered in DARMS code to a SCORE/MS code that could be accepted by a system resembling Stanford's PDP-10 (see the M.S. thesis by Cheryl Martens, SUNY Binghamton, 1982). One of its current objectives is to devise methods of adapting its software to other operating systems.

A DARMS users' manual, prepared in 1976, has recently been reprinted and is available from Bauer-Mengelberg. A new version by McLean is scheduled for release in 1986, when there is hope of holding another seminar for prospective users at SUNY Binghamton. The most complete published introduction to the 1976 version of DARMS is Erickson and Wolff's "The DARMS Project: Implementation of an Artificial Language for the Representation of Music" in *Trends in Linguistics* (Studies and Monographs, 19), Berlin and New York, 1983. See also McLean's "Design of a Portable DARMS Translator" in the *Proceedings of the 1980 Computer Music Conference.*

IML-MIR and FASTCODE

IML-MIR, developed at Princeton University in the 1960's, is no longer operative, but because it played an important role in the field of musicology and because progeny of this effort continue at the present time, we have included it in this listing. In this pair of programs, the Intermediary Musical Language (IML) was the encoding language; Music Information Retrieved (MIR) was a language for data query. The Josquin project, which has generated a host of publications, was developed on this system. Its termination was forced by Princeton's abandonment of the hardware on which it was designed to run.

Michael Kassler, a principal developer of IML-MIR and a co-author of the *Grove 6* article on Computers, has continued to maintain an interest in several different aspects of this field. He carried out studies of tonal theory with programs written in APL (A Programming Language) at the University of Sydney in the 1970's and in recent years had explored the feasibility of developing "special purpose music notation input terminals" for use in setting, printing, and arranging music.

An input language called FASTCODE was developed by Thomas Hall in the 1970's. In contrast to IML, which was more comprehensive in its original aim, FASTCODE was designed specifically to handle polyphonic music of the Renaissance. A substantial amount of data (some 500 motets by Lassus and Susato) has been entered on the IBM 3033 at Princeton, and a separate Busnois chanson project at Columbia University also relies on FASTCODE.

Associated programs facilitate plotter printing of the music entered in rhomboid shaped notes and the tracing of routes of dissemination (stemmata). Hall's "Some Computer Aids for the Preparation of Critical Editions of Renaissance Music," which appeared in the *Tijdschrift van de vereniging voor Nederlandse Muzekgeschiedinis* XXV/1 (1975), is an informative introduction that refers only to MIR but is related to the above capabilities.

MUSTRAN

MUSTRAN, originated by Jerome Wenker in 1962, is a comprehensive encoding system similar to DARMS in its overall aim of offering the possibility of describing any aspect of music that may be needed in print. It is different from DARMS in that its primary focus was originally on ethnomusicological material; its capability in handling monophonic music is well developed and use tested. Developed largely at Indiana University, MUSTRAN was used there throughout the 1970's in a computer music course and in various research projects. Data currently stored in MUSTRAN includes Wenker's collection of 93 Canadian folk songs and 277 ballad tunes.

MUSTRAN has a substantial package (c.40,000 lines) of utility programs. These include translators, file managers, analysis programs for monophonic music, and a library of subroutines that permit the user to create his own analysis questions for monphonic or polyphonic music. Because of its orientation toward ethnomusicology, MUSTRAN offers great refinements in pitch specification. A pitch can be defined to the nearest 256th of a semitone. The acceptable range in cycles per second is 16 to 25,500. The most complete source of documentation on MUSTRAN is the second volume of Wenker's Ph.D. dissertation, "An Analytical Study of Anglo-Canadian Folksong," (Indiana University, 1977).

The mainframe computers on which MUSTRAN programs have been used include the IBM 360//70, the CDC 6000 and 7000 series, and the UNIVAC 1100. To the extent that floppy disc storage permits, MUSTRAN programs can also be run on IBM PC's and compatible personal computers as well as on the Sperry microcomputer. The original programs are in FORTRAN.

Current development work concentrates on improving the operating time of existing programs and making more of them available on floppy discs for microcomputers. One utility program simplifies the task of converting other encoding languages into MUSTRAN, and opportunities to share data with other users are welcomed.

Music printing routines for MUSTRAN were developed by Donald Byrd at Indiana University (see "A System for Music Printing by Computer," *CHum* VIII/3 [1974]). This system was designed to run on CDC mainframe computers. The musical examples shown in Douglas Hofstadter's book *Gödel, Escher, Bach* were made on this system; further information on such procedures can be found in Byrd's doctoral dissertation, "Music Notation by Computer" (Indiana University, 1984). Byrd is currently interested in developing music editing programs for the Macintosh, Apollo, and Sun microcomputers.

SCORE/MS

Since the early 1970's the Center for Computer Research in Music and Acoustics at Stanford University has been using an alphanumeric music entry and printing system developed by Leland Smith. Published references to this system refer to the encoding language as SCORE, although in the current parlance of CCRMA the program that generates musical notation from this encoding language is called MS, and SCORE has connotations for acoustical manipulation and sound synthesis that lie well beyond the focus of encoding. Smith's programs are written in FORTRAN and operate on a PDP-10 computer. The principles of the encoding language are not unlike those of DARMS, although MS uses shorthand-like devices for encoding repetitions. A Versatec graphics plotter is used for printing music.

The MS program has capabilities for displaying music on the screen, for providing editing options on line, and for music printing of very high quality. MS's reliance on size-independent vector graphics permits duplication of unusual systems of musical notation, such as tablatures, and allows extensive control of the size of output, including vertical and horizontal spacing on the page and the number of pages over which a score may be distributed. Plans are underway to adapt MS's features to the Tandy 2000 microcomputer.

In musicology, SCORE/MS has been used to prepare editions of Renaissance vocal and Baroque instrumental music. It has also been used to produce thematic indices. A project to produce large-type piano music for the visually impaired is currently being carried out under the auspices of the Library of Congress.

An extensive description of the system is contained in Garrett H. Bowles' Ph.D. dissertation, "The Computer-Produced Thematic Catalog: An Index to the *Piéces de Violes* of Marin Marais" (Stanford University, 1974).

Terminal Entry Systems--Microcomputer-Based

Music Editor

This music editing program for IBM PC's developed by John C. Laffan, a retired IBM systems programmer, allows the user to place, with a cursor, notes on staves automatically produced on the screen. One of its attractive features is that it can be used simultaneously with a text editor. It is particularly compatible with Wordstar but can be used with text in any intermediate ASCII file. While Music Editor can display only four staves on the screen at one time, it can show orchestral scores with its left-right and top-bottom scrolling capabilities. Notes can be produced in three sizes and text in seven fonts. It can create scores from parts and extract parts from scores. It has a wide range of notational features including C clefs, percussion symbols, articulation marks, and unmeasured chant in modern notation. It makes transpositions readily.

Music Processor

This program, being developed by Etienne Darbellay for the Texas Instruments professional computer, is a graphics-oriented system that can provide up to nine staves on the screen with a wide range of editing and dot matrix printing capabilities oriented toward musicological needs. The program can be run on any MS/DOS system. The music is entered using redefined function keys on the computer terminal. The spacing is automatic but can be overwritten manually. It can reproduce unusual notational styles unique to particular repertories, such as mensural notation and unmeasured notation of the French Baroque.

Musicsys/3600

Musicsys/3600 is a prototype for aural and visual editing of musical data under development by Bernard S. Greenberg at Symbolics, Inc., in Cambridge, Mass. It employs a terminal entry code.

