PROCEEDINGS

SYMPOSIUM ON SMALL COMPUTERS IN THE ARTS

NOVEMBER 20-22, 1981

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symposium on small computers in the arts

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PHILADELPHIA, PENNSYLVANIA

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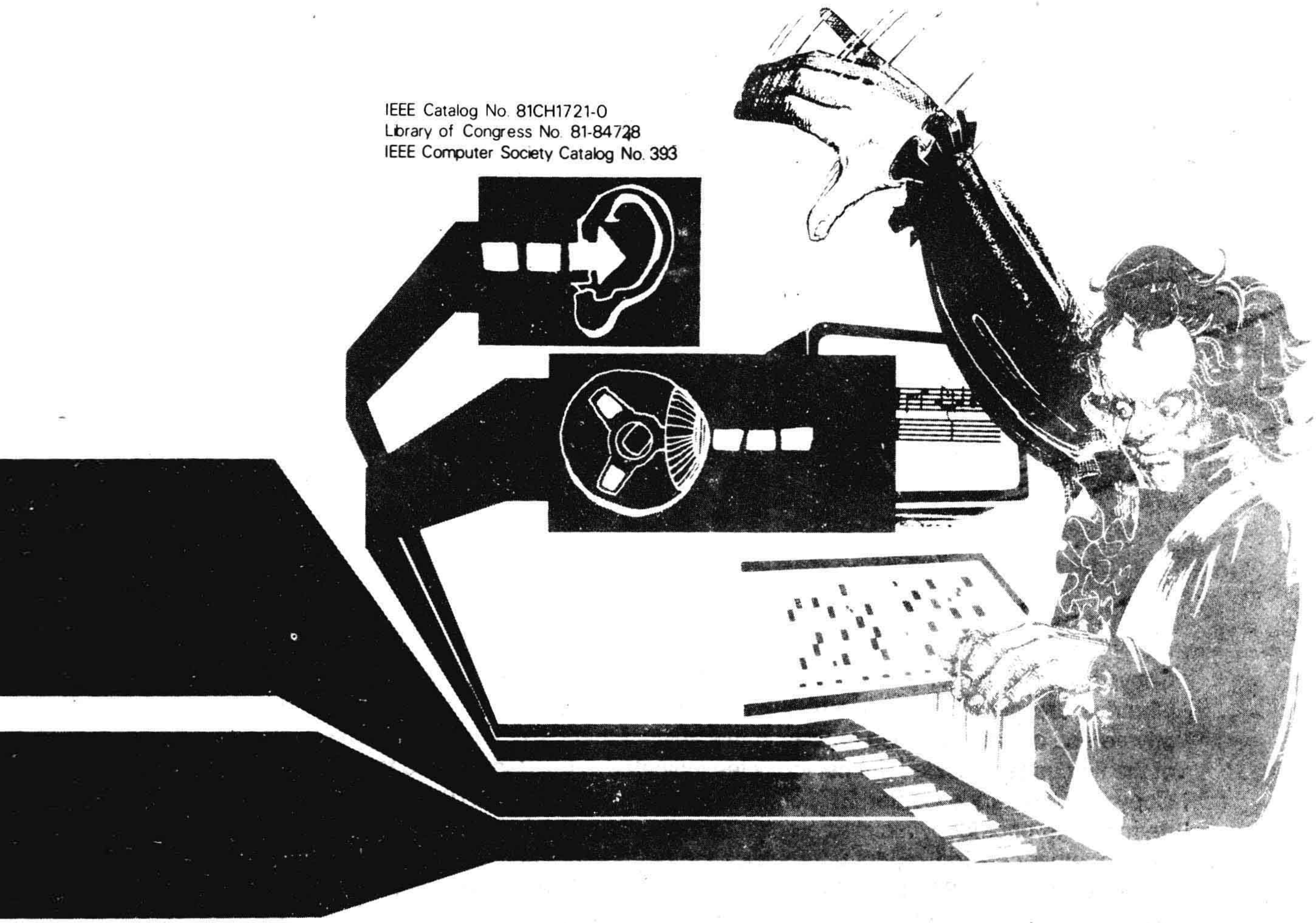

