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ABSTRACT

A feasibility (development) course investigating Computer Assisted Instruction in instrumental music was designed and administered over an eight-week trial period to 14 clarinetists of varying ability in grades seven through ten. The course concentrated on articulation, phrasing, and rhythm. Generally, a dual program was developed. 1) an aural program on-line (via CAI) emphasizing aural-visual discrimination, and 2) a playing-recording program off-line (without computers) using specially modified tape recorders programed with pre-recorded models. Some on-line recording was also done to coordinate the playing and ear-training programs more closely. After reviewing student records the program was extensively revised and is now functional on the IBM 1500 Instructional System. The present system can: present models for the student to compare with his recorded version, coordinate presentation of aural-visual stimuli, and process student typewriter or pen responses. Tables and figures of a student progress are included, and five appendices illustrate the music dictionary (for the computer), flow charts, extracts from a course listing, the instructional display planning guide, and pictures of the learning/teaching progress. (Author/SH)

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FINAL REPORT
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DEVELOPMENT AND EVALUATION OF COMPUTER-ASSISTED INSTRUCTION IN INSTRUMENTAL MUSIC

Ned C. Deihl
The Pennsylvania State University
University Park, Pennsylvania

September 1969

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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Ned C. Deihl, Principal Investigator

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University Park, Pennsylvania
September 30, 1969

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SUMMARY

The purpose of the study was to explore the feasibility of computer-assisted instruction (CAI) in instrumental music through the development and evaluation of a course in articulation, phrasing, and rhythm on the intermediate level for clarinet. Considering the newness of CAI, a feasibility or developmental approach was chosen rather than a more structured design such as a comparative study.

Generally, a dual program was developed: 1) an aural program on-line (via CAI) emphasizing aural-visual discrimination, and 2) a related playing-recording program off-line (without computers) using specially modified tape recorders programed with pre-recorded models. Some playing-recording was also done on-line, however, integrating the playing and ear-training programs even more closely.

A pilot trial of approximately eight weeks was conducted with fourteen clarinetists of varying ability in grades seven to ten. The usual procedure was an hourly student session, a half hour on-line and a half hour off-line, twice a week. On the basis of this trial which provided detailed CAI student records, the course was extensively revised, and a functioning course is now available for the IBM 1500 Instructional System. This system includes image projector, play-record audio unit, and a cathode ray tube display with keyboard and light pen.

While certain modifications in audio capability of the 1500 system might be necessary for certain other areas of music instruction, the fidelity was adequate for the present program. Although the present system cannot listen to the student recording, it can efficiently and systematically present master models as feedback for the student to compare with his recorded version. The system can flexibly coordinate presentation of aural-visual stimuli and can objectively process student typewriter or light pen responses. For aural-visual discrimination training employing such a response, CAI seems particularly well adapted.

CHAPTER I

INTRODUCTION

This project was undertaken to explore the feasibility of computer-assisted instruction (CAI) in certain areas of aural-visual discrimination and performance skills in instrumental music. Enough studies in programed instruction had been undertaken to indicate that through such individualized approaches sufficient learning could occur to warrant investigation of a computer-controlled program. The computer with its capacity for information storage and processing, as well as the coordination of the audio and visual presentation, appeared a promising medium for individualized music instruction.

At the time the current investigation was proposed to the U. S. O. E., no reports on computer-assisted instruction in music could be found. Individualized programs using non-computerized technology had been reported by Spohn (1963), Carlsen (1964), Kanable (1964), Ihrke (1963), and LeBach (1965). After the current project began, experimental work in CAI was reported by Kuhn and Allvin (1967), and a Systems Development Corporation study with keyboards was initiated.

Purpose of the Study

A developmental or feasibility study was considered the most appropriate approach because of the newness of CAI and relative lack of research in programed instruction in music. The study was undertaken with three objectives predominating: 1) investigate the feasibility of CAI for individualized instruction in aural-visual discrimination and performing skills in instrumental music; 2) develop a functioning CAI program in aural-visual discrimination integral to instrumental performance (specifically clarinet); and 3) develop a prototype drill program for practicing skills in articulation, phrasing, and rhythm on clarinet, using both CAI and non-computerized language lab machines.

Objective One: Investigate the feasibility of CAI for individualized instruction in aural-visual discrimination and performing skills in instrumental music. The investigator believes the profession has a mandate to explore new technology which might lead to significant breakthroughs in music instruction. This theme was strongly emphasized at the National Conference on the Uses of

Educational Media in the Teaching of Music. In the final report of that conference is this statement by Harold Arberg (1965), Director of U. S. O. E. Arts and Humanities Program:

> ". . .interest in the arts and humanities has never been greater. . . . [This] national interest, coupled with the technological revolution through which we are passing, brings its own imperative for the thoughtful consideration and action of music educators."

The Tanglewood Symposium also stressed the view that music educators have not effectively applied new technological developments. A continuing dialogue with manufacturers was suggested to encourage and inform industry of the technological needs and problems of the profession. Included in the Tanglewood Declaration (1968) was the recommendation that developments in educational technology and computer-assisted instruction be applied to music study and research.

Objective Two: Develop a functioning prototype CAI program in aural-visual discrimination training integral to instrumental performance (specifically clarinet). The investigator has long felt the presence of overemphasized manipulative techniques in instrumental instruction and a corresponding lack of general aural concepts and necessary discrimination training. Too often students engrossed in technical problems of blowing, fingering, tonguing, and note reading are apparently unaware of the underlying aural concepts. It would seem that a student with a sound aural concept of a particular articulation style, for example, would spend less time and commit fewer errors in attempting to execute such style on his instrument. One who has been aurally trained in phrase-oriented breathing and in articulation patterns would reasonably be expected to make fewer performance errors in breathing and articulating. Aural understanding may be no guarantee of fine instrumental performance, but apparently is a prerequisite. As Carpenter (1965) suggested, ". . . emphasis on discrimination training and training in musical imagery of ideal standards . . . would result in reduced emphasis on drill and practice."

Central to the problem of undeveloped discrimination is the limited opportunity for concentrating solely on the listening aspects unburdened with the problems of reading and manipulating. Such concentrated ear-training is seldom attempted in the typical group or individual instrumental lesson. This neglect may be due to the nature of such instruction or to the limited time allotted. A resourceful teacher could have a student play an excerpt both correctly and incorrectly, asking the class to judge, but seemingly this is seldom done. A specifically designed course with emphasis on such aural training (with integration of playing provided) would presumably improve a student's aural discrimination and hopefully his instrumental performance.

Objective Three: Develop a prototype drill program for practicing instrumental skills in articulation, phrasing, and rhythm on clarinet, using non-computerized portable language lab prototypes and CAI.

Traditional instrumental instruction revolves around the group or individual lesson with the teacher followed by a week of individual drill or practice. Such unguided practice may well include unknowing repetition of certain errors, reinforcing incorrect responses, and establishing misconcepts for the uncertain student. What teacher has not encountered the pupil who practiced an incorrect rhythm pattern for an entire week before correction or feedback from the teacher?

Without reinforcement a student may flounder in his home practice, repeating needless errors, uncertain of how the exercises should sound. Although his teacher may have previewed the lesson for him, the student may forget. Frequently, limited lesson time precludes even a preview. It is proposed that programed instruction with prompting or confirming models (computerized or non-computerized) might provide more effective practice.

A viable problem in instrumental music teaching, particularly in a school situation, is the frequent lack of an ideal aural model for the students to emulate. Although teachers are theoretically qualified to teach all of the orchestral instruments, few can expertly demonstrate them all. It is the rare band director-clarinetist, for example, who can produce a true tone quality on all the woodwind instruments, let alone the brasses, although he may know the fingerings and basic principles of embouchure for all the instruments. This observation is not surprising, however, considering the limited amount of time that can be devoted to applied secondary instruments in the teacher preparatory curriculum. Even if this performing versatility could somehow be acquired in the teacher preparatory curriculum, the prohibitive schedule of public school music teaching would hardly allow time to maintain such skills. The choice of instrument or timbre for demonstrating rhythm may not be cricical but would seem important for models in other areas of performance. Programed models recorded by experts might represent a significant advance in instruction.

IBM 1500 Instructional System

A description of the system hardware may be useful in providing the reader with further background. In December 1967 the Penn State CAI Laboratory acquired the IBM 1500 Instructional System, the first computerized system designed especially for individualized tutorial instruction.

The system currently consists of 14 instructional stations with cathode-ray tube display, light pen, typewriter keyboard, and image projector. Two of the stations presently have audio units and more will be equipped with audio in the near future. The basic components of the instructional station are described below. Each instructional station contains four optional display-response devices which may be used individually or in combination.

Cathode ray tube screen (CRT). The CRT, the central instrument connected to the computer, is a television-like unit with 16 horizontal rows and 40 vertical columns, providing a total of 640 display positions. The CRT can utilize 4 dictionaries simultaneously of 128 characters each. These characters can be alphabetic, numerical, or special, as required for musical notation.

Light pen. A light pen device enables the student to respond to graphics, letters, and figures on the screen by touching the appropriate place. By touching a specific point on the screen sensitized by the course author, the learner may respond to a question such as a multiple choice question or point to a specific note in a musical passage, for example. A program can be designed to process such responses, to confirm them or provide cues or branches to remedial material.

Keyboard. In addition to the light pen a typewriter-like keyboard is attached to the CRT. This device may be used by the learner to construct responses and have them displayed on the screen at an author-designated point although the present course uses light pen responses almost exclusively. The keyboard is also used to sign on and sign off an instructional session. Course authors may use the keyboard to enter revisions or enter new course material.

Image projector. This unit contains a 7 1/2 by 9-inch screen on which color or black and white images are shown. Interchangeable cartridges containing 16 millimeter film are automatically threaded and show as many as 1,000 images in any sequence designated by the author. An accessing capacity of 40 frames per second allows branching flexibility. Musical examples presented on this screen can be more extensive and in sharper detail than on the CRT. Although presently the student cannot respond directly on this image with the light pen, he can respond to keyed numbers or corresponding points on the CRT.

Audio unit. The audio unit permits the student to listen to pre-recorded verbal or musical messages on magnetic tape and to record a musical response requested by the program. Available for each station is a separate interchangeable cartridge containing as much as two hours of variable-length messages or blank tape for student recording. Four-track tape is used with messages recorded on three tracks and inaudible address signals on the fourth track. The tape recording for each station is independent and is coordinated with the appropriate point in the particular program. Either headphones or external speakers may be used. Fast forward and rewind speeds to positively identified messages provide branching options, although these speeds are not comparable to the extremely rapid searching available for the visual images.

The central processor of the system is an IBM 1130 computer with 32,768 sixteen bit words of core storage. The 1130 depends upon five IBM 2311 disk drives (2,560,000 words) for the storage of course information and operating instructions. Interaction between student and program is recorded by twin magnetic tape drives for later student analysis and course revision.

In the Penn State CAI Lab the 1500 Instructional System, including the 1130 computer, is self-contained.

CHAPTER II

DEVELOPMENT OF PROGRAM

The project began with a continued review of related studies initiated in the project proposal. Although a number of CAI studies and explorations were available in areas other than music, no reports on CAI in music were available at the time the project was proposed or initiated. Several programs in non-computerized programed instruction in music had been reported and were examined. Of particular interest was a project by LeBach (1965) involving pre-recorded models as comparisons with student performance.

Program objectives were studied, reviewed, and refined. At the outset it was planned to focus on articulation and phrasing at the intermediate clarinet level. Later it was decided to program most of the instrument performing drill off-line on IBM portable language lab prototype machines and to add rhythm study to explore musical notation on the CRT.

Several students of approximately intermediate level proficiency on clarinet were auditioned to help guide selection of materials. An extensive search was conducted in the wind literature for appropriate free-domain materials. In addition some original materials were written expressly for the program.

After participating in a number of instructional sessions on IBM Coursewriter I, the computer input language, the staff authored and programed several course sections and implemented this material at the computerized 1050 instructional station. The computer system in use at the Penn State Computer Assisted Instruction Laboratory at that time utilized the 1050 computerized-typewriter terminal and the 1410 computer. Transparent 2 x 2-inch slides and tape recordings were coordinated with the computerized typewriter in these initial efforts.

Conversion to the IBM 1500 Instructional System was anticipated in the early stages of the study. The audio components for this new system were to be delayed,however, for some time. It was necessary to utilize temporary audio equipment with automatic functions in order to continue programing and field testing. After conferring with engineers at IBM's Thomas J. Watson Research Center, Yorktown Heights, New York, the lab was able to secure on long-term loan two portable language lab prototypes, specially modified tape recorders with control units which permitted programing of special functions pertinent to our program. These prototype machines served as temporary on-line audio as well as the final off-line medium. Functions include automatic stop, automatic shift into record mode, and automatic replay or "instant comparison" of student version with model. They were found to be a useful medium for the coordinated off-line program in which the student does most of the actual playing on his clarinet (see Off-Line Audio, Page 16, for more detail).