The Symbolics 3600 machine on which it operates is designed for artificial intellgience applications, using Lisp. A sound "display" of up to six voices is available through its basic architecture, without a separate synthesizer, although it can also be interfaced with a Yamaha DX-7. Musical notation can be displayed on the large high resolution screen of the 3600; a mouse controlled editing capability is currently under development, while a laser printing facility is in place. Douglas Dodds has been a contributor to the development of this system.

Works entered can be edited for "performance" (that is, for sound output) by use of instructions about registration, articulation, ornamentation, tempo, and so forth. The organ is the only instrument whose sonic qualities are currently replicatable in this way. At present roughly four dozen works, principally by Bach, are resident in "edited" versions.

Keyboard Entry Systems

CCARH

The Center for Computer Assisted Research in the Humanities has its own in-house system for musical input, analysis, and printing. Still in the development stage, it was initiated in 1983 by Walter B. Hewlett. It is based on the IBYCUS operating system developed over the past decade by David Woodley Packard. IBYCUS is oriented toward high speed processing of very large quantities of data. The associated high level language is Ibyx, which was designed for string-processing. An HP-1000 is the computer on which the system is based.

Music is entered one part at a time from an electronic keyboard. The data can be played back in score or parts on a Yamaha DX-7 (MIDI interface) synthesizer. Data may be edited from text files displayed on the HP 2640B terminal or with visual display on a Conrac page makeup terminal. Printing of text and music is possible using the Epson FX-80 dot matrix printer; a score printing capability for the HP LaserJet printer is currently under development.

This system is oriented toward mass storage of musical data and complex analytical capabilities of value in traditional avenues of musicological research and teaching.

The Interactive Music System (IMS)

The Interactive Music System is a PLATO-based system that integrates musical transcription, editing, playback, and printing capabilities. It has been developed over the past ten years at the Computer-based Education Research Laboratory (CERL) at the University of Illinois (the home of the PLATO computer system). Lippold Haken is the principal developer of the IMS. Its overall orientation is toward composition, music making, and educational software, but its capabilities are very broad and it is well suited to musicological projects of many kinds.

The hardware constellation on which the IMS is based consists of a 16-channel synthesizer, a pitch extractor, a PLATO terminal, an 88-key electronic keyboard, a printer, an amplifier, and loud speakers. The editing and acoustical capabilities of the system are both well developed, so that, for example, both text and music can be edited on the screen. Timbre can be defined in several ways.

The editing program LIME can deal with scores of up to 60 parts for music in standard notation. Editing is done with a cursor. A wide range of standard notational features including tuplets (equal subdivisions of the beat in unusual demoninations) and string articultion marks is available. The music language OPAL is used to write programs to create new music and to perform analytical tasks. The programs supporting the system are written in TUTOR and C.

IMS is described in the Spring '85 issue of the *Computer Music Journal.* A user's manual by Lippold Haken and Valerie Schmid was printed in December 1984 and can be obtained from the CERL Music Group at the University of Illinois. A current objective of the IMS is to develop a laser printing capability.

Mockingbird

Mockingbird is an interactive editor for musical notation developed in 1980 at Xerox's Palo Alto Research Center by John T. Maxwell III and Severo Ornstein. It was designed primarily to transcribe piano music but can display scores of up to four staves on the screen. It utilizes much of the technology involved in the subsequent development of Apple's Macintosh computer, but this software was created on a very much more powerful machine, the Dorado (subsequently renamed the Xerox 1132), using a language called Mesa (a dialect of LISP).

When music is being transcribed, pitches are played into the computer from a Yamaha CP-30 synthesizer and noteheads (devoid of stems or beams) are distributed on a time scaled horizontal axis on staves shown on the screen, reflecting the sequential file structure that supports the system. Screen editing is carried out with a mouse and a pop-up menu. There are icons for stems, beams, barlines, accidentals, ornaments, and other non-pitch related symbols. Large quantities of material can be quickly inserted or deleted; parts can be created from a score and a score from parts. An unusual feature of this system is that it can create a rhythmic abstract of a complete work showing only bars and stems; from this the user can identify a precise location within a work. There is no capability for integrating text, either in tempo designations or in underlay, with music. Once entered and arranged to the user's satisfaction, music can be played back over the synthesizer or printed in hard copy by a laser printer.

As a research prototype dependent on experimental hardware and software, Mockingbird is inaccessible to the general public but an achievement greatly respected by others involved in the challenge of devising computer-based techniques for editing music. While there are no formal plans for further development of Mockingbird, there is informal discussion of converting it to run on a Dandelion computer.

Other Systems

Some other encoding and/or editing programs that have been in recent use but on which there is insufficient documentation to provide a detailed description are these:

Gregory's Scribe was a printing program for Gregorian chant developed by David Crawford at the University of Michigan. It relied on an Apple graphics tablet and a Malibu dot matrix printer (the latter is no longer in production) and is described in the *Computer Music Journal* VII/1 (1983).

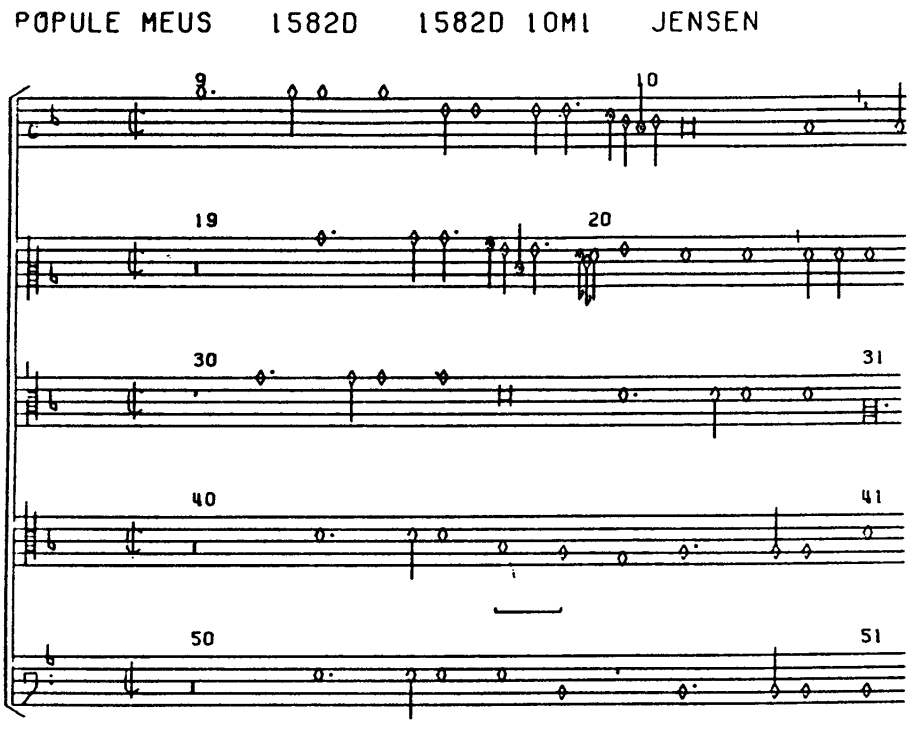
LMIL (Linear Music Input Language) was developed and used by Lynn Trowbridge at the University of Illinois in the 1970's for a study of chanson repertories. The programs are in COBOL and were run on an an IBM 360//75.