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ORGANIZING COMMITTEE:

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PREFACE

THE ENTRY OF THE SMALL COMPUTER IN TO THE HOME CREATED A NEW GROUP OF COMPUTER USERS. THESE PEOPLE DO NOT HAVE A LARGE COMPANY OR UNIVERSITY WATCHING OVER THEIR SHOULDERS, MONITORING THEIR WORK. THEY USE COMPUTERS FOR FUN, NOT PROFIT. ALL OVER THE WORLD WE ARE DISCOVERING INDIVIDUALS WHO ARE USING SMALL COMPUTERS TO HELP THEM HAVE FUN, AND THAT INCLUDES, NOT SURPRISINGLY, MAKING ART. WE USE THIS TERM BROADLY, MEANING MOVIES, GRAPHICS, MUSIC, SCULPTURE. OF COURSE, MANY PRODUCTION TASKS MAY MAKE USE OF A COMPUTER TO ASSIST IN SOME ROUTINE LABOR. FOR INSTANCE, THE POET MAY USE A WORD-PROCESSOR TO EDIT AND TYPE HIS POEMS. BUT THE REAL PURPOSE OF THIS SYMPOSIUM IS TO BRING OUT THE APPLICATIONS WHICH RELY ON COMPUTERS; THOSE THAT INVOLVE THE COMPUTER DIRECTLY IN THE CREATIVE TASK, AND INVOLVE THE ARTIST WITH THE MEDIA IN A NEW WAY. IT IS HERE THAT WE ARE FINDING NEW IDEAS, NEW WAYS OF THINKING ABOUT ART, NEW WAYS OF REPRESENTING IDEAS, AND NEW PALETTES OF RAW MATERIALS.

THE PERSONAL COMPUTER IS ONE MACHINE UNDER THE CONTROL OF ONE INDIVIDUAL. THAT PERSON IS DIFFERENT FROM THE TYPICAL LARGE COMPUTER USER IN THAT HE OR SHE DOES NOT HAVE CONSULTANTS, PROGRAMMERS, OR DEPARTMENTS SET UP FOR ASSISTANCE. A PERSONAL COMPUTER USER MAY OPERATE SOLO. THIS IS ESPECIALLY TRUE IN THE MUSIC AND ARTS APPLICATIONS. FOR THESE REASONS, IT IS IMPORTANT TO HAVE THIS GATHERING OF PEOPLE INTERESTED IN THE ARTS, WHERE THEY CAN COMMUNICATE WITH OTHERS AND GAIN INSIGHTS INTO THE TECHNIQUES AND PHILOSOPHIES OF THEIR COHORTS.

HISTORICAL NOTES

THIS SYMPOSIUM GREW OUT OF A COMPUTER MUSIC CONCERT HELD IN DOWNTOWN PHILADELPHIA IN 1978. IT WAS PLANNED AS PART OF THE PERSONAL COMPUTING '78 SHOW HELD AT THE CIVIC CENTER. JOHN DILKS, THE FOUNDER OF THE SHOW, GRACIOUSLY BACKED THE IDEA AND PROVIDED A HOTEL BALLROOM FOR THE EVENT. AS WORD OF THE UPCOMING CONCERT SPREAD, WE RECEIVED CALLS FROM PEOPLE AS FAR AWAY AS THE WEST COAST ASKING IF THEY COULD PARTICIPATE. ONE MUSICIAN FROM NEW YORK ACTUALLY ARRANGED A PIECE FOR COMPUTER AND CLARINET ESPECIALLY FOR THIS CONCERT.

THE EVENING OF THE CONCERT OVER 500 PERSONS SHOWED UP AND TRIED TO SQUEEZE INTO A ROOM THAT ONLY HELD 300. THE CONCERT WAS RECORDED, AN ALBUM WAS MADE, AND IT IS NOW SOLD BY CREATIVE COMPUTING.