Some playing was done at the CAI station along with the aural discrimination program. Basically, however, a two-pronged program was developed with the ear-training at the computerized instructional station, and the related playing program off-line using the non-computerized portable language laboratory prototypes.

In December 1967, the Penn State CAI Laboratory converted from the 1050 computerized-typewriter terminal and 1410 computer to the IBM 1500 Instructional System, the first computerized system designed specifically for individualized instruction. As described earlier, each instructional station in the 1500 system consists of a cathode ray tube with an attached light pen and keyboard, image projector, and audio play/record device.

The 1500 system utilizes Coursewriter II, an input language quite different from the Coursewriter I used with the former system. Much staff time and effort was consumed in mastering this new computer language and in learning to utilize the new system to its greatest effectiveness. Sections previously written for the 1410 computer could not be used on the new 1500 system. After unsuccessful attempts to translate these segments via computer, the program sections were completely rewritten in Coursewriter II language. This conversion to the new system, plus a year's delay in receiving the audio components, caused some setback in the time table of the project. The advantages of the new system, however, outweighed the delay and inconvenience.

The image projector (1512) of the 1500 system offers greatly increased storage and access speed although new visuals cannot be readily added at any time, as was the case with the Carousel slide projector. It was, therefore, considered wise to field test new program segments with hard-copy visuals and make necessary additions, revisions, or deletions before converting images to the film-strip cartridge.

In the eighth month of the study those parts of the program which had been developed by that time were field tested with five clarinet students, grades 7-9, using hard-copy visuals and a conventional tape recorder with index counter. (The IBM prototype language labs with automatic functions were not yet available at that date.)

A wide range of student ability, for which CAI is particularly well adapted, was observed. One student branched to almost all of the remedial sections while another required practically no remedial branches. Student records of those earliest ear-training sections showed the slowest student required twice as much time as the fastest student to complete the program.

As a result of this first field test, some frames were revised and instructions clarified, but generally the field test confirmed the supposition that at that stage the program was basically satisfactory.

Development of new materials continued as the graphics personnel began final preparation of musical images by copying the 5 x 8-inch music cards in precise notation with black ink on specially prepared 8 1/2 x 11-inch forms with musical staves. This work can be accomplished without aids such as LeRoy tools but requires an artistic hand (see Image Preparation, page 10). This was one of the first image reels developed for the IBM 1500 Instructional System at the Penn State Lab and required some experimentation to achieve satisfactory quality.

All recording of final tapes, including the re-recording of earlier tapes made for field testing purposes, was done with the assistance of a professional recording technican. Recorded excerpts were performed on clarinet by the investigator. Recording examples with programed errors and incorrect practices or subtle discrepancies proved to be a challenging task (see On-Line Audio, page 12). All recordings were monitored and some recorded again. (Later, as a result of the pilot study using fourteen subjects, a few recordings were further revised.)

When all tapes had been finally approved, it was necessary to edit, splice, sequence, provide time intervals and labels, duplicate copies, and insert address signals. From the master tape a narration tape was made for the instructional stations. Coursewriter commands for audio were then written, and an audio symbol table was constructed.

Dictionary

It was evident during the early development of the program that the display of musical notation to the student was going to be a complex process.

The former system included a Carousel slide projector and enclosed screen. Musical notation was photographed and developed into slides and the computer was instructed to seek and display a certain numbered slide.

Because the present 1500 system uses an image projector rather than a slide projector, musical examples were photographed and placed on a filmstrip instead of slides. The filmstrip, containing 1000 available spaces for photographic display, is wound around a plastic canister to form a compact package called an image cartridge.

Although most examples were intended to be displayed by the image projector, it was desirable to place some examples directly on the cathode ray tube (CRT). CAI personnel developed a special music dictionary for the purpose (see Appendix A for detail).

Preparing Images for the 1512 Projector

The procedure for developing images for the 1512 rear-projection screen was as follows:

Rough draft of musical selection on a 4 x 6-inch music manuscript card;

Design of specially scaled form with music staff for optimum clarity on image screen;

Precise notation in black ink on special master form by the graphics staff (size 8 1/2 x 11-inch);

Proofreading of these master copies;

Revisions of errors detected in proofreading;

Paste-up of some images to provide ample margins;

Proofreading of revised master copies;

Photographing and processing film for cartridge;

Examination of film cartridge;

Re-photographing of master copies or film cartridge;

Duplication of film cartridge for student instructional stations.

Meticulous, clearly legible music manuscript for images proved to be a time consuming task for the two graphics artists hired for this purpose. One, a graduate student in art, found this particularly slow work since he could not read musical patterns. His manuscript was very neat, but he made numerous errors which had to be corrected. The other copyist, a graduate student in music, did the work in considerably less time, almost as neatly, and with a better interpretation of the spacing involved between notes in conventional notation.

White notation on black background appeared to have less glare and greater clarity than black on white and was selected for the final image format.

In addition to the illustrations which can be displayed on the image projector, visuals can be presented in the flow of the course materials on the CRT screen. Although there are no absolute parameters for deciding whether an illustration should be presented via one apparatus or the other, the course author can be aided by knowledge of the different capabilities of both machines. These capabilities have been summarized in Figure 1 as follows.

Image Projector	CRT
Colored material	Blue material on black field
Complex designs	Simple designs
Quantity material	Less material
Shaded drawings	Line drawings
Photographs	-
-	Animation
-	Student responses
Easily displays same material over span of several frames	Difficult
Any symbols can be used	Symbols must be available in one of the dictionaries
-	Displays must "fit" on the screen with other instruction.

Fig. 1. Comparison of CRT and Image Projector Display.

Preparation of On-Line Audio

Former system (1050 terminal). The first audio tapes in the project were made to accommodate the 1050 terminal in use at that time. That station featured a Uher Universal 5000 tape recorder. Models at that time were recorded at 7.5 ips using a Wollensak T-1980 tape recorder, a Model 676 Electro-Voice dynamic cardioid microphone, and Scotch 175 magnetic tape. After the editing and splicing process, the 7.5 ips master tape was duplicated via a second Wollensak T-1980. The duplicate tape was recorded at 3.75 ips, the designated speed for the audio units in the 1050 terminal.

Each duplicate tape was placed on a Uher tape recorder modified with the capacity to record short bursts of 400 Hz tone. While the tape was playing, a 400 Hz burst was placed after each message and at the beginning and end of the tape with a push button device. The 400 Hz tones were inserted on the right channel of the tape while the music and messages were on the left channel. A strip of sensing tape approximately three inches long was applied to the beginning and end of the tapes.

Recordings made in this manner were accessed by programing the system to position or play, or both position and play, a tape message according to a specific number. Messages were arranged sequentially on a single track. Four short tapes were made, one for each course section that was written for this system. The quality of the tapes was basically satisfactory although fan noise from the ventilating system cooling the slide projector caused some interference.

Basically, the former system with the 1050 terminal had adequate audio. The course segments developed at that time were rather linear as there was virtually no branching. With longer messages and branching, however, the searching time on this single tape track might have been a problem.

Present System: first phase. The present system, the IBM 1500 Instructional System, was initially installed without the audio component. The audio component, being developed by Bell and Howell, was not ready at the time the other components were installed and did not become operational until a year later. Consequently the bulk of the program was developed using the language lab prototypes as stopgap audio measures.

In order to field test program material, it was necessary to synchronize the programed tape recordings with the presentation on the CRT. This was done during the first phase by utilizing the remarkable consistency of the Uher Universal 5000 index counter.

Index counters on tape recorders indicate relative locations on a tape. By setting the index counter at zero for the beginning of a tape, numerical reading for any tape message can be noted. Fast forwarding or rewinding of the tape to a specified index reading can then access random tape messages. For this field testing duplicates at 3.75 ips were made of 7.5 ips master tapes being prepared for the IBM 1506 audio component.

In the first field test of course material, the following procedure was used. Subjects were seated at a station, one at a time, and a Uher tape recorder was placed on a cart next to the terminal. A large external speaker was connected to the recorder. As the student worked through the course, the monitoring operator located and played necessary tape messages. All audio control was achieved manually at the tape recorder using listed index counter settings as guidelines. The procedure was occasionally cumbersome, but adequate for early field testing.

<u>Second phase</u>. The IBM portable language laboratory prototypes mentioned earlier were obtained from the Thomas J. Watson Research Center, Yorktown Heights, New York, by the end of the first year of the project. Although these devices were primarily intended for the off-line playing program, their automatic functions were effectively utilized as a temporary means for the on-line audio (see Off-Line Audio, page 16).

The tape is set in motion by pressing the PLAY control and continues until a 400 Hz tone in encountered. The REPEAT button rewinds the tape to the beginning of a message and replays the message. By using the PLAY and REPEAT controls it was possible to simplify coordination of the audio material with the CRT.

During a second phase of field testing and for demonstrations, these prototypes served as the audio device. More lengthy searches, such as would occur when a student branched ahead in the program, still depended on monitoring the index counter, but linear presentation of tapes and repeats of individual messages were considerably simpler than with a conventional tape recorder.

Final phase. The audio manual was studied and the course was reprogramed to utilize the appropriate symbolic audio commands of the 1500 system.

With the arrival of the IBM 1506 audio unit the audio development entered its final stage. The 1506 is a compact unit containing a tape recorder and is located adjacent to the CRT. The student listens through a headset or external speaker and can record musical excerpts in accordance with programed commands from the computer. The flexibility of the 1506 proved to be quite satisfactory. Fidelity of music reproduction was remarkable considering that the tape speed in this system is 1.875 ips.

Preparation of tape cartridges for the 1506 was a rather complex process involving six stages: 1) preparation of the narration tape, 2) building audio symbol tables, 3) audio assembly, 4) audio substitution, 5) preparation of working master cartridges, and 6) preparation of student cartridges.

Narration tape. The original recorded tape containing the audio material (music and verbal messages) is referred to as the narration tape. There may be any number of narration tapes in a program; the present program used seven.

In addition to course material a narration tape contains lengths of 400 Hz cue tone that parallel the messages on the other half of the tape. These lengths of cue tone are the signals to the computer indicating the location of the messages on the tape. The cue tone parallels the message and precedes it by one full second. The 400 Hz cue tones are placed on the tape via a cue tone generator which plugs into the tape recorder and operates with a simple on-off button.

The recommended procedure is to record the cue tones at the time of the musical recordings, not at a later stage. In the present project cue tones were added in a later stage because the recommended Ampex narration transport (remote controlled tape recorder) was not available in time for the master recording.

The final master tapes were recorded by a professional recording technician with a Roberts Model 192 half-track monaural machine at 7 1/2 ips, using an RCA 77-DX ribbon microphone. Superior quality duplicates were then made from the edited and spliced masters on professional equipment at 15 ips. Following this, the cue tone generator was used to record the cue tones on one set of duplicate tapes which then became the narration tapes.

Audio symbol tables. Each recorded musical excerpt, speech, and blank tape segment for later student recording is given a symbolic name of the form AAnnn, that is, two letters and three numerals. The assemblage of symbolic names is grouped into symbol tables which are entered into the computer and these skeletal audio entries are completed in the audio assembly process.

Audio assembly. Audio assembly is the process wherein messages on the narration tape are duplicated on a tape cartridge that contains addresses readable by the computer. Each message is assigned to a specific track and address.

The narration tape to be assembled is mounted on the remote control narration transport. Using the cue tones as a guide, the computer plays each message separately.

In one of the 1506 audio units a tape cartridge is mounted containing four tracks. Tracks 0, 1, and 2 are used for the messages; track 3 is reserved for square wave signals spaced 0.25 seconds apart. The combination of the 1.875 ips speed and the three-track capacity enables a large amount of narration tape material to be placed on a relatively short length of cartridge tape. As the narration tape plays, the messages are placed on tracks 0, 1, and 2 of the cartridge tape.

The audio assembly program updates the symbol table. Address, track, and length of message information are added to the symbolic information.

This audio assembly process produces what is known as a source master cartridge. Only one half of a cartridge may be assembled on a source master, about one hour and twenty minutes of audio time.

Audio substitution. Audio substitution is a computer program that takes the address, track, and length of message from updated symbol tables and reads that information into the Coursewriter II program. The original skeletal audio entries then provide the information needed for the computer to locate and play any programed tape message. After this stage the course is operable.

Preparation of working master cartridges. Source master cartridges utilize only one half of the available tape. Two source master cartridges are combined into one working master cartridge by means of a Viking tape duplicator. Since tape recorder-patchcord techniques will not satisfactorily duplicate the square wave signals, the special equipment is necessary.

The production of working master cartridges provides maximum security and preservation of the source master cartridges. The entire cartridge, not just one half, is utilized.

Preparation of student cartridges. The working master cartridge is duplicated to produce student cartridges. As many as six student cartridges can be produced simultaneously with the Viking duplicator. These cartridges are the actual tapes used during instructional sessions.

In the development of the present program, the entire audio preparation process was followed. Although difficulties were encountered in the tape duplication process, these did not prevent course presentation because the working master cartridges were used in lieu of student cartridges until satisfactory duplicates were made. After the audio assembly process stopped prematurely a few times, it was found that assembly of a few messages at a time rather than long sections of narration tape made premature stops less likely.