Musicode A was developed at Ohio State University by Thomas Whitney in *c.*1970 and has been used there every since, where its primary users have been Fred Hofstetter in Ann Blombach. It has an associated query language, SLAM (Simple Language for the Analysis of Music).

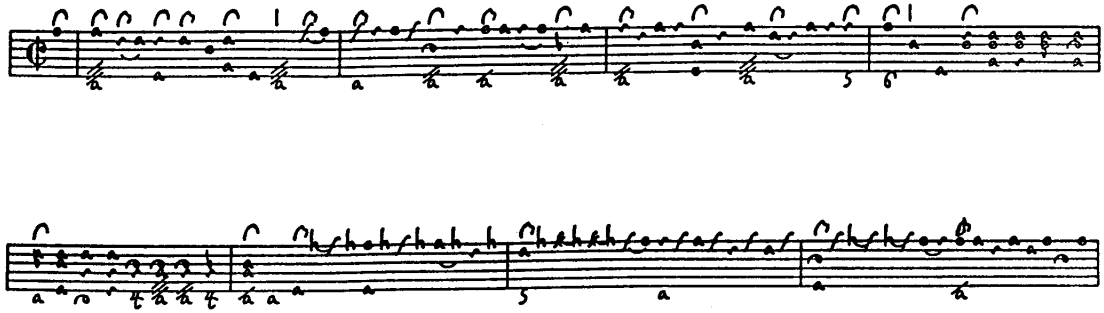
Plaine and Easie is an alphanumeric code that has been used extensively for thematic indexing. Its output form is a letter code that facilitates searches for comparably shaped melodies.

FASTCODE

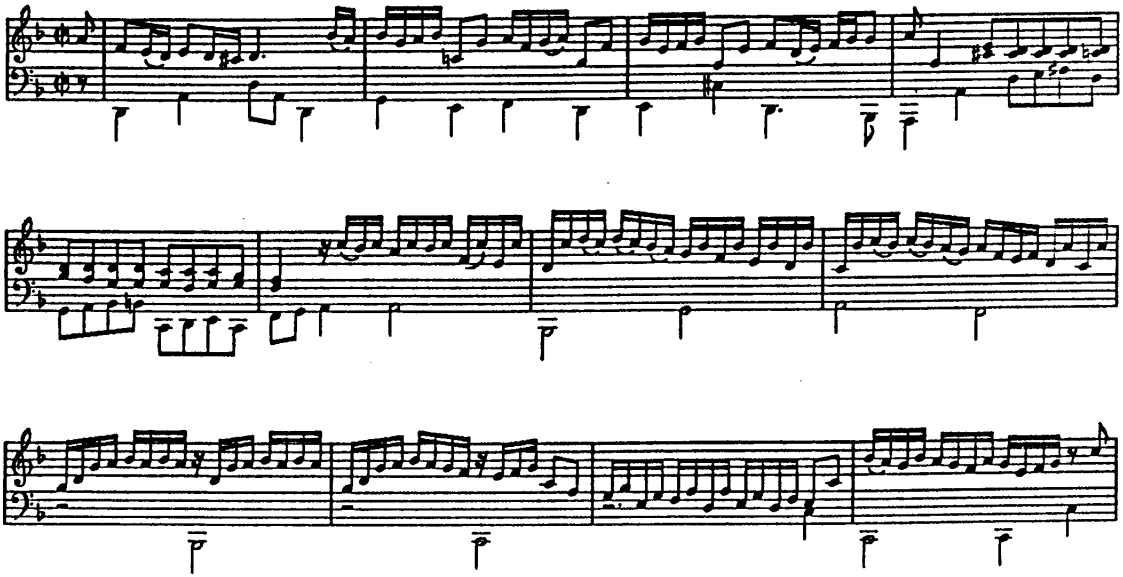
Excerpt from Lassus' motet "Popule meus."



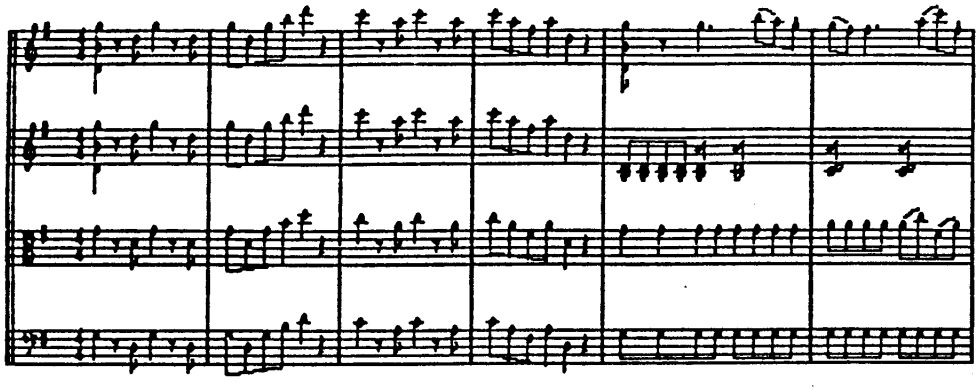
(a) Facsimile of a dance for lute by S. L. Weiss (see Smith/Weiss).



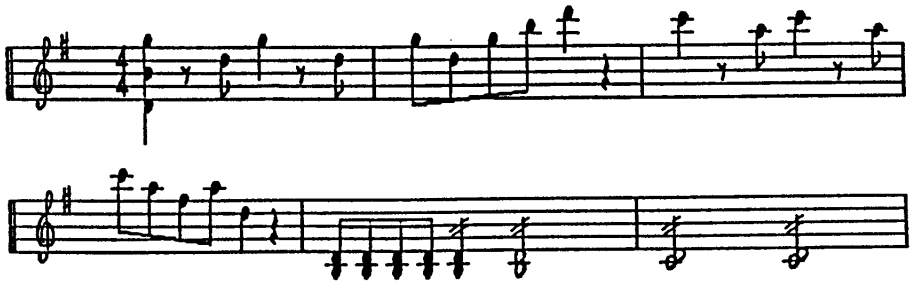
(b) The same piece in modern notation.



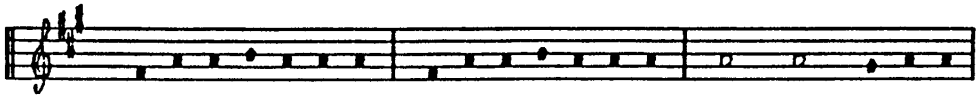
(a) Score of Mozart's "Eine Kleine Nacht Musik."



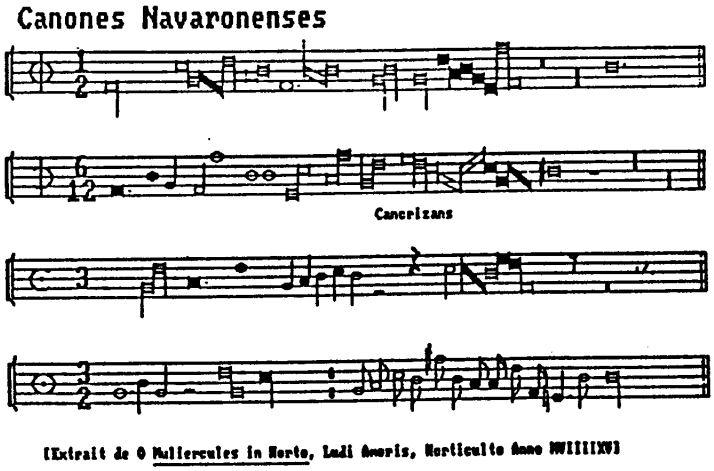
(b) Second violin part.