THE SUCCESS OF THAT CONCERT LED THE ORGANIZERS TO FORM AN INFORMAL PERSONAL COMPUTER ARTS GROUP TO PRODUCE SIMILAR EVENTS AND TO ACT AS A CLEARINGHOUSE FOR THOSE INTERESTED IN COMPUTER APPLICATIONS IN THE ARTS. THE 1979 PERSONAL COMPUTER MUSIC FESTIVAL, SPONSORED BY THE GROUP, INCLUDED TALKS AND DEMONSTRATIONS DURING THE DAY IN ADDITION TO THE EVENING CONCERT. IN 1980, A SEPARATE DAY OF COMPUTER GRAPHICS TALKS AND DEMONSTRATIONS WAS ADDED TO MAKE THE PERSONAL COMPUTER ARTS FESTIVAL. ALL THESE EVENTS WERE HELD AT THE PERSONAL COMPUTING SHOWS IN PHILADELPHIA AND WERE BACKED BY JOHN DILKS. A FEW OTHER EVENTS PROMOTING COMPUTERS IN THE ARTS WERE HELD DURING THE LAST YEAR.

IT HAD ALWAYS BEEN OUR DESIRE TO SOME DAY ORGANIZE A MAJOR MEETING SOLELY DEDICATED TO THE USE OF SMALL COMPUTERS IN THE ARTS. THIS DREAM BECAME A REALITY WITH THIS SYMPOSIUM THANKS TO THE SUPPORT OF THE IEEE COMPUTER SOCIETY AND THE IEEE PHILADELPHIA SECTION.

THE PERSONAL COMPUTER ARTS GROUP, AS A VOLUNTEER NOT-FOR-PROFIT GROUP, CONTINUES TO PROMOTE THE USE OF COMPUTERS IN THE ARTS THROUGH ITS NEWSLETTERS, CONCERTS, AND OTHER EVENTS. TO CONTACT THE GROUP, WRITE TO: PERSONAL COMPUTER ARTS GROUP, BOX 1954, PHILADELPHA, PA, 19105.

SYMPOSIUM ON SMALL COMPUTERS IN THE ARTS

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PART I

SMALL
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PERFORMANCE
COMPOSITION
AND
SYNTHESIS

INTRODUCTION

1981 MARKED THE INTRODUCTION OF SEVERAL NEW COMMERCIAL SYSTEMS FOR MAKING MUSIC ON PERSONAL COMPUTERS. THE READY AVAILABILITY OF RELIABLE SYSTEMS HAS BROUGHT COMPUTER MUSIC TO A NEW AUDIENCE: THE COMPOSERS AND MUSICIANS. IN THE SAME WAY THAT "APPLIANCE" HOME COMPUTERS SAVED THE USER FROM THE UNNECESSARY COMPLEXITY OF BUILDING A COMPUTER SYSTEM FROM SCRATCH, NOW MUSIC PROGRAMS AND PERIPHERALS FREE THE MUSICIAN FROM LOW-LEVEL HARDWARE AND SOFTWARE INCONVENIENCE. THIS IN TURN HAS SPAWNED INDEPENDENT SOFTWARE PROJECTS. WE ARE SEEING THE FIRST WAVE OF CREATIVE, INDIVIDUALIZED MUSIC SYSTEMS.

THE SYMPOSIUM POSES SOME SPECIFIC ANSWERS TO THE PROBLEMS OF MUSIC COMPOSITION BY COMPUTER. PAPERS ON PATTERN MANIPULATIONS, STOCHASTIC PROCESSES, AND CANON WRITING, SHOW HOW THE COMPUTER CAN HELP THE COMPOSER GENERATE MUSICAL MATERIAL. OTHER WORK TREATS THE PROBLEM OF REAL-TIME PERFORMANCE, WHERE THE COMPUTER MAY ASSIST THE PERFORMER IN CONTROLLING AN INSTRUMENT.

THE FINAL AND MOST TECHNICAL SECTION PRESENTS SOME NEW WORK IN SOUND SYNTHESIS. MANY FUNCTIONS WHICH HAVE BEEN DEVELOPED ON LARGE SYSTEMS ARE BEING IMPLEMENTED THROUGH CREATIVE HARDWARE AND SOFTWARE DESIGNS FOR SMALL SYSTEMS.