White noise, a faint hissing background sound, was present during messages played by the 1506. Although not on narration tape, the white noise is audible on source master, working master, and student cartridges. It was apparently easy for the listener to concentrate on the clarinet, however, as no student indicated difficulty in hearing the music or concentrating on the musical excerpts. An anticipated inverse of 9 db may minimize this condition.

During the audio assembly process, blank tape segments were reserved for student recording. Students' recordings at the instructional station apparently had sufficient fidelity for making comparisons with models.

Preparation of Off-Line Audio

Preparation of master tapes for the off-line playing program was a four-stage process. First, the music and messages were recorded. Second, the signals necessary for stopping, reversing, and shifting to record mode were added to the tape. A test was then conducted to determine whether all signals were functioning. Finally master tapes were duplicated to provide a sufficient quantity of tapes for use by students.

Recording. The recording of the master off-line tapes is done with a Uher Universal 5000 tape recorder at 3.75 ips. This machine is the type modified for compatibility with the IBM language laboratory prototypes used in the project.

In an earlier stage of development master tapes were made at 7.5 ips on a Wollensak machine and 3.75 ips duplicate was made on another Wollensak. The resultant duplicate was lower in pitch on either Uher machine. Had a specially constructed patchcord with a German plug at one end and an American plug at the other end been available, it might have been possible to duplicate the Wollensak tape on a Uher machine. It would have been necessary, however, to play the duplicate tape on the slave Uher and consequently mandatory to make separate duplicates for other Uhers.

The microphone used for recording was an Electro-Voice 676 dynamic cardioid microphone. An adapter was specially constructed in a local electronics shop to permit use of the American microphone plug with the German microphone receptacle which is part of the audio cable system connecting the Uher tape recorder with the IBM language laboratory prototype. Scotch 175 audio tape was used throughout.

Uher microphones were used briefly in an earlier developmental stage. The results were judged generally inferior to those obtained with the Electro-Voice microphone.

The tapes in their final form after recording have music, some verbal messages, and necessary blank tape for student recording, all on the left channel of a half-track tape. In earlier developmental stages splicing was used to remove mistakes, but in the final recording stage mistakes were usually circumvented by a second recording.

Insertion of record mode signals. A 30-Hz tone of two seconds duration on the left channel is the signal for the tape recorder to automatically switch to record mode. After the music and speech have been recorded, these signals are put on the tape by means of a Hewlett-Packard TS312/FSM-1 sine wave generator and a Wollensak T-1980 recorder. The tape is mounted on the Wollensak, and the output cable from the generator is plugged into the left channel microphone input receptacle on the Wollensak. Volume is adjusted until the VU meter indicates 0. The recorder is then started in playback mode; when a place for a 30 Hz signal is encountered (immediately prior to a blank section for student recording), the instant stop lever is depressed and the machine is switched manually to record mode. The release of the instant stop lever then permits the tape to continue moving while the 30 Hz tone is recorded. After two seconds the instant stop lever is again depressed, the machine is switched back to playback mode, and the lever is released to permit the tape to move forward at 3.75 ips to the next place where a signal is needed.

Early in the developmental stage, when signals were placed on a 3.75 ips duplicate made from a 7.5 ips master, 30 Hz signals were spliced into the tape at appropriate locations. A 5-inch reel of continuously sounding 30 Hz tone was recorded using a tone generator, and segments 7.5 inches long to be used as splices were cut as needed. This procedure permitted very exact signal placement, but the splices tended to stick and jerk when a tape had not been played for a few days. Better splicing techniques improved the situation, but the procedure of going directly from the tone generator to the tape was found to be more efficient.

Insertion of stop signals. A short burst of a 400 Hz tone on the right channel is the signal for the tape recorder to stop. If the machine has been recording, it automatically rewinds to the previous 400 Hz signal, then reverses and plays ahead to the signal that started the rewind, thereby playing back the model and student recording. A signal input device, a short cord with a button on one end and a plug on the other, is plugged into the machine. A quick press and release of the button records the signal of Hz burst.

Prior to signal placement, the tape is played on a Uher machine modified to include the right channel recording capacity for 400 Hz tones and index counter numbers are noted to serve as checkpoints. This is necessary because of the need for stop signals following long blank sections and immediately preceding models.

After the tape has been clocked, it is replayed with the burst device plugged into the machine and signals are applied at appropriate locations. Since these signals must be fairly strong, the input volume level was set at 7.

Tape duplication. Tapes are duplicated by means of a Uher patchcord connecting the micro/phono receptacles of each machine. The master tape is placed on one machine and a blank tape is placed on the other. Both machines are started, the master machine adjusted to play at a normal level while the slave machine records at a moderate level. This part of the duplication process duplicates the instructional content and the 30 Hz tones on the left channel.

The Uher tape recorders do not have the capacity to record on the right channel except for short 400 cycle bursts input directly with the burst device.

The patchcord does not carry the 400 Hz signals from the master tape. Therefore, while the slave machine is recording, index counter numbers for the duplicate tape are noted as checkpoints for signal placement. The duplicate tape is then played with the burst device inserted into the machine and the 400 Hz signals are placed at appropriate locations in a separate procedure.

For exact pitch it is essential that each tape be played only on the machine upon which it was recorded. Master tapes must be played on the Uher used for the original recording and duplicate tapes must be played on the slave machine. If the tapes are exchanged, the slave tape sounds sharp in pitch on the master machine, and the master tape sounds flat in pitch on the slave machine. This discrepancy is attributed to the fact that the two machine speeds did vary slightly. Quality of fidelity on the master machine was quite good, whereas the tone quality of the duplicate tape on the slave machine was somewhat inferior.

CHAPTER III

DESCRIPTION OF THE PROGRAM

The following behavioral objectives reflect the aims and content of the course. When students did not achieve the established criterion levels, they were branched to remedial material.

Program Objectives

I. Articulation:

The student will be able to:

1. aurally compare three brief excerpts as to sameness in articulation;
2. aurally identify eight basic articulation patterns;
3. aurally identify three articulation styles (staccato, unmarked, and portato);
4. detect aural-visual discrepancies in articulation pattern and style;
5. aurally-visually compare two similar performances differing only in the correctness of articulation and select the better example.

Performance:

The student will be able to:

record a given passage with correct articulation pattern or style as demonstrated in a pre-recorded model.

II. Phrasing:

The student will be able to:

1. aurally and/or visually identify the end of a phrase;
2. detect aural-visual discrepancies (implicit and explicit) in crescendo and dimuendo nuances;
3. detect clipped or abruptly terminated phrase endings;
4. detect a breathing gap interrupting a phrase;
5. aurally-visually identify the peak note or melodic climax of a phrase;
6. aurally-visually compare two similar performances differing only in the phrasing and choose the better example.

Performance:

The student will be able to:

record a given passage with correct phrasing as demonstrated in a pre-recorded master model.

III. Rhythm:

The student will be able to:

1. aurally recognize duple or triple meter;
2. aurally compare three very brief excerpts regarding rhythm for sameness;
3. detect aural-visual discrepancies in rhythm;
4. aurally determine possible meter signatures for a recorded excerpt;
5. visually detect the measure which has an incorrect amount of time values according to time meter;
6. discriminate correct mathematical relationship between sixteenth, eighth, quarter, half, and whole notes.

Performance:

The student will be able to:

record a given passage with correct rhythm as demonstrated in a pre-recorded master model.

Discrepancies range from subtle to obvious; criteria, necessarily arbitrary, have been revised in some cases along with the program.

Description of CAI Course Content

A dual program including ear-training and playing was developed. The ear-training program was conducted via CAI. Although some playing was also done in the CAI lab, the bulk of the playing was done off-line with the portable prototype language lab machines developed and loaned by IBM (see Preparation of Off-line Audio, page 16).

An effort was made to coordinate the aural-visual discrimination training and playing aspects as closely as possible. Students did not begin performing the articulation exercises, for example, until finishing the first aural discrimination training section in articulation. Many of the excerpts and melodies used off-line were duplicates or similar versions of material used in the on-line aural training program.

Probably the best integration of listening and application in playing occurred in the CAI sections where the student was presented two similar versions of performances, one slightly better in one of the areas under study. After choosing the better performance, and indicating why (i.e., which area was superior), he was given the opportunity to play the excerpt on his instrument, record it, and compare it with the better of the pre-recorded models.

After the instant comparison, he had the option of hearing the model again, hearing his recorded version again, re-recording, or going on to the next excerpt. The course progresses generally from simple to complex. It begins with simple aural discrimination of three very brief excerpts (same or different) and progresses to multiple, subtle aural-visual discrepancies which may be in any of the three areas (articulation, phrasing, or rhythm), or a comparison of two versions to judge which is better and indicate why.

The present project was limited to the areas of articulation, phrasing, and rhythm. As the flowchart indicates (see Appendix B) the program involves articulation sections first, moves to the study of phrasing, then rhythm, more on articulation, phrasing again, and finally an integration of all three areas of articulation, phrasing, and rhythm.

Strategies. Since this was a feasibility or developmental study, there was freedom, even obligation, to explore a number of strategies. The prevailing strategy was to introduce a concept with some explanatory materials and musical illustrations; sometimes both positive and negative examples were employed. This was followed by a number of frames concentrating in that area.

Criterion checkpoints were positioned throughout for branching purposes. A criterion (e.g., eight correct out of ten frames) was established to determine whether students should branch to remedial segments, or to move on to new or more advanced material. Since listening requires an attentive set which may be jeopardized by momentary lapses, this type of criterion was considered more suitable than decision points based on any one or two items. At this point in the program development (indeed, in the program literature of the music field), it is dubious whether we can determine with certainty a sequence of rigidly sequenced items in a fixed heirarchy and say with certainty one item alone represents a truly reliable criterion.

In the remedial sections explanations and additional practice material, usually of a simpler nature, were presented to clarify concepts and sharpen discrimination not consistently demonstrated by the students failing to meet the criterion.

In cases of strictly aural discrimination the feedback to a wrong response might consist of the notated examples along with a repeated hearing of the item.

Student-directed choice options also were employed. In the rhythm segment, for example, a student may choose which meter he would like to review. In the articulation section, he may hear or re-hear any articulation pattern he chooses.

A diagnostic quiz was also employed at the beginning of the rhythm section. Two remedial sections were provided as a follow-up for students showing exceptional difficulties in this area, that is, inadequate knowledge of basic fundamentals deemed necessary to successfully pursue the intermediate level rhythm program.

A repeat option is built into the program on almost all of the items requiring listening. This option was chosen frequently by the students, including the stronger pupils. Student records indicate all responses chosen as well as repeat options.

Feedback of some kind followed every student response. In the ear training program, this feedback might simply ask the student to listen again or provide a cue or, depending on the stage of the program and number of attempts, present him with specific feedback; e.g., "Articulation faulty in entire passage--not enough separation in staccato," or perhaps,"Correct! You're doing very well."

In the performance frames, the feedback was the pre-recorded model with which the student could make an instant comparison. The various options (both on-line and off-line) are described later in the report.

Another strategy explored was the loop sequence. In this case the student was presented for review all those items in the section which he did not answer correctly on the first attempt earlier in the program. In a few sections of the program, students were given unlimited attempts to respond correctly before moving on; that is, they could not proceed until they answered correctly. It was anticipated that all students would probably get the correct answer by three or four attempts at the most. In a few rare cases, however, the student actually registered ten or eleven attempts with a repeated listening to the excerpt after each wrong response. A check with those students substantiated the belief that such a rut was quite frustrating. (But is it interesting to note that on the same items which really stymied certain students, others would respond correctly the first time.)

In the revised course this frustration is prevented by simply furnishing the correct answer if the student does not respond correctly by the second or third listening. This might remove some challenge for the lazy student, however, who comes to realize that he'll be told the right answer after the second or third attempt and moved ahead. Perhaps moving on, after unsuccessful attempts, and looping back to the item at a later time would be the best solution.

In addition to the more structured remedial sections involving cue and mental set, another revision is the looping back to the instructional block which preceded the remedial material.

A revised feedback on the aural identification of articulation patterns of scales is the playing of the student's erroneous choice to contrast with the model in question. This playback is then followed by the repeated item and pattern in question.

Aural Discrimination. The listening program, involving areas of articulation, phrasing, and rhythm, begins with the simple discrimination of sameness (same or different) in articulation. This format is strictly aural comparison of three brief examples and progresses to identification, "Which two are the same?" and later to the variation, "Which one is different?"

Visual Discrimination. Strictly visual discrimination without aural aspects was purposefully limited in the program. A brief section is included which requires the student to compare two notated but very similar examples and to indicate the discrepancy if there is one. This task is generally construed as easier to accomplish since the student has almost unlimited time to make the comparison, but is considered a means of increasing his awareness of subtleties in notation.

In one section of the rhythm segment the student is asked which measure of a notated passage does not agree with the time signature. Rhythmic notations can be made on the CRT and the student simply points with the light pen to the measure in question.