(c) Chant as used in modern practice.

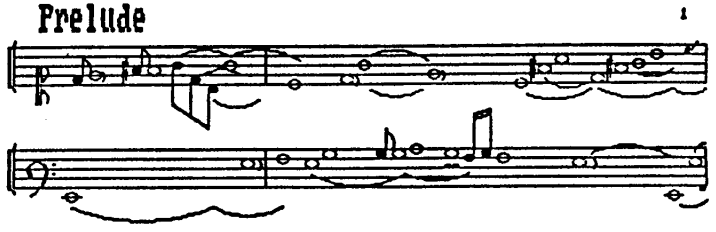


(a) Mensural notation.



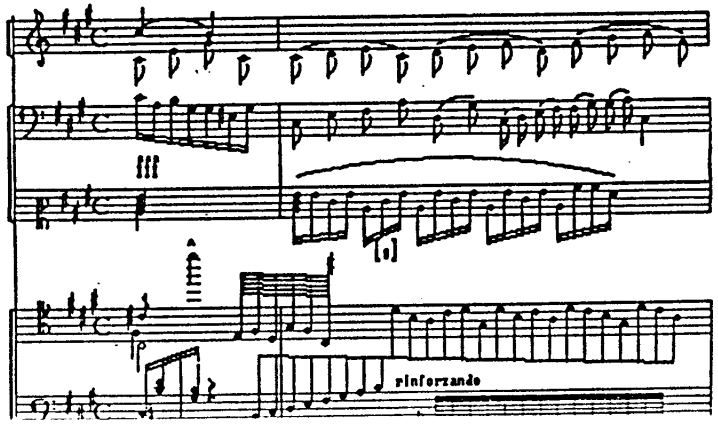
[Extrait de O Hallercules in Horto, Ludi Amoris, Horticulto Anno MDIIIIXVI

(b) Unmeasured notation.



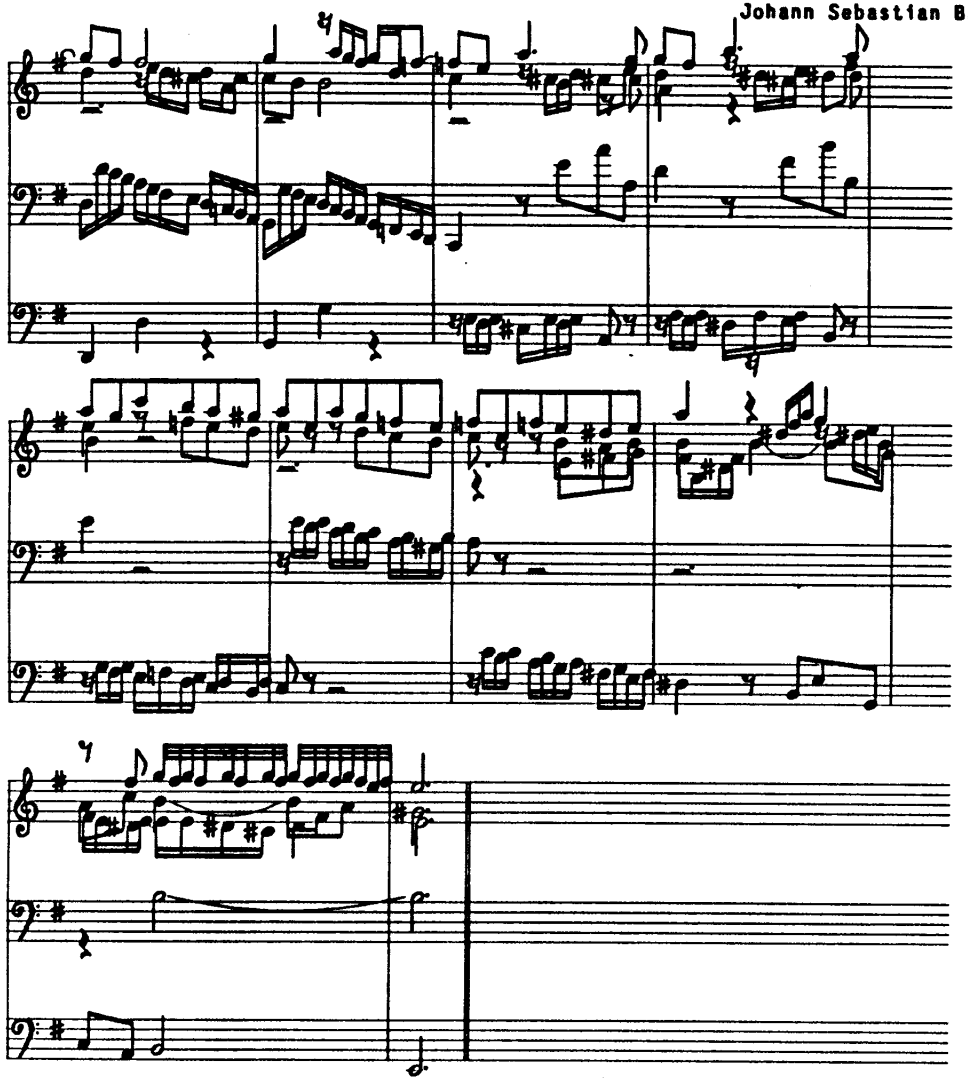
[Extrait des Pièces de Clavecin, Jean Henry d'Anglebert (1689)]

(c) Score with unusual notational requirements.