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THE PIPE ORGAN AND THE MICROCOMPUTER

Dr. Robert Suding

Problems facing a microprocessor assisted pipe organ

Earliest versions of "pipe organs" date back many centuries to Pre-Christian times. The pipe organ as generally known today in churches was well developed by the end of the 17th century except for electrical keying and wind pressure blower systems. These latter two were accomplished almost 100 years ago. The pipe organ is indeed a very old and mature technology, and most innovations have traditionally met with a great deal of resistance.

Even such a common idea as coupling the pipe system(s) to the keyboard with electricity is discarded by some, claiming that without the mechanical linkage they lost a tactile sense and a playing style when only electrical contacts are made.

Another fear is what will occur under a failure condition. The pipe organ is a mass of parallel matrix switches, the proper selection resulting in a pipe "speaking". Two failure modes are typical. The most common failure is that a pipe does not speak when ordered. The other more serious failure is that a pipe speaks without being selected, referred to as a cipher. The first problem is temporarily overcome by not using the group of pipes where the silent one resides, or using another similar rank to fill in for the missing note. The cipher is cured by removing the offender from its pipe rack and treating the problem as a missing note.

Now visualize the position of yourself trying to introduce a new fangled microcomputer to a pipe organ. This pipe organ can have from 1000 to 10,000 pipes. Can you imagine the sound that would occur if a microprocessor failure turned on every pipe?

The typical pipe organ wiring system is conceptually relatively simple, but works with thousands of wires and contacts in parallel. Some have suggested that since the pipes take a certain amount of time to react to the keying of the wind pressure, about 1/10th of a second "refresh" time would be adequate to sample the key, calculate the pipes required, and turn on the required valves. Unfortunately this produces an effect that nullifies the "personality" of a performer. In the real world, chords are not simultaneously struck, but are "rippled on", so that lower (or upper) parts of the chord come on ahead of the rest of the chord. While difficult to pinpoint the cause of the realism lack, experiments indicate a key/calculate/pipe refresh cycle requirement of 4 milliseconds or less.

A pipe organ typically enjoys a very long life, often measured in centuries. Electronic technology however is not so stable. Obsolescence is measured in years or even months. While defects may occur on the pipe organ mechanical parts, replacement parts are readily available a century later. Which electronic part do you think will be available for easy replacement in 2081?

Advantages of a microprocessor assisted pipe organ

The microprocessor does offer an outstanding advantage: Flexibility. The typical cabling system for an organ consists of several large cables of thin wires going through a number of mechanical relay banks to tables of pipes. Several miles of wire are involved and many thousands of contact points, even in a small pipe organ system. The stop tabs and couplers on the console are then engraved to reflect the wiring architecture. End of job for 20-30 years. But tastes change. Pipes hardwired to one division often are captive. Experimental ensemble combinations are discouraged by the permanence of the wiring.

The microprocessor driven pipe organ gives a degree of freedom and experimentation to practice sessions. The performance may be digitally logged and replayed. But the degree of replay may be customized. The replay of notes can be accompanied by a new combination of stops and couplers. The performer is able to eliminate muddy passages, or trim the ensemble effect to achieve the composer and performer's interpretation of each passage. Initial practice sessions may record a single hand on a difficult passage. Replay of the prelogged performance may then be "ORed" with the next hand, creating the ensemble effect lost when only a single (or foot) is utilized initially.

The last (and least desireable) possibility is the complete performance by the computer. Insistence on this obvious possibility will guarantee failure. The organists of the world will

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PROBLEM	COMMENT
• New systems not accepted.	• Show as an aid to the organist, not a replacement.
• The tactile feel of a tracker action is lost.	• "Solid State tracter action" would introduce a new and highly marketable system.
• Failure may result in a catestrophic sound, or total crippling during a performance.	• Redundant system architecture needed, and fail safe anti-cipher designs are mandatory.
• "Inhuman effect" caused by computers' inflexible timing subsystems.	• Update system cycles in less than 4ms. Randomizing programming required if "player organ" implemented.
• Technology obsolescence	• Extremely difficult to avoid. Use only the commonist parts. Provide easily redefinable subsystems to allow substitution. Provide spare parts. Far overrate. Overprotect. Provide standard connectors.