Aural-Visual Discrimination. The bulk of the listening program is centered around aural-visual discrimination. In such items the student is presented musical notation, some as long as 16 measures, containing one or more aural discrepancies. In the final integrated section, the discrepancy may be in any one (or two) of the three areas of articulation, phrasing, or rhythm. In the final apex of the program, the student is asked to compare two similar versions differing only slightly in any one of the three areas (articulation, phrasing, and rhythm), indicate which version is better, and in which area. When he completes that phase, he is permitted to play the excerpt on his instrument and record his version with reference to the preferred model. This section is considered a synthesis of the foregoing strategies.

Description of Off-Line Playing Course

The off-line playing program was coordinated with the computerized aural-visual discrimination program and utilized the IBM portable language laboratory prototypes. Preparation of student tapes was somewhat simpler for off-line than for the 1506 computer-controlled audio unit, but the off-line tapes offer fewer student options for a given frame.

Although basically linear in concept, the prototype recorder can be programed for either a prompting sequence (model before student plays), or a confirming sequence (model after student plays).

The manual control board is very simple for the young student to operate because it consists of only three controls: PLAY, REPEAT, and BACKUP.

In a common sequence the student presses PLAY and hears a pre-recorded master model, sees an automatic record mode red light signal and records his version, gets an automatic rewind and hears instant comparison of model followed by his recorded version, and then an automatic stop. If he feels he matched the model satisfactorily, he then presses PLAY and proceeds to the next frame. Unless he encounters some difficulty, he activates this entire sequence by pressing just one button.

If the student chooses to hear the comparison again, he presses REPEAT just once and starts a replay of both model and student version. (There is no danger of erasing the models.) If he wishes to record again, he presses BACKUP (which rewinds and stops, allowing him to practice) and PLAY (which gives a replay of the model followed automatically by the record mode.

This mode could be programed so that the student would not automatically hear the model again after each recording attempt, but instead would hear only his own recorded version. This latter sequence appears more desirable for those with technique problems, students who may need a number of recording attempts and do not necessarily need the aural reference of the model after each recording attempt.

Generally, more flexibility of options requires more manual control on the part of the student.

Another sequence used late in the program (and less often than the prompting mode) was the confirmation mode in which the student played before he heard the model. In this sequence he presses PLAY, sees the red light signaling him to record, plays the excerpt, waits for automatic rewind and hears replay of his version. He then presses PLAY to go forward and hears the pre-recorded model for that particular excerpt followed by an automatic stop. To record his own version again he presses BACKUP twice. The most advanced student in the pilot study expressed a preference for the confirmation mode.

CHAPTER IV

PILOT TRIAL AND CONCLUSION

Pilot Trial of Program

Approximately nineteen months after initiation of the project, the pilot trial with fourteen pupils began. The students in this sample were limited to clarinetists beyond beginning level in grades 7-10, the actual sample consisting of seven seventh graders, three eighth graders, two ninth graders, and two tenth graders.

Because of the restricted nature of the sample, the length of the program, (approximately eight weeks) and the necessary travel to the CAI laboratory on The Pennsylvania State University campus, only volunteers from the local school system were involved. The sample, therefore, is not considered a random sample, nor was a random sample considered necessary in this feasibility study.

The general plan was to schedule each student twice a week for an hour session, half an hour of ear training at the computerized station and half an hour recording with the off-line language lab prototype. This schedule was not always possible during the vacation period after public school classes terminated in June, but was considered the optimal arrangement.

Generally the pilot trial proceeded with few mishaps or "bugs" in CAI parlance, particularly that part of the course which had been field tested the previous year with five students. The computerized equipment performed with high reliability. The off-line prototype machines occasionally malfunctioned but generally performed well. (Malfunctions seemingly were due to recorder, not control unit.)

Two instructional stations were equipped with the 1506 audio units and installed in individual, acoustically treated rooms. Two off-line stations for playing and recording were set up, also in separate rooms. The usual procedure was to provide transportation daily for four students from the schools to the CAI lab, start two students on-line and two students off-line, and switch shifts after a half hour.

Both programs were individualized so the student resumed study at the approximate point he had terminated the previous session. In the computerized program, the search for the resumption point was made by the computer. Off-line, of course, control was accomplished by the proctor. Each student was assigned a number at the beginning of the course and used this identification for signing on at the beginning of each CAI session.

In the Lab the Sharpe earphones seemed to offer somewhat better fidelity for clarinet than the external speaker provided with the Ampex narration transport. When the student recorded his clarinet on-line, however, the external speaker was used.

Because of an unavoidable delay in starting the pilot program, all students were scheduled for sessions during the early part of summer vacation. Cooperation was excellent and all students completed the basic CAI course.

Individual performance records were recorded on magnetic tape during instructional sessions, and a special computer program printed out the itemized information.

Performance records of two types were obtained. Student-oriented records list performance information in chronological order for a given student. Course-oriented records list information in the order of question identifiers, the name given to each request for a student light pen response. Figure 2 illustrates a section of a course-oriented listing of performance records.

The program, as presented to the fourteen clarinetists in the pilot study, consisted of almost 10,000 Coursewriter statements (9728 by sector estimation), 432 audio messages, and 275 different musical images.

The extreme two students took 6 hours 21 minutes, and 11 hours 25 minutes to complete the CAI course and differed greatly in number of correct responses (see Table 1).

These times do not include the off-line playing program or the playing-recording segments included on-line (which all of the students did not complete). The off-line playing-recording program would probably require some 8-10 hours for many intermediate students to complete; hence, the entire combined program could conceivably take roughly 15-20 hours or approximately 8-10 weeks of two hour sessions per week.

From the student records an item response analysis chart was constructed by the staff. This chart indicated right or wrong responses only. Another chart was constructed to show the actual frequency of attempts and number of errors for each item in the program. Various charts can be derived from student

Course Segment	Student Number	Frame Identifier	Response Latency	Response Identifier	Date	Time of Day	Frequency of Attempts
CLARI 1	X10	QUK122	15.0	WP	7/7/69	9:32.41	1
RESPONSE - ROW 05 COL 25							
CLARI 1	X12	QUK122	8.3	CC	7/9/69	11:36.20	1
RESPONSE - ROW 08 COL 07							
CLARI 1	X4	QUK122	1.5	CC	7/8/69	14:12.32	1
RESPONSE - ROW 08 COL 07							
CLARI 1	X5	QUK122	2.8	CC	7/8/69	9:42.83	1
RESPONSE - ROW 12 COL 07							
CLARI 1	X6	QUK122	3.0	LA	7/10/69	9:22.23	1
RESPONSE - ROW 12 COL 16							
CLARI 1	X6	QUK122	4.3	CC	7/10/69	9:22.57	2
RESPONSE - ROW 08 COL 07							
CLARI 1	X9	QUK122	10.0	CC	7/10/69	15:46.32	1
RESPONSE - ROW 08 COL 07							

Fig. 2. Course-oriented records for one frame.

<u>Legend for Figure 2.</u>

CLARI is the code name of the present course.

The "1" following CLARI indicates that the information shown relates to a question in Segment 1 of the course.

The number identifies the student responding.

QUK122 is the identifier for this response request.

The number following shows the time or response "latency" in seconds.

Next is a two-character identifier assigned in the program to a particular lighted area or set of coordinates on the CRT.

WP represents "phrasing," in this case a wrong response.

CC means correct answer chosen.

LA indicates the student elected to listen again to the example.

The date, expressed in month-day-year format, is followed by the exact time of the student task.

The final digit indicates the cumulative number of attempts the student made on this particular question.

RESPONSE row and column indicates the CRT coordinates (where the light pen touches the CRT) for the response.

Table 1

Student Time to Complete CAI Aural Program
(Does Not Include Student Recording)

Rank Order	Time Hours	Time Minutes
1	6	21
2	6	44
3	7	06
4	7	07
5	7	20
6	7	23
7	7	30
8	7	49
9	8	05
10	8	07
11	8	15
12	8	27
13	9	32
14	11	25
Mean =	7	56

Less than 7 hours: 2 students

Between 7 and 8 hours: 6 students

Between 8 and 9 hours: 4 students

Over 9 hours: 2 students

records, depending on the needs of the investigator. A segment of the right-wrong response chart used in the present program is shown in Table 2.

Revision of the Program

A careful analysis of student errors provided a basis for revision of the program, including revision of decision points or criteria for branching, more structured remedial (or additional practice), and deletion of items which appeared questionable or invalid.

On some items all fourteen of the subjects, or nearly all of them, made incorrect responses. This may have been because the discrepancies to be detected were too subtle or, in some cases, despite checking and proofreading, because an error appeared in recording, image, or programing. Questionable items were reviewed by the investigator and, if validity of an item appeared doubtful, it was deleted from the present revised program. In some cases the images were revised. Some were recorded again and shall be tried at a future time. An abundance of items in most categories has insured a seemingly adequate number of items remaining despite deleting items not working effectively. Further studies may indicate new items need to be added. The flow chart (see Appendix B), along with the accompanying frequency listing of items within categories, represents the revised course as it now stands.

In some cases the instructional blocks were completely restructured. A pervasive question in designing such instruction is whether to allow the student unlimited attempts on a listening item. This approach was taken in several segments. On a few items, not considered especially difficult by the staff during the developmental stages, a few students registered 6, 8 or more erroneous attempts. Naturally, this would be a frustrating experience; the possibility of this recurring was precluded by restructuring the program to provide a clue after the first response, a rehearing, and then, if the student missed a second time, the answer and another mandatory hearing. (Optional repeats are provided on almost all listening items.) A continuous pattern of limited attempts may tend to encourage laziness on the part of less motivated students, knowing they will be given the correct answer after the second attempt regardless of the response. Another strategy employed was simply passing on to the next item after two wrong responses, returning to the missed item at a later point. This is another advantage of the computerized memory and branching capabilities.

Table 2

Extract From Student Response Chart

Student Number	Instructional Frames					Remedial Frames				
	72	73	74	75	76	77	78	79	80	81
1	0	0	X	0	X	0	0	0	X	0
2	0	X	0	0	0					
3	0	0	X	X	X	X	X	0	0	0
4	0	0	0	0	0					
5	0	X	X	0	0	X	0	0	X	X
6	0	X	X	0	0	X	0	0	X	0
7	0	X	X	0	0	0	0	0	0	0
8	0	0	0	0	X					
9	0	0	0	X	X	X	0	0	0	0
10	0	X	X	X	0	X	0	0	0	0
11	0	0	X	0	0					
12	0	0	0	0	0					
13	0	0	0	0	0					
14	0	X	X	0	0	X	0	0	0	0

0 = Correct response

X = Wrong response

One of the final tasks in the program, locating two different discrepancies in two different unspecified areas, proved to be too difficult for the pilot sample of students. Either the program had not prepared them for such demanding listening, or else the task is unrealistic for that group of students. Items of this nature were restructured, specifying the two areas such as articulation and phrasing, and asking the student to simply locate a discrepancy in each of the two areas.

In a course section of frames asking which phrase did not crescendo, the entire section was deleted. Based on student responses and subsequent review of the items by the staff, it was decided that the subtle differences in volume could not be readily detected. Perhaps, through several generations of tape duplicating, some fidelity or volume was lost tending to invalidate the item. This crescendo section may be revised in further studies. Another section, involving both crescendo and diminuendo, proved to be more successful.

Additional revision of the program included the programing of student control after a visual message. Originally, an estimated amount of time for an average reader was anticipated and the visual message terminated as the program automatically passed on to new material. Allowing the student to manually control his own progress, however, seems a more flexible and satisfying procedure for the student. The word PRESS appears on the CRT and the student merely touches the space bar on the keyboard to signal the computer for subsequent material.

The articulation pattern identification was revised by programing a playback of the incorrect pattern chosen by the student. He then may hear what he perceived as the pattern followed by the pattern in question again.

Another revision involved the addition of more PRR's or sign-on points. When a student signs on for a session, the computer continues the program at the last PRR encountered by the student. Preferably a student would finish a section before signing off rather than terminating and resuming later in the middle of a section. In the longer sections, however, this was not always possible; and returning to the beginning of the section (where the PRR may have been located) resulted in considerable repetition of materials already covered by the student. To prevent this more PRR's have been added, particularly in the longer course sections.

Item difficulty. Some resequencing of items was done after analyzing frequency of student errors on each frame or item. Sequencing items according to difficulty, less critical in intrinsic or branching programs than in strictly linear programs, can only be approximated until field trials provide adequate data regarding relative level of difficulty.

Even when a program has been thoroughly field tested, it may be dubious to branch on the basis of any one listening item since a momentary lapse may be crucial. Criteria for branching in the present program, therefore, have been based on a group of frames rather than on any one frame. In the development of the program an attempt was made to place easier items in the remedial sections. In some cases these items did not prove easy in the pilot trial, but data from that trial provided some basis for deletion or revised placement of items.