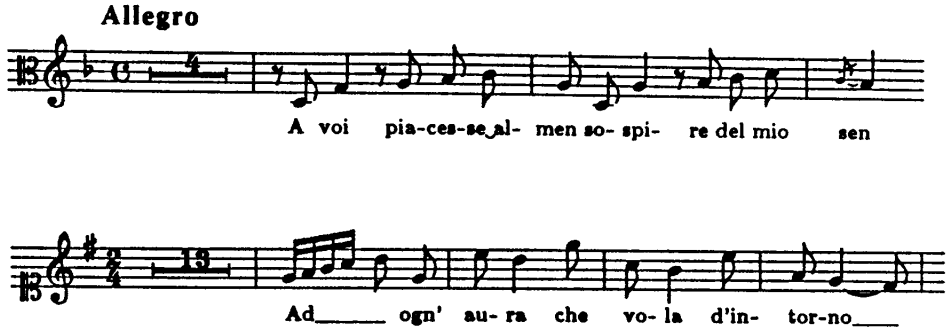


Prelude in E Minor, of "The Wedge" fugue

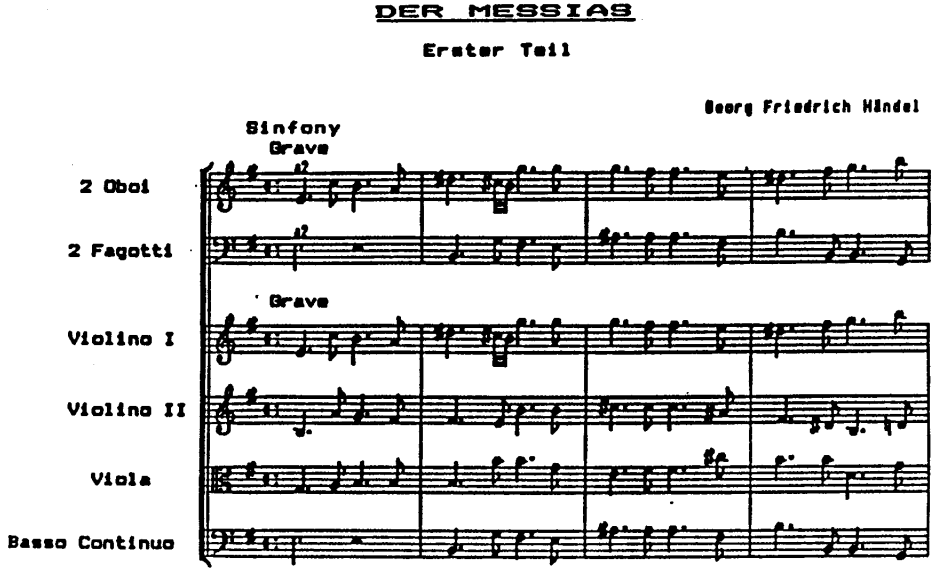
Johann Sebastian Bach



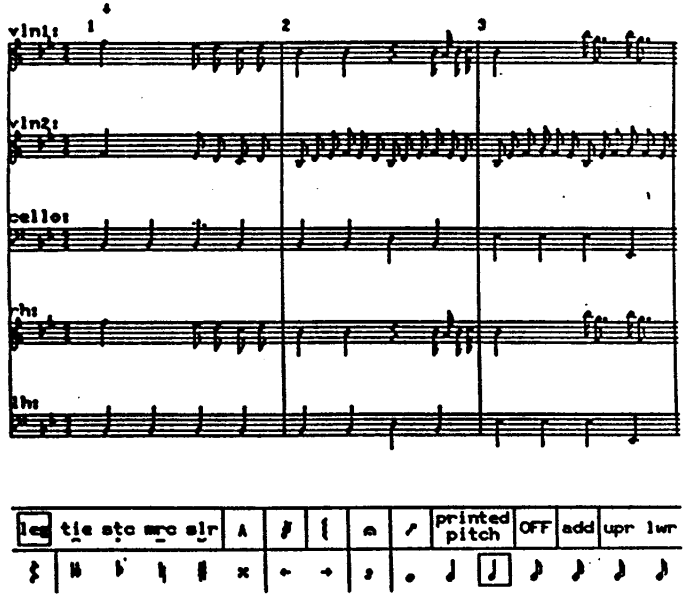
(a) Melodic incipits of Marcello cantatas produced by LaserJet printing (see Selfridge-Field/Marcello).



(b) Score of Handel's Messiah produced by the Epson FX-80.

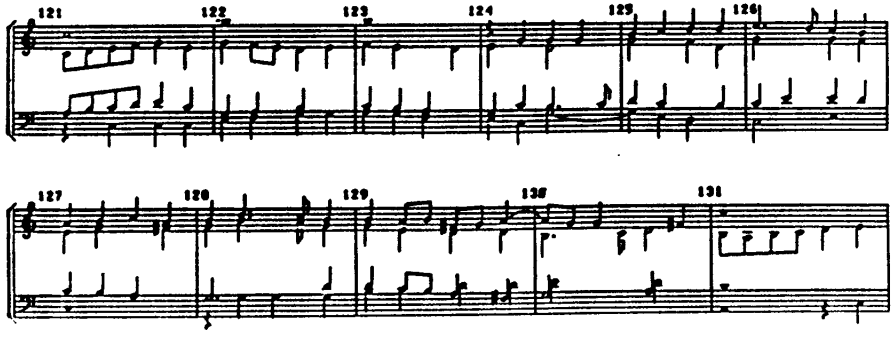


(a) Screen display of music to be edited.



The LIME display has three parts: the arrow, the music, and the touch squares. The arrow appears in the top right corner; this is where typed input from the keyset is plotted. The music takes up most of the screen; a cursor (↓) points at the current location in the music. The touch squares are plotted at the bottom of the screen.

(b) Sheet music produced by dot matrix printer.



Efforts to Establish Standards for Musical Information

Some representatives of the computer industry favor the adoption of a single standard for musical information. Recent efforts to promote this goal are noted here.

ANSI

On May 7-8, 1985, a study group representing computer makers, software developers, synthesizer manufacturers, film makers, and academic computer users was convened by Charles Goldfarb at IBM's Palo Alto facility to determine the need for forming a committee to adopt a standard for musical information interchange. The standard, if developed, would be considered for adoption by the American National Standards Institute. A recommendation to form such a committee has now been forwarded to ANSI. The standard should have the capablities both of producing printed music and of driving music devices such as synthesizers.

KERMES

In October 1984 a group was convened by Donald Byrd at the International Computer Music Conference in Paris to consider the feasibility of standardizing music editing functions. KERMES (Kernel Music Editing System) also issued one news- letter. The view of this group was that the effort to establish a comprehensive standard was premature at this time. Relevant considerations are cited in the correspondence in the *Computer Music Journal* VIII/1 and 4 (1984).

MIDI

In 1983 manufactures of synthesizers world-wide adopted MIDI (Musical Information Digital Interface) as a standard for compatibility among hardware developers, that is among the makers of electronic keyboard instruments and the makers of personal computers. Not all currently available synthesizers use this interface, because many were designed and manufactured prior to its adoption. There is, however, a gradual conversion to this standard. As of this writing, the only widely available personal computers to which a MIDI instrument could be interfaced easily were those of the Apple II series. The MIDI standard is geared to the needs of music makers: for example, there is no distinction between enharmonic equivalents (*e.g.*, F# and Gb), but such information can be inferred from appropriate programs.

Programs of Study

Very few programs of study for scholars interested in acquiring computer skills of use in musicology exist at the present time.

The only structured, comprehensive program of study is that leading to the M.A. degree in Computer Studies in Musicology at the University of Nottingham, England. The curriculum includes courses in applied programming, analytical method, use of databases, and the history of applications in music. The faculty includes Ian Bent and John Morehen.

The use of computers is an integral part of seminars taught by David Crawford at the University of Michigan and John Hill at the University of Illinois. Crawford also coordinates information about computer use by members of the American Musicological Society.

At the University of Amsterdam a computing center for musicological needs is currently being established by Leigh Landy and Leo Plenkers. Its main orientation is toward sound synthesis and experimental music, but a capability for music analysis using DARMS encoding is also being considered. Cyber and Macintosh computers will be used.

The Center for Music Research at the Florida State University School of Music offers a Certificate in Computers in Music. The emphasis of the program is on music synthesis and courseware.

The University of Arizona is offering a summer workshop for teachers and administrators in the use of computers in teaching music. Courses in beginning programming and software usage are based on Apple and IBM microcomputers, synthesizers with a MIDI interface, and Mountain Computer Music Systems. The director is J. Timothy Kolosock. (A similar workshop was provided last summer in Denton, Texas.)

The University of Arizona also has a Committee for Music and Technology which aims to "provide leadership in the national and international music community in the application of high technology equipment in music composition, instruction, and analysis."

Instructional Software

We have not attempted to list instructional software that is currently being used in colleges and universities or offered for sale by private vendors.

People mentioned elsewhere in this directory who are also actively involved in the development of computer assisted instruction (CAI) include Mark Ellis (music instruction, Huddersfield [U.K.] Technical Institute) and David Stech (music theory, University of Alaska).