GAIN	COMMENT
• Flexibility	• Minimize matrix wiring subsystems. Do not skimp on driver system. Do not try to take input shortcuts.
• Practice assistance	• Provide alterrate real time input and output systems. Spend the majority of the design time at the critical interchange points.
• Performance aid	• Auto-detect ciphers and disconnect if possible, otherwise notify which rank has the cipher.

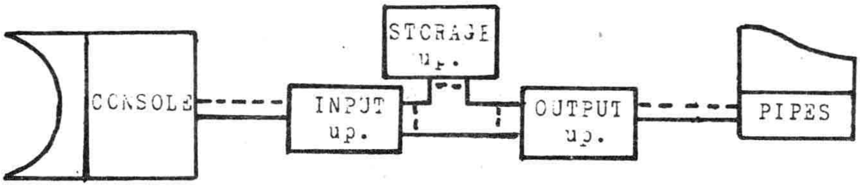
rise enmasse and stomp on your IC's.

The architecture of the pipe organ computer system must be designed to overcome the problems, while achieving the gains. The table above lists the problems and gains with comments.

System Alternatives

Many architectures are possible, but the need for flexibility and speed eliminate most. The key item to remember is that over 200 inputs myst be scanned and over 1000 pipes must be potentially actuated at a rate of greater than 250 times a second (4 ms each time). A complete scan, calculate, and output in 4 ms is far beyond present economical technology.

However, voice and video technology are both pointing towards various reduced bandwidth systems. Perhaps the delta modulation systems may provide an acceptable solution. Investigations of how pipe organs are actually played show that over the desired 4 ms time slice comparatively small amounts of change occur when compatred with the previous 4 ms time slice. The solution then resolves to building a work list of changes to be made. General Housekeeping is performed during "No Change" time slices, Failure Prevention Housekeeping is accomplished during "No Key Input" time slices, etc. Over a dozen time slice job list functions have been defined. Some are difficult, some easy. A Failure Prevention subroutine is simple; but coupler tab actuation with a sustained chord severely taxes the 4 ms limit.



PIPE ORGAN MICROPROCESSOR SYSTEM

The figure above illustrates a simplified block view of my selected architecture. Three microprocessor subsystems, consisting of Z-80B based modules proved 1) Input and delta worklist maintenance, 2) Output, calculate, and failure bypass, and 3) Storage, retrieval, and auto-calibrate.

The input requirement consists of gathering the 200 plus input lines into memory and checking for changes. Either parallel or parallel load-serial transfer systems are feasible. I have chosen the serial transfer system since this reduces the interconnect lines and provides a greatly reduced number of lines on the input microprocessor board (read that improved reliability!). The inputs consist of a 4021 CMOS I C for each set of 8 inputs. Although there are over 200 inputs, a cable of only 8 wires (+, -, Load, Clock, and Data) connects the console to a remotely located input microprocessor. One hundred percent redundancy is another 5 wire cable. The change analysis subroutines require a small amount of dual buffering. Keys, Stops, and Couplers are separately maintained in logically partitioned areas of the buffers. The work list buffering is Fifo-like in architecture, pouring its preliminarily processed data into the output microprocessor's workspace.

The output microprocessor also may be a parallell or serial/parallel based subsystem. In my case, I again selected serial transfer over a 5 conductor cable plus a redundant cable. A 4094 CMOS 8 bit shift register and latch is used for each 8 pipe magnets.

2N6724's at 20 cents apiece provide the magnet drivers with a current capacity of 2 amps, although only 150 ma is typically required.

The actual driver cards are separate from the output microprocessor and contain enough drivers for one or two ranks (each rank contains 32-97 pipes). The output microprocessor is in charge of these output cards and handling the partially processed data from the input microprocessor and any input from the storage microprocessor. Should the output microprocessor fail to send new data to any rank for more than 10 ms, the rank drivers will go to a "silent pipes" failsafe condition. The output microprocessor has the capacity to reassign pipe ranks to other divisions as well as make unique stops and couplings appropriate to certain musical combinations, (e.g. a soft or loud mixture rank formed to support a division).

The storage microprocessor is the most flexible, and many commercially available microprocessor systems are viable here, but the redundancy requirements would eliminate most systems. Off line storage could take many forms, but the Winchester disk offers speed/capacity that permits a rapid "simultaneous" read/write capability. "Simultaneous" read/write allows the perfomer's input from the console to be logged while the storage subsystem is also providing input to pipe driver in "play along with the computer" applications. Computer assisted composing would also utilize the "simultaneous" read/write storage system.