Table 3 shows the percentages of correct responses of the fourteen pilot subjects on the remaining items in the revised program; these items do not include the remedial frames or the sections of combined on-line listening and recording. Percentages of correct responses are not reported on the remedial frames since all fourteen subjects did not take those items. In some sections only a few of the students were branched to remedial material.

Figures in Table 3 show a wide range of performance. The goal for the revised program, including remedial material, would be to bring all students close to criterion level on a posttest; the present developmental study did not propose to investigate this.

By no means is the data considered conclusive; the pilot trial in this developmental study was a part of a continuous process of trial and revision, a procedure basic to the development of an effective CAI program.

Revision of remedial material. Verbal explanations seemed of rather limited value when a student was having difficulty with aural concepts. Generally, remedial material in the present program consisted of additional practice on similar but easier material, along with some general cues or explanations. In addition to this approach, several alternatives for remedial sections appear feasible and are incorporated in the revised program. One addition includes more structured listening, providing a mental set or specific cue for listening.

Table 3

Frequency and Percent of Correct Responses
on Revised Program
(Not Including Remedial Branches)

Rank	Percent
1	87.3
2	86.7
3	80.9
4	76.3
5	75.7
6	74.0
7	71.7
8.5	69.9
8.5	69.9
10	68.2
11	67.6
12	67.1
13	59.5
14	56.6

These items do not require an overt response from the student and break the chain of incorrect responses which branched the student to the remedial section. Another feature now provides, in some cases, a mandatory repeat of the instructional block preceding the remedial branch. Such review provides additional practice, and records of responses allow some further check on the student's progress. In some instances combination sections are included with both specifically structured listening and conventional frames followed by a decision point determining whether the student should review or move ahead to new material, probably of a different or more advanced nature.

Audio Capability of
IBM 1500 System

The fidelity of the 1506 audio unit was adequate for the present program. In fact, considering the tape speed of 1.875 inches per second, the musical fidelity was remarkably good. Several minor problems were encountered, however, among them the presence of white noise, a background hissing. This phenomenon, although not obtrusive, is being investigated by the computer engineers in the CAI Laboratory and at the IBM Laboratory in San Jose, California.

Another problem was bleeding, or faint sound of a message on one track overlapping to silent points of a message on an adjacent track. Because messages are placed on three of the four tracks on the tape, the closeness of the tracks demands perfect alignment of the playback heads. Again, the bleeding sound was generally minor and students did not seem to find this distracting.

The most objectionable problem in the investigator's estimation was the occasional bubble in the recorded tone. The phenomenon seemed to occur randomly and appeared to be caused by a momentary disruption of the tape speed. Investigation revealed that the bubbles were not present on the narration tape but were on the source master cartridges, indicating that the cause apparently was in the assembly process. Fortunately, it did not occur often. Items affected by this phenomenon could possibly be re-recorded at the 1506 station although the operation would be a delicate one. Tapes have been sent to the San Jose IBM Advanced Systems Laboratory for analysis of this problem.

Another minor but inexplicable problem has been the variance of fidelity between channels. Messages are located on tracks 0, 1, and 2, with track 3 being reserved for square wave digital signals. For some reason, the fidelity on track 1 sounded definitely superior to track 0 and slightly superior to track 2.

Computer engineers have been apprised of all these problems and are investigating them.

Reliability of the audio 1506 unit has been excellent and no trouble has been encountered with searching and playing the right audio message at the right time.

Visual Capability of IBM 1500 System

In general, the most efficient means of displaying musical notation in this program was the image projector, IBM 1512. Although the image display could not accept a direct light pen response, the image could be coded (for example, numbered measures) with corresponding numbers on the CRT. If the correct response, for example, was measure 8, the student could simply touch the number 8 on the CRT with the light pen.

Music notation could be placed on the CRT by means of a special dictionary, and this display would accept a direct light pen response. But the programing of such notation consumed considerable time and was limited to very short and simple examples. Slur markings and beams for note groupings presented special problems. The CRT was used for displaying rhythmic notation, however, in the present program. The CRT could also be programed with music notation graphics, although this alternative was ruled out in the present study. Consultants in the Penn State Laboratory felt that the use of graphics in the present system caused the instructional system to slow down in response time. As indicated earlier in the report, the image projector was better suited for longer, more detailed musical notation. The image cartridge was extremely simple to load and unload, and the search time very rapid and reliable.

Student Playing-Recording: Comparison of On-line and Off-line

Most of the actual student playing-recording was done off-line with specially modified but non-computerized tape recorders. Some of the student playing, however, was programed via CAI along with the computerized aural training.

Although the student practice and recording time is more expensive on-line than off-line, the on-line program segments of listening and playing achieved the closest integration of the two aspects. In these on-line segments a student could aurally diagnose or judge a musical excerpt and then immediately play and record that same excerpt. With CAI it was possible to control the student recording procedure more closely than off-line since a student could be prevented from recording an example before he heard and demonstrated some understanding of it.

In addition, the on-line playing and comparing with models could be more flexible on-line than off-line. The computerized program allowed the student to elect any of the options on any item (hear model, record, hear his own recorded version, proceed to next item), whereas with the off-line machine he generally followed a predetermined sequence.

Currently there is not computerized evaluation for the student's playing-recording; the computer did not listen to the student's playing but did present a master model. He might conceivably be branched on line by his own choice if he felt that the performing technique required was too difficult or not sufficiently challenging. This is a possibility for future program development.

The computerized playing-recording frames did involve more complex preparation of audio than did off-line items. Replacement of a musical example on the computerized program was difficult,and preparation of images for the 1500 system was a rather lengthy procedure. At present images are not easily revised once the image cartridge has been made. (The Carousel slide projector used with the former 1050 system was more flexible in the developmental stages of a program although not as positive in seeking.)

The off-line program with the prototypes offered both advantages and disadvantages as compared with the on-line system. Advantages included simpler preparation of audio and visual materials, relatively inexpensive instructional time, the capability allowing the student to abort a recording in process, mobility and accessibility of the machines, and convenience of monitoring a student's recording at a later point. Disadvantages included fewer choices of options for the student on a given item, problems in variance of pitch and fidelity on duplicate tapes and machines, slightly lower reliability in mechanical functioning, and necessity for keeping account of student progress and setting up the tape at a proper point in the program.

The off-line program with prototype machines could be coordinated with a CAI program in two ways. Off-line practice could be an implementation of the student's aural concepts acquired on-line, or could be practice for on-line playing-recording in order to prevent spending excessive computer time on psycho-motor skills required in instrumental performance. In the present program the off-line playing was considered primarily an application or follow-up of the computerized listening program.

Essentially, the off-line tapes were programed in a linear manner, that is, a predetermined sequence of prompting or confirming rather than a completely free choice of student options for each excerpt. A predetermined sequence offers the convenience of fewer manual controls, but more flexibility is possible through more manual control by the student. The off-line program was generally linear except for repeats and stops when the student could practice at his own pace. No branching occurred within a tape.

Considering the present state of the art, the most feasible arrangement would seem to program most of the playing-recording off-line on modified tape recorders. A few recording sessions could be effectively integrated on-line with a CAI aural program. Generally, that is the approach adapted in the present program.

Conclusion

Computer-assisted instruction does offer potential for music education and research in music learning. CAI, a sophisticated medium for coordinating aural-visual stimuli and processing student responses, lends itself to instruction in music, an aural art with visual symbols. The branching options and print-out of student's course history provide the framework for a more objective analysis of individual learning patterns than available heretofore.

Present costs would seemingly limit current CAI curricula in music to the basic concepts, with supplementary drill or additional specialized work coordinated off-line with the language laboratory equipment such as the portable prototypes used in the present study. Considering, however, that a completed program may be used by as many as 32 stations (1500 system) simultaneously and repeatedly, the costs are not insurmountable.

Currently this CAI system does not listen to the student perform on an instrument, although computerized pitch discriminators may be a step in this direction. The investigator believes, however, that the student judgment involved in the process of comparing student version with model is a valuable part of the learning experience and should not be discarded completely, even in the event that a computer could eventually provide an evaluation of a student's playing. Probably a combination of capabilities would be ideal to suit various types of learners.

The current system, with some adjustments in the audio capability, seems well adapted to aural-visual discrimination training in a number of areas in music.

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APPENDIX A

Music Dictionary

Music Dictionary

With a special music dictionary written by staff members of the CAI Laboratory, it was possible to put limited musical notation on the CRT, enabling students to point directly with the light pen to the musical notation in question.

In addition to the system dictionary of conventional characters, there are three possible dictionaries of special characters, one of which is the music dictionary. A dictionary may contain a maximum of 128 characters which could be letters, numbers, or special symbols. These figures are displayed on the CRT by illuminating tiny white dots on a dark background.

The music dictionary developed for the present project includes noteheads, stems, rests, staff lines, beams, flags, dots, cleffs, and fragments of pseudo-curved lines. A true curved line such as a slur or tie was unavailable since the configuration of dots that outline all dictionary characters must be in a parallel, perpendicular, or diagonal relationship.

The music dictionary worked satisfactorily for rhythm patterns without staff lines. The rhythm quiz and meter signature sections rely extensively on the dictionary, and feedback in certain other sections also used the dictionary in displaying a particular note or patterns.

For conventional musical examples the music dictionary proved to be cumbersome. The number of characters (250 by cards, 128 by keyboard input) that could be input at one time was limited. The constant maneuvering necessary to produce musical notation on a staff usually consumed the character limit well before the example was completely input. It was not possible to add to a display which was input in a previous statement without erasing from the screen part of what was already there; thus musical examples of more than three or four measures could not be displayed. If the erasing inherent in the system could be suspended, the music dictionary would have greater potential.

As indicated earlier in the report, most of the musical notation in the present project was satisfactorily displayed on the image projector and coded for responses on the CRT.

Examples of music dictionary characters follow.

WHOLE NOTES

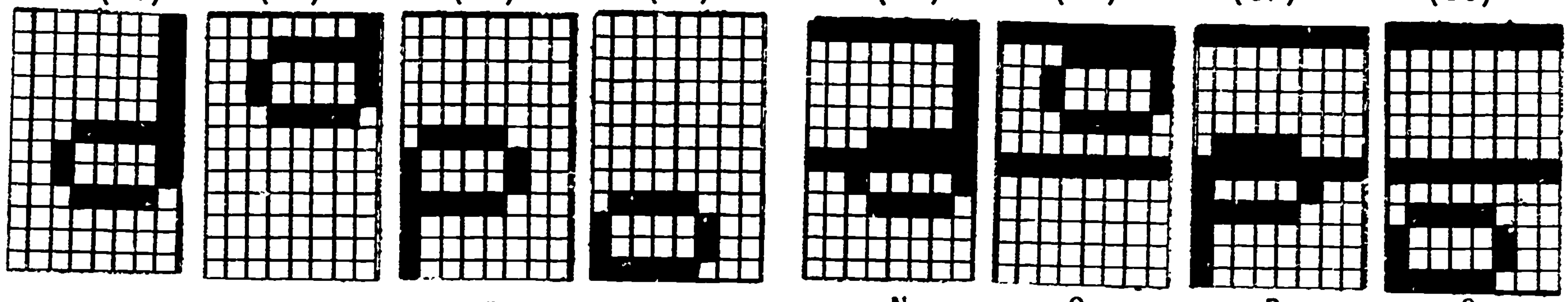
(19) (20) (83) (84)

l m L M

HALF NOTES

stems up stems down stems up stems down

(21) (22) (23) (24) (85) (86) (87) (88)

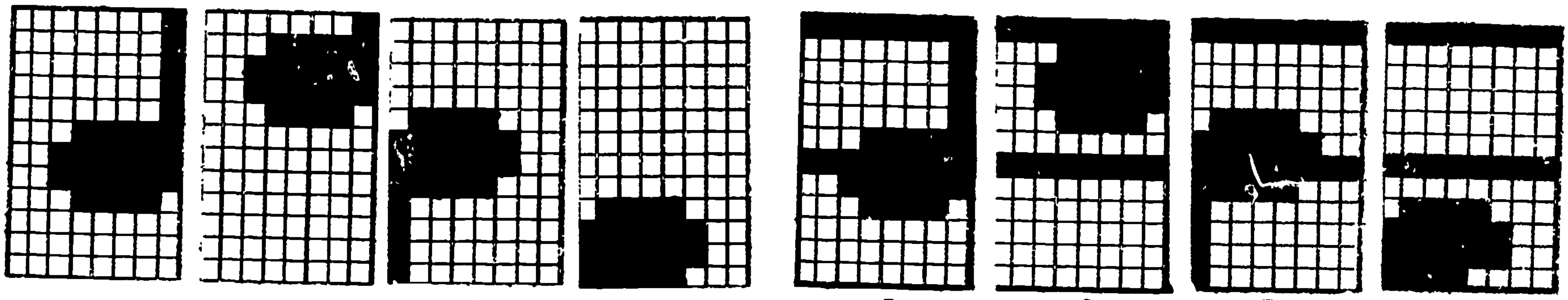


n o p q N O P Q

QUARTER, EIGHTH, SIXTEENTH, ETC.
NOTES

stems up stems down stems up stems down

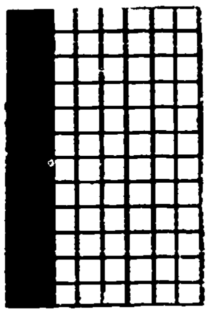
(25) (34) (35) (36) (89) (98) (99) (100)



r s t u R S T U

STAFF and BAR LINES

(074)