One group effort in CAI is the MAESTRO series of programs under development at UCLA by Roger Kendall and Irene Levenson. Drill activities in keyboard theory rely on an Apple IIe and a Mountain Music System, with programs in 6502 assembly language and a custom designed encoding system. Other purposes will be served by programs involving the Intel 360/86-3A and the Thunderscan encoding system designed for the Macintosh computer.

Specific CAI programs at the University of Minnesota and the University of Nebraska--Omaha are described by Dorothy Gross in the *Computer Music Journal* VIII/4 (1984).

Gerald Shapiro at Brown University is attempting to create a campus-wide network of music hardware devices, including synthesizers and Macintosh computers. The software to link and operate these is under development, and a broad range of courseware for music theory classes is intended for later development.

Ann Blombach at Ohio State University, who has been involved in the development of computer assisted music theory instruction for several years, is on leave in 1985-86 to tour facilities that are developing computer capabilities in music.

Efforts to use computers in the teaching of species counterpoint are under consideration at Yale University.

More in the field of artificial intelligence (AI) than of CAI are programs by Bill Schottstaedt at CCRMA (Stanford), "Automatic Species Counterpoint" (May, 1984), and Bernie Greenberg at Symbolics, Inc. (1985). The first follows Fux's advice, including rules for the creation of parts against a cantus firmus; the latter generates counterpoints in first, second, and third species according to a variety of eighteenth-century rule systems. Greenberg's software also generates harmonizations of a figured bass.

Current and Recent Applications

Computers are used in a great variety of ways. We have categorized this uses into three main areas--bibliography, databases, and analysis. Projects undertaken or completed since 1980 have been given priority over earlier work. Details about hardware and software are indicated to the extent that they were provided by respondents.

Bibliographies and Indices of Text

HillG/Historical Editions
Title: *Music in Historical Editions*
Aim: production of a comprehensive guide to the contents of monumental editions, based on the model of the Heyer book
Chief researcher: George R. Hill (with Garrett Bowles, Irving Godt, Richard Jones, Sterling Murray, Barbara Renton, and Gordon Rowley)
Time frame: 1984-9

Malm/Stearns Collection
Title: *The Stearns Collection of Musical Instruments: A Catalogue* (Vol. I in press)
Scope: lists 2,000 musical instruments
Chief researcher: William Malm, with James Borders
Place: University of Michigan
Software: SPIRES

Murray/Examples
Title: *A Guide to Standard Anthologies of Musical Examples*
Scope: 35,000 records of information about 48 anthologies of musical examples, with index and genre codes
Chief researcher: Sterling Murray, with Benjamin Trumbore
Place: West Chester University
Hardware: Honeywell Sigma 9
Software: custom designed

Bent/19th-Century Music Theory
Title: *Bibliography of 19th-Century Music Theory*
Scope: printed sources of music theory, 1750-1910
Chief researcher: Ian Bent
Place: Nottingham University
Time frame: 1982--
Hardware: ICL 2988
Software: FAMULUS
Literature: "The 'Compositional Process' in Music Theory, 1713-1850," *Music Analysis* III (1984).

Bernstein/Scotto
Title: *A Catalogue of the Music Published by Girolamo Scotto*
Scope: 1,000 pages of information
Chief researcher: Jane Bernstein
Place: Tufts University
Hardware: DEC VAX
Software: see Lewis/Venetian Printers

Clinkscale/Motet
Title: *Sixteenth-Century Motet Répertoire*
Scope: data on 1,000 works of the period
Chief researcher: Edward Clinkscale
Place: UC Riverside
Hardware: Apple II
Software: custom alphabetic code handled in Pascal

Davis/Concertos
Title: *A Thematic Identifier Catalogue of Eighteenth-Century Concertos*
Scope: comprehensive index of the standard repertory
Chief researcher: Elizabeth Davis
Hardware: Cyber 170
Software: MUSTRAN

LaRue/Symphonies
Title: *A Thematic Identifier Catalogue of Eighteenth-Century Symphonies*
Scope: comprehensive index of the standard repertory (100,000 records)
Chief researcher: Jan LaRue

Place: New York University
Time frame: 1982-5
Hardware: Cyber 170
Software: MUSTRAN

Lewis/Gardano
Title: *A Catalogue of the Music Published by Antonio Gardano*
Chief researcher: Mary Lewis
Place: Brown University
Hardware: DEC VT100
Software: see Lewis *et al.*/Venetian Printers

Lewis *et al.*/Venetian Printers
Title: *Catalogues of the Music Published by Venetian Printers in the Sixteenth Century*
Scope: cataloguing of music and text underlay in all sources printed in sixteenth-century Venice; 10,000 pieces of music in 1,000 editions are involved in the overall project
Chief researchers: Mary Lewis, Jane Bernstein, Stanley Boorman
Hardware (original): Honeywell Level 68//DPS (MIT)
Software (original): custom designed by Carl Hoffman and Allan Wechsler in MacLisp (a dialect of Lisp)

Lincoln/Madrigal
Title: *The Italian Madrigal and Related Repertories: Indexes to Printed Collections, 1500-1600*
Scope: 35,000 melodic incipits representing 6,000 works
Chief researcher: Harry B. Lincoln
Place: SUNY Binghamton
Hardware: IBM mainframes, Zeta plotter
Software: DARMS
Literature: "A Description of the Database in Italian Secular Polyphony held at SUNY-Binghamton, N.Y.," *Fontes Artis Musicae* XXXI/3 (1984)

McCrickard/Stradella
Title: *Thematic Catalogue of the Works of Alessandro Stradella*
Scope: listing of textual and musical incipits of 300 works, based on a survey of 1,000 sources
Chief researchers: Eleanor McCrickard and Carolyn Gianturco
Place: UNC at Greensboro
Hardware: Apple II
Software: Quick File (text)

Rees/Pyron Collection
Title: *Catalogue of the Pyron Collection of Violoncello Works (1630-1850)*
Scope: detailed listing of 8,000 works for cello collected in photographic copies by Nona Pyron and housed in Fullerton, CA
Chief researcher: Fred Joseph Rees
Place: University of Queensland
Hardware: PDP-1090 and IBM 3083 (text only)

Selfridge-Field/Marcello
Title: *Benedetto Marcello (1686-1739): A Thematic Index of His Works*
Scope: listing of textual and musical incipits of 700 works, based on a survey of 3,000 sources
Chief researcher: Eleanor Selfridge-Field
Hardware: HP-1000 using IBYCUS operating system and HP laser printer
Software: custom designed by Walter B. Hewlett

Temperley/Hymn Index
Title: *Hymn Tune Index*
Scope: listing of 115,000 hymn and Psalm tunes associated with English texts (1536-1820)
Chief researchers: Nicholas Temperley and Charles G. Manns
Place: University of Illinois
Time frame: 1982--
Hardware: IBM terminal and Cyber computer
Software: custom designed
Literature: *Fuging Tunes in the Eighteenth Century* (Detroit, 1983)

Discographies

CrawfordD/Renaissance
Title: *Music from 1400 to 1550*
Scope: a catalogue of the contents of 4,400 recordings of Renaissance repertory
Chief researcher: David Crawford
Place: University of Michigan
Hardware: Amdahl 5860

Gray/Klezmer
Title: *Klezmer Recordings on 78 rpms*
Scope: creation of a relational data base of discographic and musical material
Chief researcher: David Julian Gray
Place: Berkeley, CA
Hardware: CP/M microcomputers with a Mountain Music System
Software: under development in Z-80 machine code to accept keyboard and sung input (the texts involved are Greek, Romanian, Russian, and Yiddish)