The costs will vary widely, but my rule of thumb for pure component costs is approximately one dolloar per input or output bit (a bit may be a key, stop, pipe or magnet) for the medium sized input and output subsystems. The organ of 3 manuals and 60 stops along with 24 ranks (1500 pipes) which I have will have abjout $1200 in parts. Redundancy will add about 50 percent. The offline storage doubles the previous costs. If the system were to be made into a commercially available package, $10,000 might be a reasonable price to expect. But you are greatly enhancing the capabilities of a $100,000 pipe organ. The on site wiring costs of this sized pipe organ could exceed the cost of the microcomputer system. The music hobbiest should be aware that used pipe organs of 40-60 years old vintage are often sold by churches and theaters. The cost of these "old relics" can be surprisingly low, frequently in the range of $2-$4 per pipe for a repairable organ system. Visitors to my house tend to bring their wives along to see my 1500 pipe organ. The wives generally conclude that their husband's hobby isn't so bad.

If only a simple input and/or playback function is desired, the ports of a microprocessor can be only connected to the keyboard of an organ. While simpler, flexibility suffers. Electronic organs (ugh!) may also be coupled to a microprocessor. Even toy organs can use a microprocessor's output ports, but the system sinks to a lowly "player organ".

The computerized pipe organ produces an effect truly worthy of the King of Instruments. It is infinitely superior to any musical experience you have ever had.

MANUSCRIPT: Music Notation for the Apple][

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MANUSCRIPT is a high-resolution music editor which produces pages closely resembling printed notation. The use of special compilers makes MANUSCRIPT files compatible with all music peripherals for the Apple][system. This paper illustrates the decision-making process involved in construction of an editor which is visually pleasing, easy to operate, and does not require any additional hardware.

The ability to place notes, stems and beams in any location on the musical staff, to write dynamics and phrasing markings, and the inclusion of song lyrics have been seen as desirable features in music writing. To date, music editors which incorporated these items (such as those by Leyland Smith of Stanford University, and Donald Byrd of Indiana University) could only be found on minicomputers or larger systems. The major goal of MANUSCRIPT is to provide the microcomputer user with a seemingly infinite piece of blank manuscript paper, upon which can be written any item found in conventional musical notation.

The proliferation of musical hardware for the Apple][(ALF, Mountain Computer, MMI, AlphaSyntauri, to name a few) poses a problem of incompatibility among their editors. Imagine the dismay in discovering that the file you spent two weeks perfecting on your MMI system can not be played on your friend's Mountain Computer boards. The development of individual, highly specific music editors by hardware manufacturers is analogous to the use of interpreted computer languages like Applesoft which save development time at the sacrifice of portability and speed. A secondary goal of MANUSCRIPT, therefore, is to produce files which can be compiled differently depending upon the hardware used. A side benefit is that MANUSCRIPT can become compatible with any future music systems merely by writing new compilers. This issue is complicated, though, by the fact that the number of simultaneous voices currently ranges from one (Apple speaker) to sixteen (Mountain Computer), necessitating the use of various coding methods (stem direction, color) to separate the melodic lines.

The creation of any music editor involves numerous compromises imposed both by hardware and software considerations. For example, my selection of Applesoft BASIC (rather than Pascal) and paddle controllers (instead of a joystick or light pen) was intended to facilitate wide usage, since these items are readily accessable to Apple][and][plus owners. Most difficult has been my constraint to 48k of memory, although space problems can be resolved somewhat through segmentation of the program into different functional groups (such as text writing, dynamics marking...).

Prior, to use of the MANUSCRIPT program, numerous options may be selected. These include: automatic measure checking for correct rhythms, display of note name corresponding to cursor position, audio feedback of note insertion using the Apple speaker, and specification of distinct voice lines. After, or during creation of a note file, it is possible to change into dynamics

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marking or lyric writing modes. A post-processor is also available for automatic beaming (connection of eighth notes etc.) and note alignment (spacing within measures according to note value).