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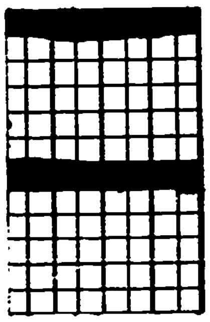
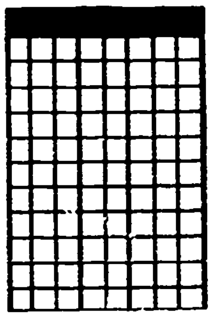


"
2

(051)



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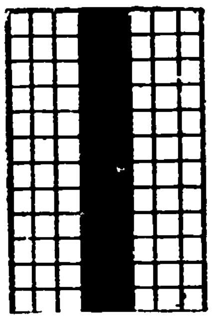
3

(052)



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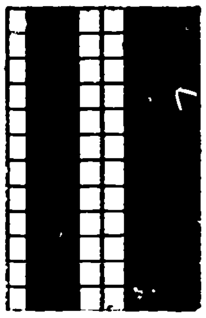

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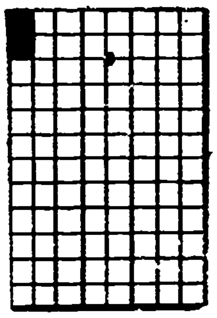
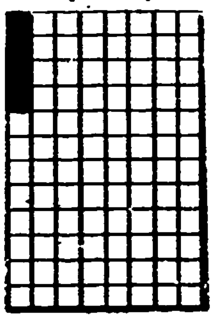
STEM EXTENSIONS

(125)



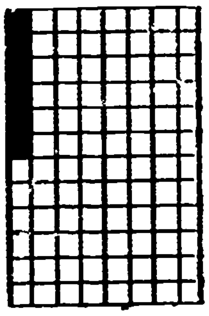
' (apostrophe)

(107)



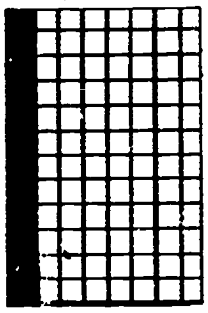
, (comma)

(075)



. (period)

(097)



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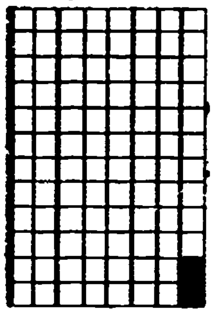

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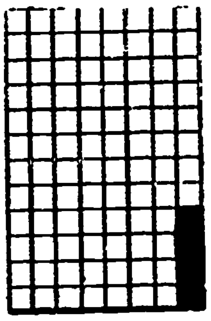

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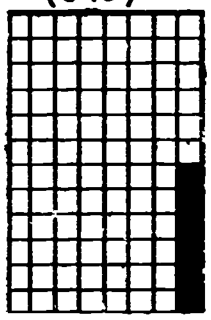
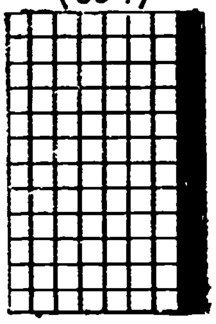


X (times)

(094)



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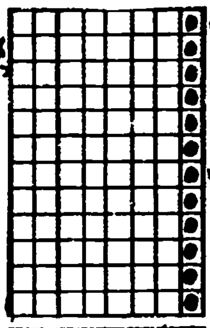

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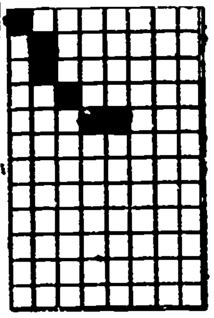

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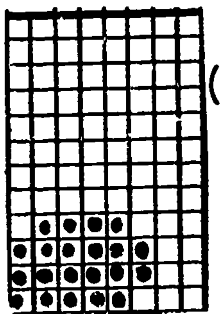
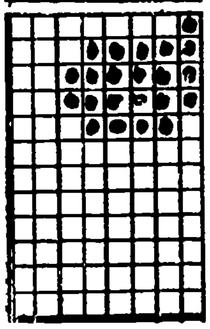


(036)*or (024)*

can be used here

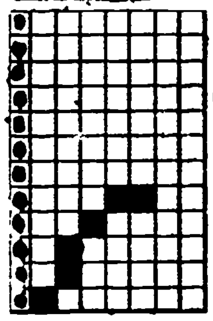
u or q



(022) or (034)*

can be used here

o or s



(062)

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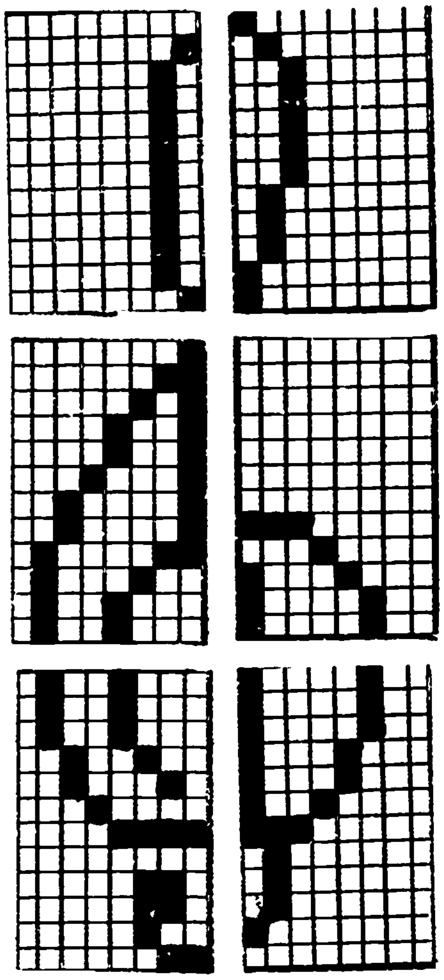
* This character has been repeated at another place

CLEFS

(113) 1 — (114) 2

(115) 3 — (116) 4

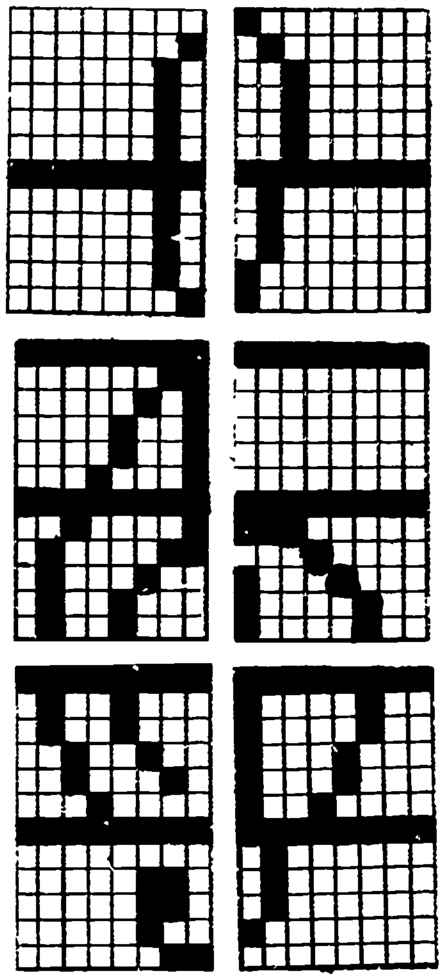
(117) 5 — (118) 6



(110) > — (076) <

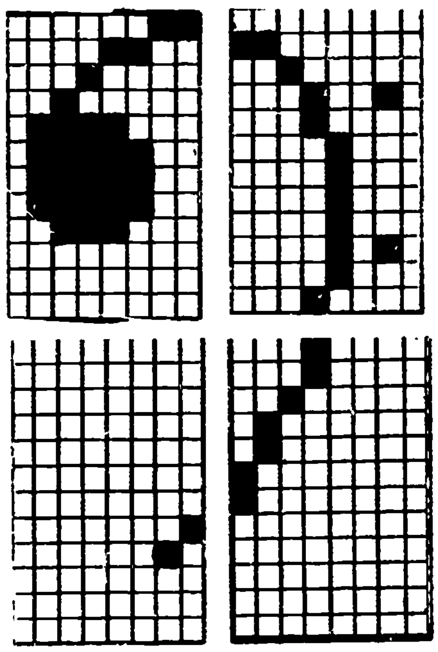
(123) # — (091) $

(108) % — (090) !



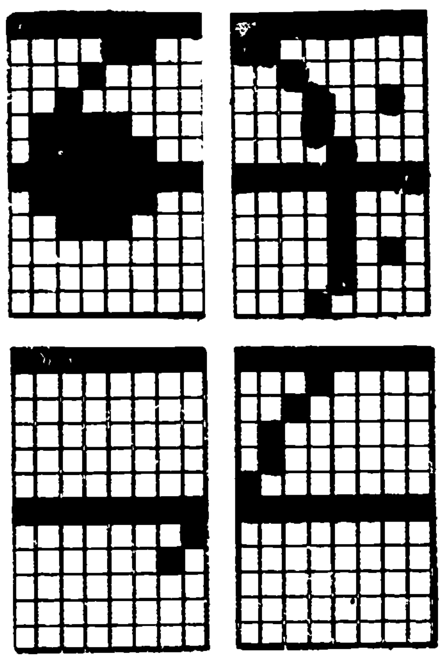
(119) 7 — (120) 8

(121) 9 — (112) 0



(080) & — (092) *

(077) (— (093))



BEAMS

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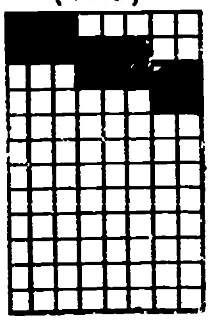

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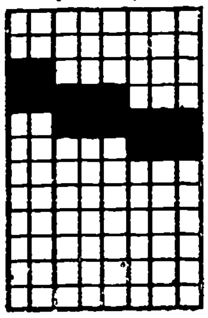

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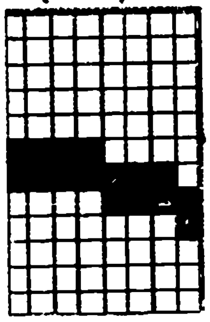

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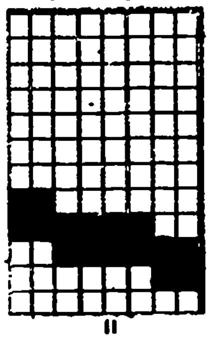

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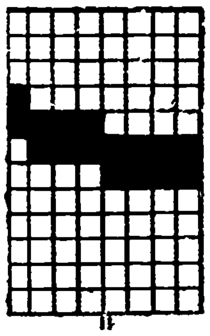

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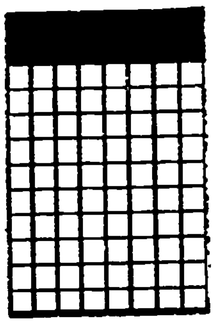
(000)



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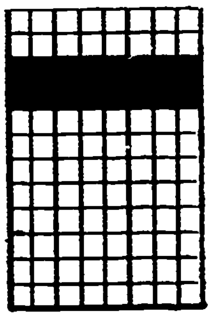
(010)



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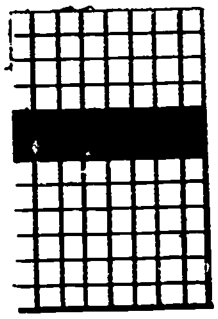

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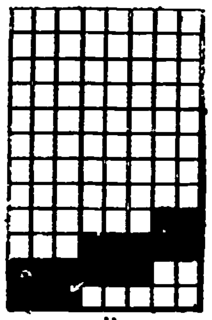

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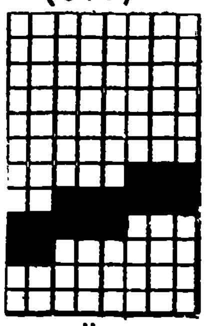
(013)



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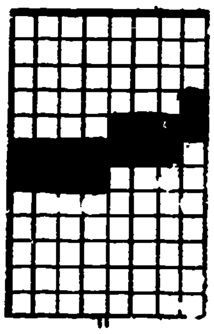

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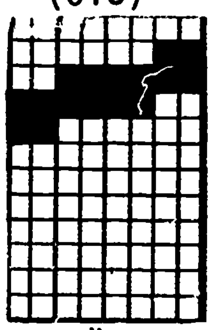