Data Bases of Text

Monson/Italian Opera
Title: *Database for Eighteenth-Century Italian Opera*
Scope: data concerning performance (date, theater), libretti, personnel (librettist, composer, performers), and surviving music for 15,000 opera productions cited in the Sartori libretto index and other catalogues
Chief researcher: Dale Monson
Place: University of Michigan
Hardware: Amdahl 5860
Software: TAXIR

Perry-Camp/Mozart
Title: *Non-musical Markings in Mozart Autograph MSS*
Scope: a complete compilation of data (240 MSS to date)
Chief researcher: Jane Perry-Camp
Hardware: Cyber 760
Software: custom designed (music) with Sir II (database)
Literature: article forthcoming in *Mozart Jahrbuch*

UCB *et al.*/Italian Lyric Poetry
Title: *Italian Lyric Poetry of the Renaissance in Musical and Literary Prints*
Scope: 100,000 poetic texts; data base of publication information; retrieval of "lost" poetry from music part-books; music *per se* involved in long-term plans
Chief researchers: Michael Keller, Anthony Newcomb (UCB); Thomas Walker (U. of Ferrara); five Italian literature specialists including Louise Clubb (UCB and Villa I Tatti)
Locations: UC Berkeley, Pisa, Ferrara, Rome and elsewhere
Time frame: 1985-95
Hardware: numerous kinds including IBM PC
Software: under development

CCARH/Bach
Title: *The Complete Works of J. S. Bach*
Aim: creation of a database of the complete works of a major composer; works already entered include the *Two- and Three-Part Inventions*, *The Well-Tempered Clavier*, Books I and II, and the *French* and *English Suites*; work proceeds on the remaining harpsichord pieces, the organ sonatas, and the orchestral suites
Place: Menlo Park, CA
Hardware: HP-1000
Software: custom designed by Walter Hewlett, using the IBYCUS operating system

HillJ/Editions
Title: *Illinois Music Editions*
Aim: to create a large-scale, open-ended general anthology of music before 1800 (comparable with the Denkmäler of *c.*1900); music already entered includes roughly 60 concertos of the eighteenth century as well as six ensemble pieces and five *grands motets* of the seventeenth century
Coordinator: John Hill
Place: University of Illinois (with intended distribution by cable television
Time frame: 1985--
Hardware/software: PLATO Interactive Music System

Hughes/Rhymed Offices
Title: *Late Medieval Rhymed Offices*
Scope: thousands of manuscripts and ten printed volumes of text relating to repertory from the tenth through the sixteenth centuries
Chief reseracher: Andrew Hughes
Place: University of Toronto
Time frame: 1974--
Hardware: various S100 Z-80 machines
Software: custom designed encoding system to handle square and Gothic plainchant notation

Hultberg/Spanish Tablature
Scope: various studies of Spanish tablature from the fifteenth through the seventeenth centuries involving transcription, indexing, and analysis (reported in several publications)
Chief researcher: Warren Hultberg
Place: SUNY Potsdam
Hardware: Apple IIe and Macintosh
Software: modified DARMS code with BASIC, Pascal, and PL/1
Literature: "Data Bases for the Study of Relationships among Spanish Music Sources of the 16th-17th Centuries," *Fontes Artis Musicae* XXXI/3 (1984)

Kennedy/Burgundian Chanson
Title: *Six Chansonniers: A Study of the Central Repertory of the Burgundian Chanson*
Scope: interest in determining degrees of melodic similarity between works (several hundred incipits)
Chief researcher: Duff Kennedy
Place: UC Santa Barbara (Ph.D. thesis in progress)
Hardware: Tandy 1000
Software: modified version of Hughes' chant code for programs in BASIC

Perkins/Busnois
Title: *The Secular Works of Busnois*
Scope: examination of the music and sources of 200 chansons, oriented toward preparation of a critical report for the Busnois Edition
Chief researcher: Leeman Perkins
Place: Columbia University
Hardware: IBM
Software: FASTCODE and RENARC (the latter provides source control over pertinent documents), both designed by Thomas Hall

Powers/Lassus
Title: *The Motets of Lassus and Susato*
Scope: storage, analysis, and editing of 278 motets by Lassus 250 by Susato
Chief researcher: Harold Powers with Lawrence Earp
Hardware: IBM 3033
Software: FASTCODE and MIR with SPITBOL
Literature: "Tonal Types and Modal Categories in Renaissance Polyphony," *Journal of the American Musicological Association*, XXXIV (1981)

Smith/Weiss
Title: *Silvius Leopold Weiss: Complete Works for Lute*
Scope: preparation of 10 volumes of music both in a computer-generated "facsimile" of the original tablature and in modern edition for publication in *Das Erbe deutscher Musik*; roughly 50 works from 37 manuscripts are involved
Chief researcher: Douglas Alton Smith, with David Fitzpatrick
Place: CCRMA, Stanford University
Hardware: PDP-10 (editing and page makeup); Commodore-64 (data entry)
Software: SCORE/MS with adaptations by Leland Smith; tablature facsimile script designed by Douglas Smith
Time frame: 1983--

Analytical Studies

Baroni/Chorale Melodies
Title: *Computer Generatation of Melodies* in *CHum* XVII (1983)
Scope: tries to deduce grammatical rules for the construction of the chorale melodies used by Bach
Chief researchers: Mario Baroni and Carlo Jacoboni
Place: University of Bologna

Baroni/Grammar
Title: *Proposal for a Grammar of Melody: The Bach Chorales* (published by Les Presses de l'Université de Montréal, 1978)
Aim: systematic examination of rules governing construction of chorale melodies
Chief reserachers: Mario Baroni and Carlo Jacoboni
Place: University of Bologna

Bevil/Uplands
Title: *Centonization and Concordance in the American Southern Uplands Folksong Melody*
Scope: concentrates on process of oral transmission of Celtic-American music in Appalachia
Researcher: J. Marshall Bevil
Place: North Texas State University (Ph.D. thesis, 1984)
Hardware: Apple II+
Software: custom designed to link data about pitch, duration, and stress

Blombach/Bach

Title: *Harmony vs. Counterpoint in the Bach Chorales* in *Computing in the Humanities*, ed. Richard Bailey (North Holland Publishing Co., 1982)
Scope: 150 Bach chorales queried for note and interval counts, ranges, pattern analysis, and relationships between vertical and horizontal features such as scalar contradictions and harmonic implications
Chief researcher: Ann K. Blombach
Place: Ohio State University
Software: Musicode A with SPITBOL

Camilleri/Schubert

Title: *A Grammar of the Melodies of Schubert's Lieder* in *Musical Grammars and Computer Analysis* (Florence, 1984)
Researcher: Lelio Camilleri

Ellis/Bach

Title: *Linear Aspects of the Fugues of J. S. Bach's Well-Tempered Clavier: A Quantitative Approach*
Scope: data entered in numerical code for counts of patterns, note recurrences, and pitch/interval or rhythmic groupings
Chief researcher: Mark Ellis
Place: University of Nottingham (Ph.D. thesis, 1980)
Hardware: ICL 2900 with Benson graph plotter
Software: FORTRAN

Gross/Analysis--Programs

Title: *A Set of Computer Programs to Aid in Music Analysis*
Chief researcher: Dorothy Gross
Place: Indiana University (Ph.D., 1975)
Hardware: CDC mainframes
Software: MUSTRAN with SNOBOL4