MANUSCRIPT's high-resolution display is designed for simplicity and ease of use. The black figures on a white background provide close similarity to paper notation. The basic configuration displays four 5-line staves, although the user may select 1, 2, or 3 staves and 4-lines or 6-lines for use in banjo or guitar tablature. The bottom tenth of the screen contains a menu of musical symbols. This is a multi-page menu organized according to function as follows:

PAGE 1: Treble, bass and four C clefs (SATB), user defined meters from 0-99 over 1, 2, 4, 8, 16 or 32.

PAGE 2: Note and rest values from whole to 64th, measure bars, dotting, ties, accidentals, 8va, 15va.

PAGE 3: Repeats, 1st and 2nd endings, da capo, coda, dal segno, voice selection.

PAGE 4: Tablature notation

PAGE 5: Dynamics markings

PAGE 6: Ornamentation (trills, slurs...)

Certain of the menu items, such as voice selection and tablature notation, may only be active when those options are in effect.

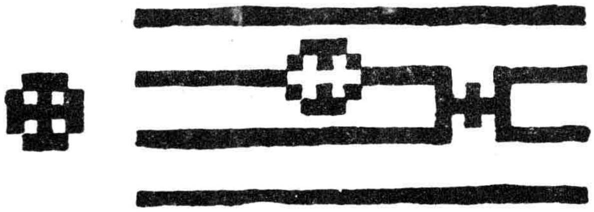

FIGURE A

Cursor design and appearance on lines or spaces.

A special cursor (see figure A) was designed to assist in correct note placement. When the cursor is on a staff line, it appears differently than when it is on a space, thus reducing entry problems. The paddles independently control x and y motions of the cursor. Menu items are selected by moving the cursor to the desired symbol and then pushing the paddle button. The chosen item will now appear shaded on the menu, and when the cursor is moved to any area on the manuscript paper, pushing the paddle button again will deposit the character at this location. The cursor may then be repositioned on the page without having to return to the menu. In the audio feedback mode, notes are heard as they are installed onto the page, and various click sounds are also available to indicate menu selections, rest entries and cursor movement.

Special care was taken in the design of the note shapes. Printed music has evolved over many hundreds of years to the point where it has become aesthetically pleasing. For a graphic music editor to be truly effective, the subtle curvatures, proportionalities and shadings of printed music must be replicated. The direct transfer from a graph paper representation to pixels is, unfortunatly, not possible because of the peculiarities of the video medium. A note head that appears almost square on paper is perceived as round when viewed on a monitor. One or two pixels, properly

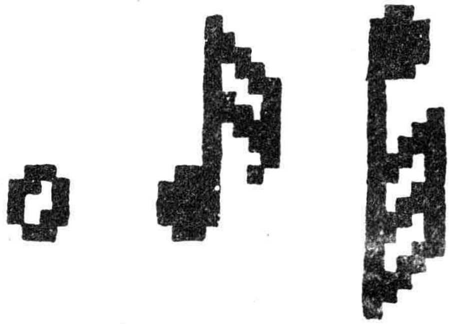

FIGURE B

Examples of whole, 16th and 32nd note formations.

FIGURE C

MANUSCRIPT display showing excerpt from Boris Godunov and examples of chord construction. Clef and time signature menu appear beneath the music.

placed, can provide the illusion of smoothing out the jagged lines that are problematic in graphics systems without gray scale levels. Universal visual perception problems with parallel lines can cause well-formed objects to look peculiar when superimposed upon the staff; tests had to be performed in order to insure that a note would look well on either the lines or the spaces. Figure B illustrates the design of some of the characters created.

A current MANUSCRIPT display can be seen in Figure C. The program is still under development - future plans include the addition of a special notation for digitally produced sounds as well as commands for non-diatonic tunings. Further information about MANUSCRIPT can be obtained by writing to the author.

REFERENCES:

Byrd, Donald, An Integrated Computer Music Software System, Computer Music Journal, April 1977.

Grout, Donald, The History of Western Music, rev.ed., W.W. Norton and Co., Inc, 1973.

Ross, Ted, The Art of Music Engraving and Processing, Charles H. Hanson Music and Books, Inc., 1970.