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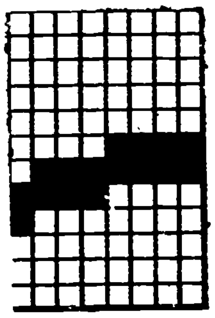
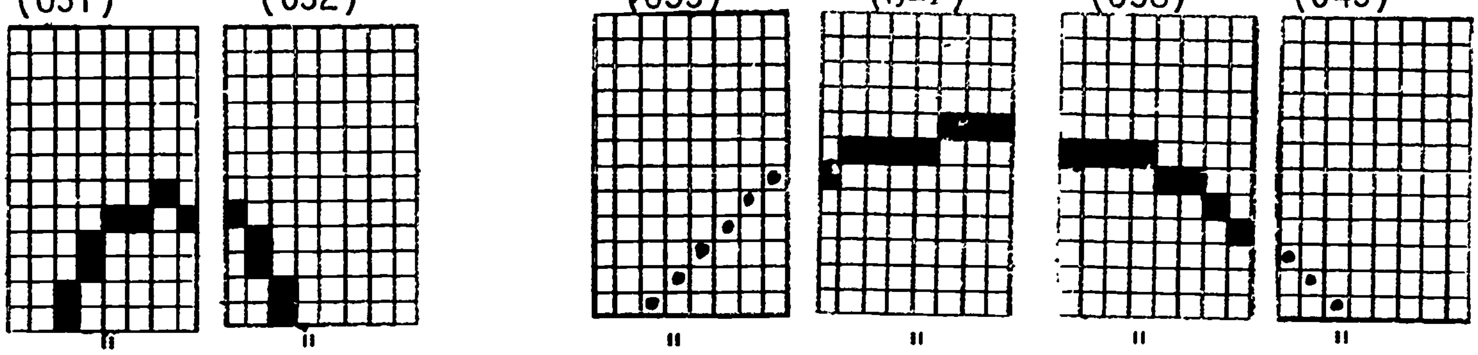
(016)



"
h

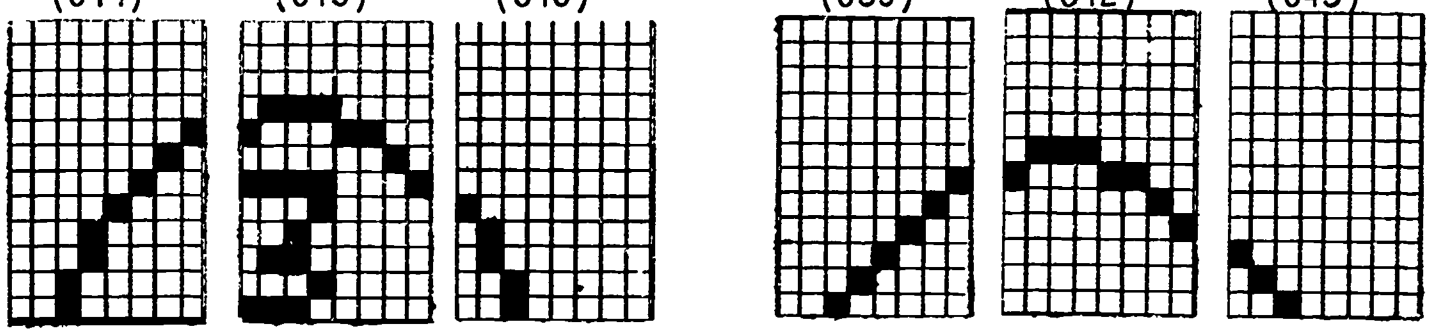
SLURS - PHRASES

(031) (032) (033)* (047) (058) (043)*



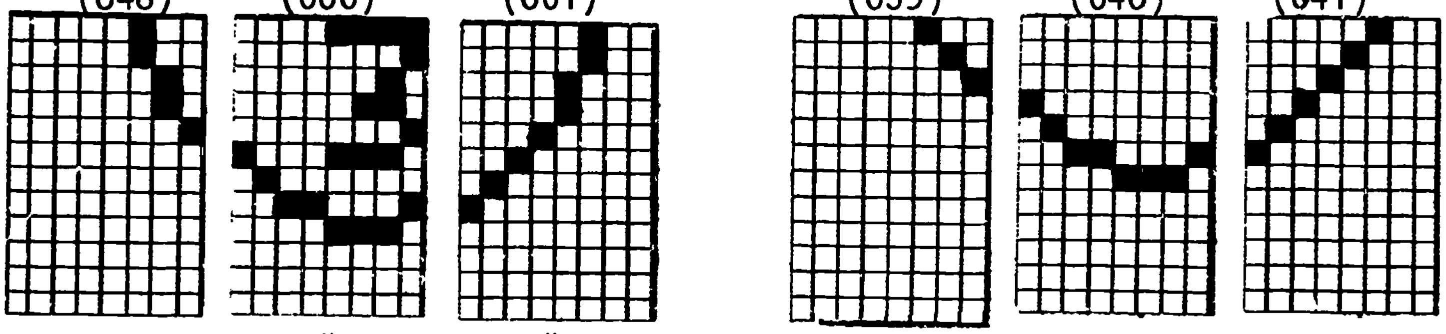
" " " " " "
n o p v w r

(044) (045) (046) (033) (042) (043)



" " " " " "
s t u p q r

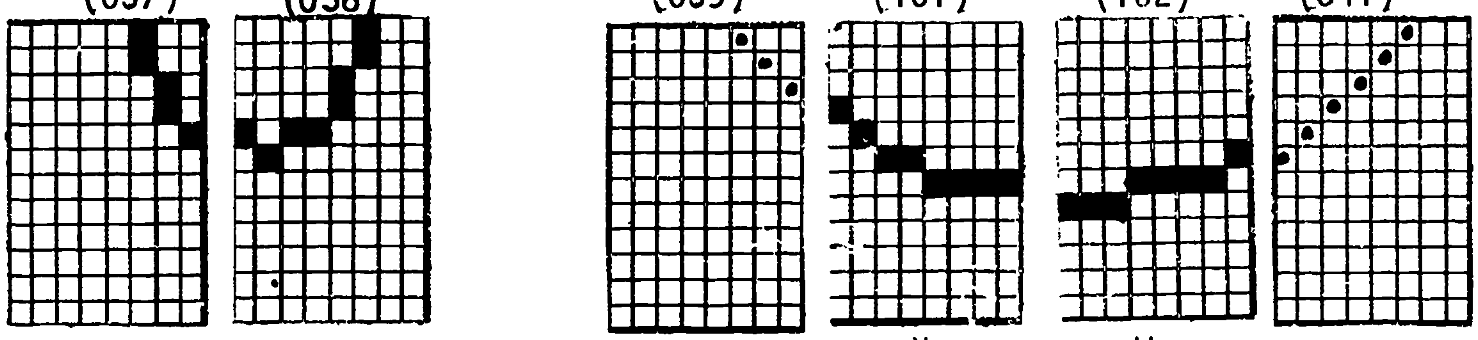
(048) (060) (061) (039) (040) (041)



" " "
Ø y z x y z

* These characters are repeated on this page.

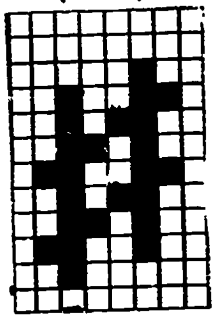
(037) (038) (039)* (101) (102) (041)*



v w x V W z

KEY SIGNATURES

(017)



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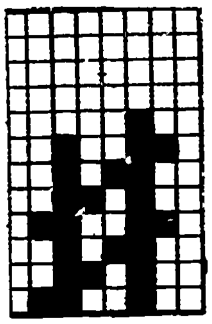
(006)



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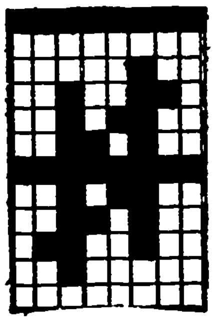

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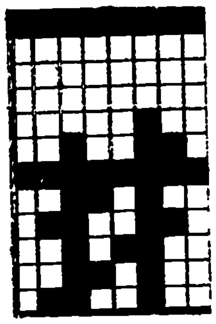
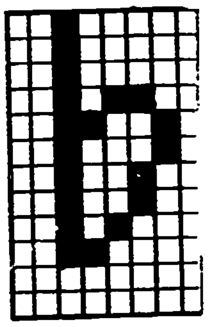


F

(009)



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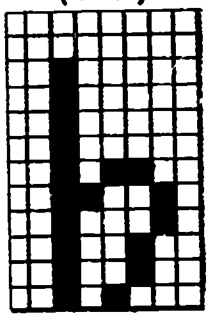
(007)



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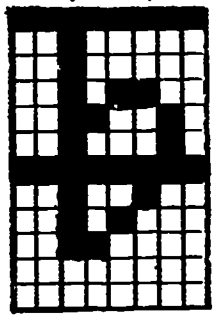

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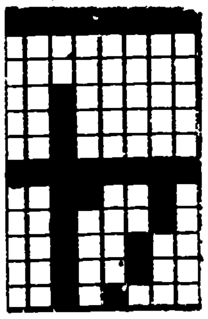
(069)



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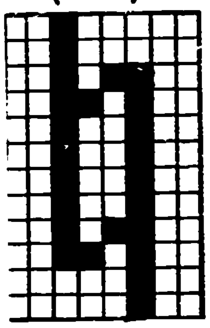
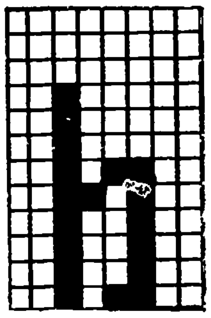
(018)



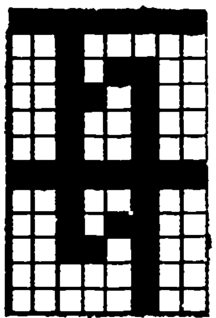
k

(005)



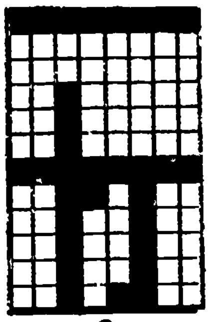
e

(082)



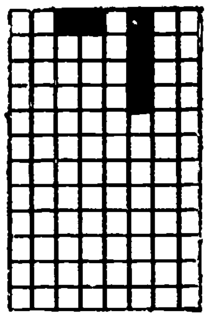
K

(071)



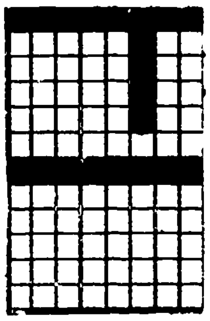
G

(008)



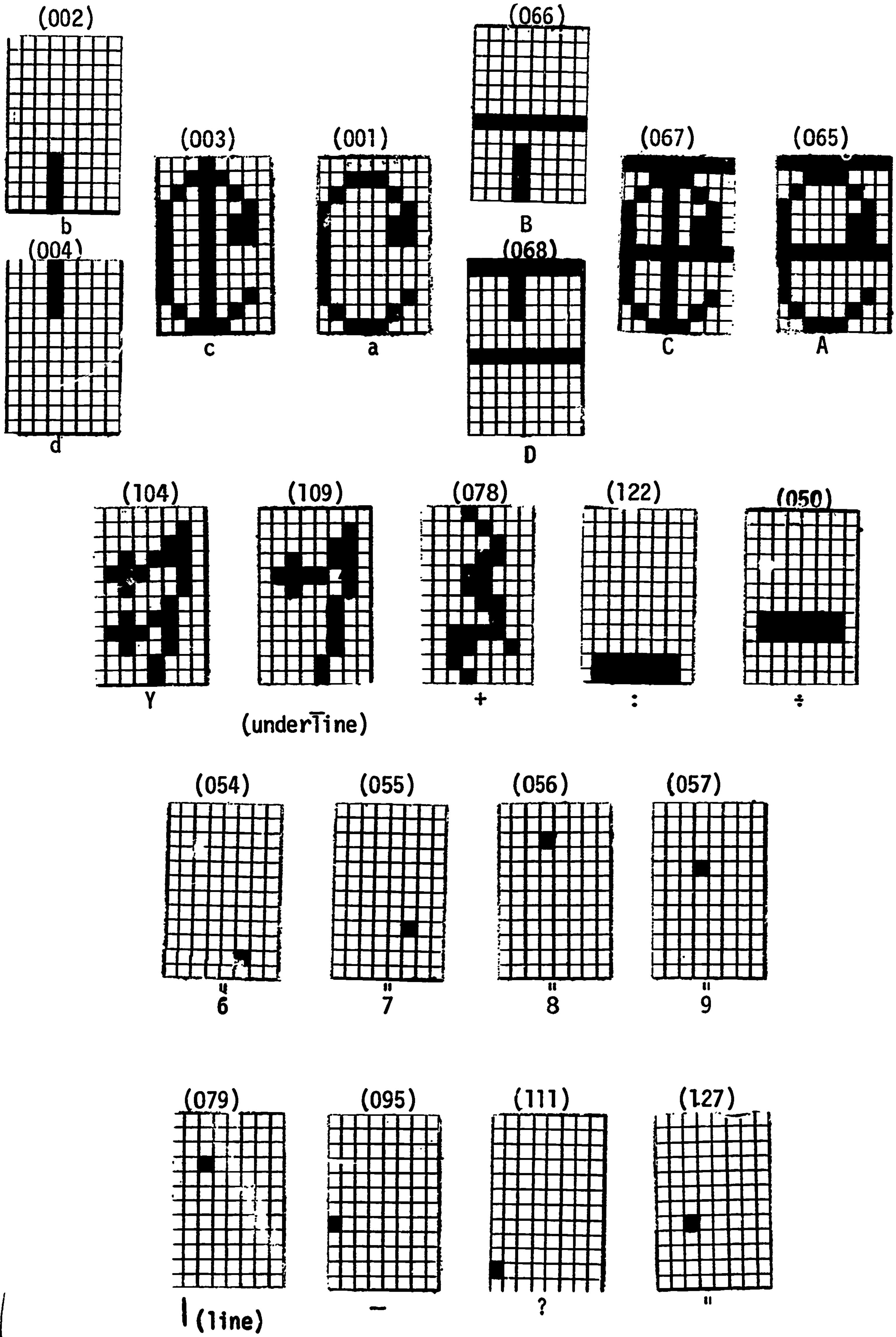
h

(072)