Gross/Analysis--Projects
Title: *A Computer Project in Music Analysis* in *Computing in the Humanities* (Lexington, MA 1981)
Chief researcher: Dorothy Gros
Place: University of Minnesota
Hardware: CDC mainframes
Software: MUSTRAN with SNOBOL4

Gross/Harmonic Analysis
Title: *A Project in Computer-Assisted Harmonic Analysis* in the *Proceedings of the International Computer Music Conference*, ed. Hubert S. Howe (San Francisco, 1980)
Chief researcher: Dorothy Gross
Place: University of Minnesota
Hardware: CDC mainframes
Software: MUSTRAN with SNOBOL4

Gross/Rhythmic Complexity
Title: *A Study of Rhythmic Complexity in Selected Twentieth Century Works* in *Musical Grammars and Computer Analysis* (Florence, 1984)
Chief researcher: Dorothy Gross
Place: University of Minnesota
Hardware: CDC mainframes
Software: MUSTRAN with SNOBOL4

Hanzelin/Software
Title: *The Software for Computer Assisted Graphical Representation of Single Instrumental Melodic Lines and Harmonic Spectra*
Researcher: Fred Lee Hanzelin
Place: University of Illinois (D.M.A.thesis, 1978)
Software: DARMS

HillJ/Parodies
Title: *Text Parodies and Contrafacta in Italian Baroque Vocal Music*
Scope: development of an analytical procedure that can determine the migration of aria texts from one musical setting to another; involves syllable division, verse scansion, etc.
Chief researcher: John Hill

Place: University of Illinois
Hardware: IBM PC AT
Software: Savy (made by Excalibur)

Houle/Articulation
Title: *Eighteenth-Century French Articulation as Described by Engramelle and Dom Bedos de Celles*
Scope: study based on descriptions of organ mechanisms
Researcher: George Houle
Place: Stanford University
Hardware: IBM PC
Software: custom designed by Roland Hutchinson

Kottick/Harpsichord
Title: *Analysis of Harpsichord Tone Spectra*
Data: 40 reels of tape samples of harpsichords (roughly half of which are antique instruments)
Chief researcher: Edward L. Kottick, with William Savage
Place: University of Iowa
Hardware: IBM PC; Prime

Jackson/Analysis
Title: *Horizontal and Vertical Analysis Data Extraction Using a Computer Program*
Aim: retrieval of selected musical data (roots, pitch classes, intervallic relationships) from twentieth-century repertory
Researcher: David L. Jackson
Place: University of Cincinnati (Ph.D. thesis, 1981)
Hardware: Amdahl 4700
Software: custom designed encoding system with FORTRAN

Jungleib/Modes
Title: *Music Possible* (Los Altos, CA., 1985)
Scope: a systematic listing of all modes of two through ten notes; a discrete numbering system (1 to 2025 for seven-note modes) is derived from the sequence of diminished, perfect, and augmented seconds in each
Researcher: Stanley Jungleib
Place: Los Altos, CA

Longyear/Macroanalysis
Aim: development of macroanalytical procedures for study of eighteenth and nineteenth century repertory
Chief researcher: Rey Longyear, with Kate Covington
Place: University of Kentucky

Plenkers/Cantigas
Title: *A Pattern Recognition System in the Study of the Cantigas de Santa Maria* in *Musical Grammars and Computer Analysis* (Florence, 1984)
Researcher: Leo J. Plenkers
Place: University of Amsterdam

Pont/Handel's Notation
Aim: to show that apparent discrepancies in Handel's notation of "non-sonic" information (*e. g.*, stems and beams) was more systematic than is generally believed
Researcher: Graham Pont
Place: University of New South Wales
Time frame: 1983--
Hardware: DEC VAX 11/780
Software: UNIX environment, DARMS code, Pascal

Schulenberg/C.P.E.Bach
Title: *Collation of Variants for the Concertos of C.P.E. Bach*
Scope: examination of all sources for selected works
Chief researcher: David Schulenberg
Hardware: Kaypro II
Software: standard database packages with letter code

Sentieri/Style Change
Title: *A Method for the Specification of Style Change in Music: A Computer-Aided Study of Selected Venetian Sacred Compositions from the Time of Gabrieli to Vivaldi*
Scope: deals with selected passages from three works by each of six composers
Researcher: Richard Sentieri
Place: Ohio State University (Ph.D. thesis, 1978)
Software: Musicode A, SLAM

ShapiroA/Tune Families
Title: *Handbook of British-American Tune Families*
Scope: 3,000 tunes from the most frequently used collections of British-American folksong, with data about stressed tones, cadence tones, etc.
Chief researcher: Ann Dhu Shapiro
Place: Harvard University
Time frame: 1983-86
Hardware: DEC VAX (text); Macintosh with Yamaha DX-7 (music)

Software: custom designed by David Epstein and Kate Fissell in C with UNIX operating system

Silbiger/Major-Minor
Title: *Emergence of the Major-Minor Key System*
Scope: repertories from *c.*1580 to 1680
Chief researcher: Alexander Silbiger, with J. Michael Allsen
Place: University of Wisconsin
Time frame: 1983-4
Hardware: Apple II and IIe
Software: numerical representation in BASIC

Silbiger/Tonal Types
Title: *Tonal Types in the Keyboard Music of Frescobaldi* in the *Proceedings of the Ferrara Frescobaldi Conference*, 1983)
Reseacher: Alexander Silbiger
Place: University of Wisconsin
Time frame: 1982-3
Hardware: Apple II and IIe
Software: numerical representation in BASIC

Stech/Microanalysis
Title: *A Computer-Assisted Approach to Micro-Analysis of Melodic Lines* in *CHum* XV/4 (1981)
Scope: 3,000 records
Researcher: David Stech
Place: University of Alaska (Ph.D. thesis, U. of Michigan, 1976)
Hardware: IBM mainframe
Software: FORTRAN

Steel/Troubadours
Title: *Evolution of a Musical Style: Early and Late Troubadours*
Scope: compares repertory of twelfth and thirteenth-century Provencal troubadours in diverse neumatic notations
Researcher: Matthew Steel
Place: Kalamazoo, MI
Software: custom designed encoding system

Sward/Babbitt and Xenakis
Title: *An Examination of the Mathematical Systems Used in Selected Compositions of Milton Babbitt and Iannis Xenakis*
Chief researcher: Rosalie Sward
Place: Northwestern University (Ph.D., 1981)

Trowbridge/Chanson
Title: *The Fifteenth-Century French Chanson: A Computer-Aided Study of Styles and Style Change*
Scope: attempts to provide attributions for c.90 anonymous works associated variously with Binchois, Dufay, Ockeghem, and Busnois, whose individual traits are closely examined
Researcher: Lynn Trowbridge
Place: University of Illinois (Ph.D. thesis, 1982)
Software: LMIL with COBOL

Tune Index/I
Title: *The National Tune Index*, I: *Eighteenth-Century Secular Music* (published in microfiche by University Music Editions
Scope: concordances of 38,500 secular tunes, songs, and dances of the eighteenth century in American, Canadian, and British libraries
Chief researchers: Carolyn Rabson and Kate Van Winkle Keller
Software: modified DARMS; the musical material is printed in a numerical format

Tune Index/II
Title: *The National Tune Index*, II: *Eighteenth-Century Wind Music* (in preparation)
Scope: a concordance of eighteenth-century wind music in American, Canadian, and British libraries
Chief researcher: Raoul Camus
Software: modified DARMS; the musical material is printed in a numerical format

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