H

RHYTHM


(002)
b
(004)
d
(003)
c
(001)
a
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B
(068)
D
(067)
C
(065)
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Y
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(underline)
(078)
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(054)
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(055)
" 7
(056)
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(057)
" 9
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(095)
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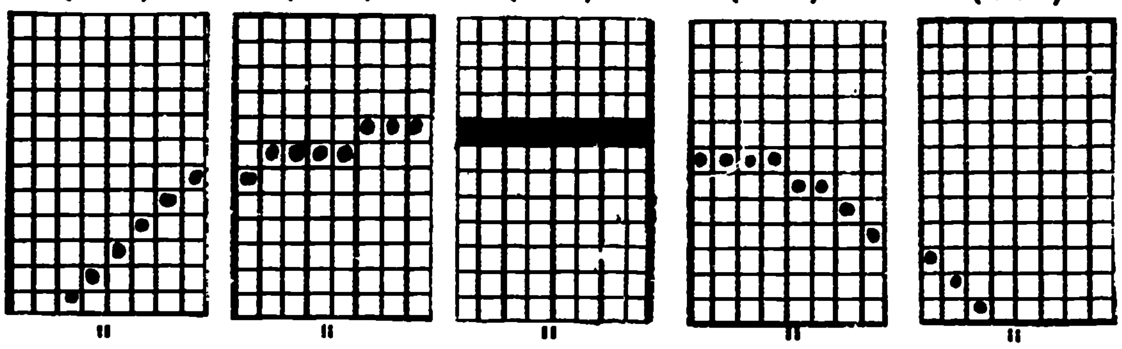
(127)
"

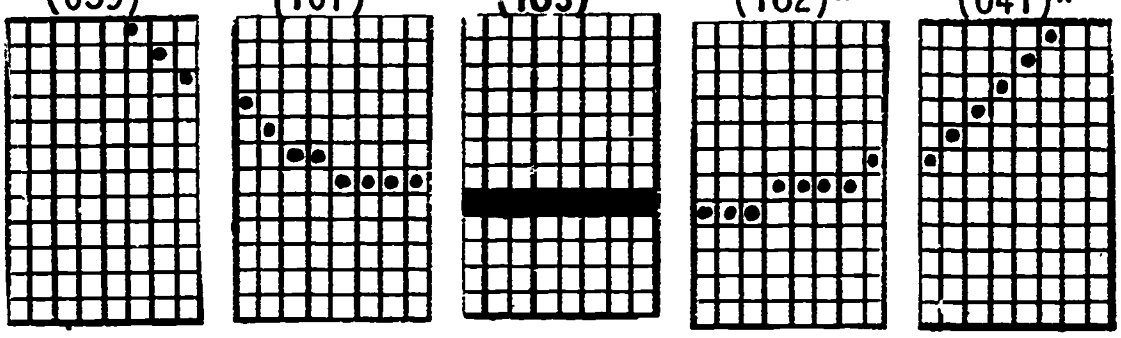
2

(033)* (047)* (059) (058)* (043)*



p̈ v̈ ẍ ẅ r̈

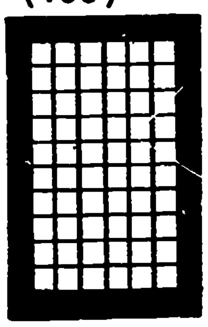
(039)* (101)* (103) (102)* (041)*



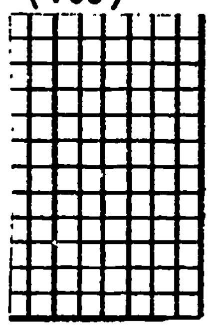
x V X W z

NOTE: The span of the slur can be extended by repeating the middle character (X or ẍ) as many times as is needed.

CURSOR (106)

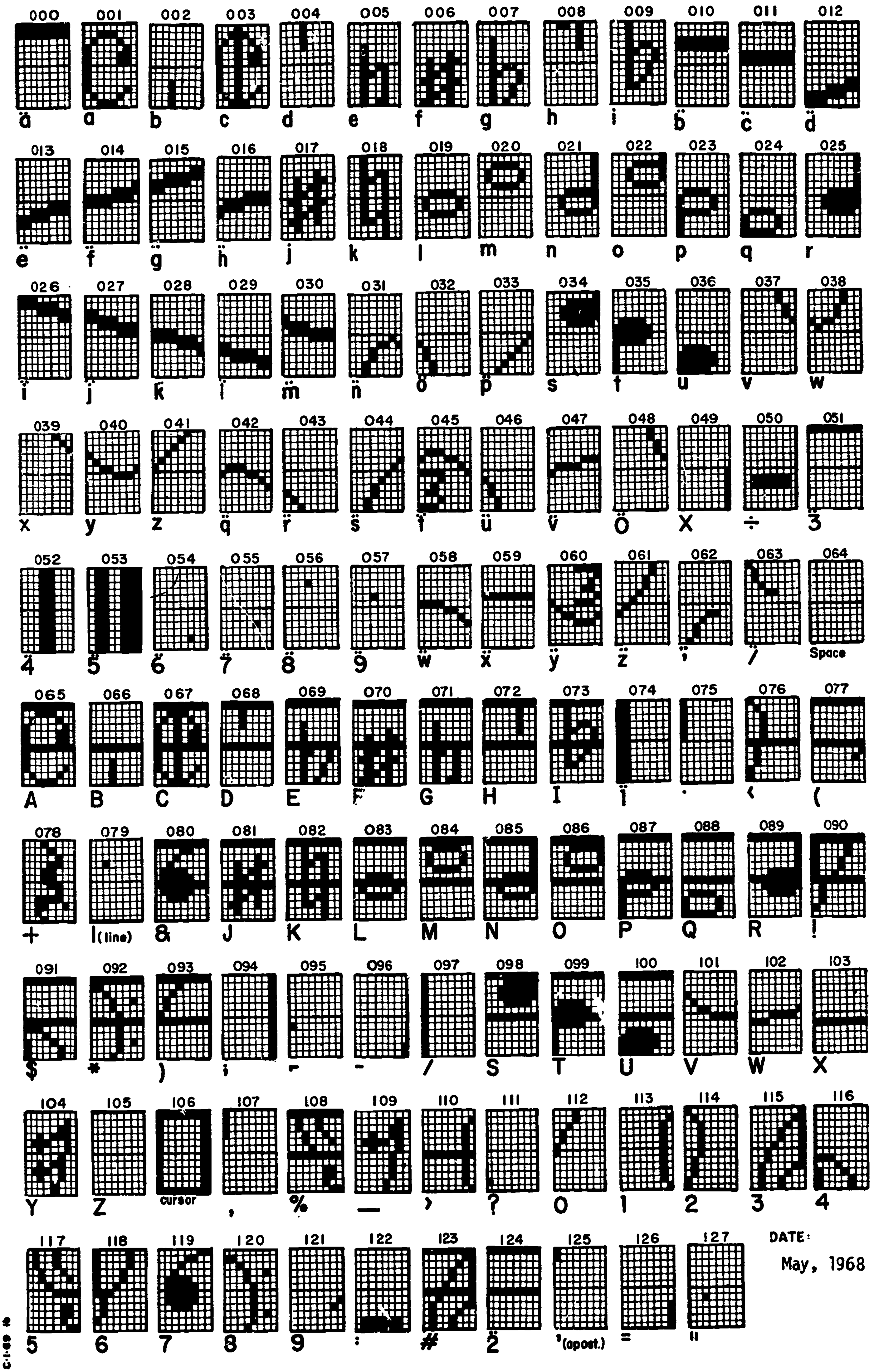


BLANK (105)



THE PENNSYLVANIA STATE UNIVERSITY
COMPUTER ASSISTED INSTRUCTION LABORATORY

DICTIONARY NAME: MUSIC
AUTHOR: PELOQUIN

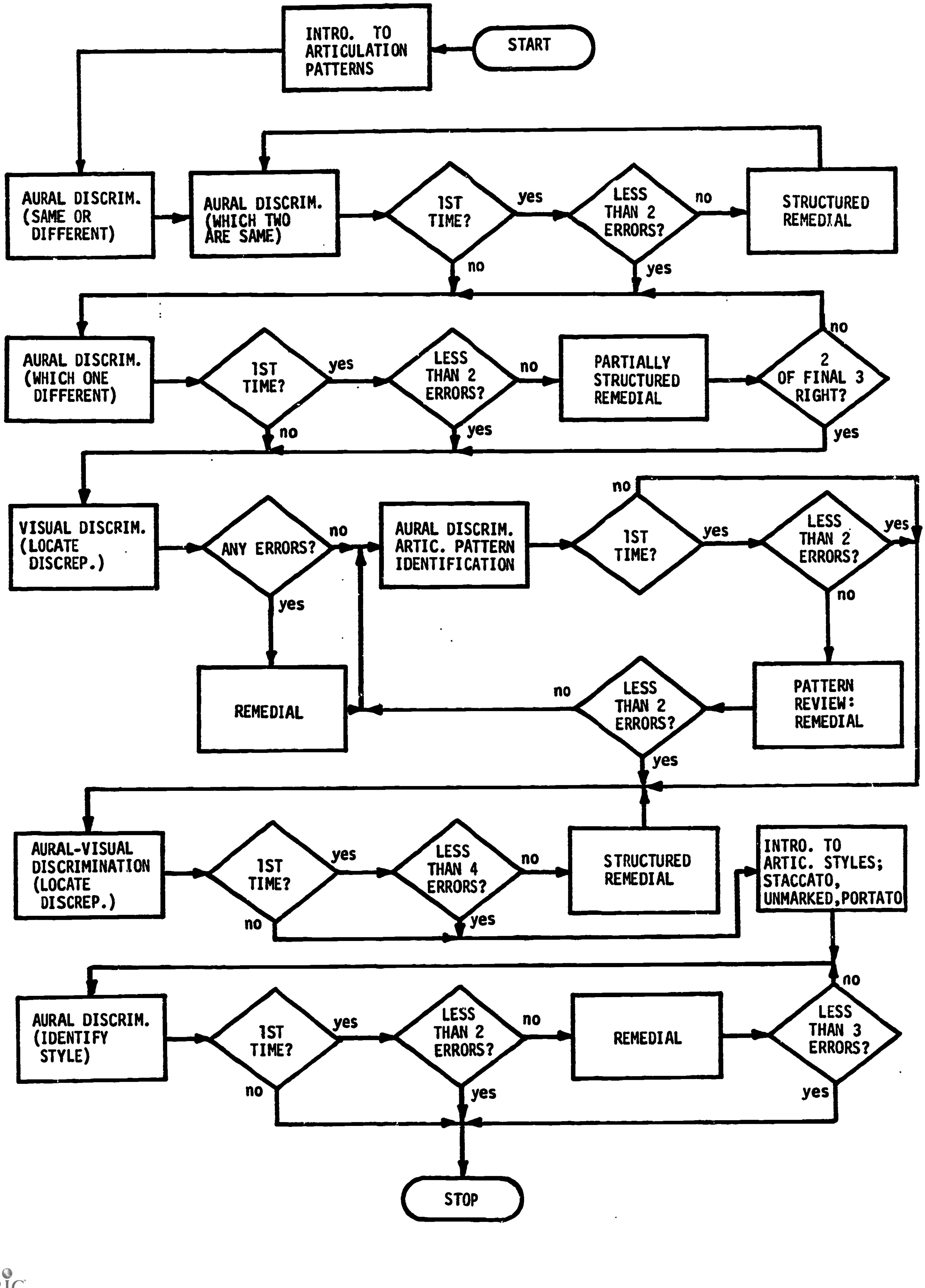


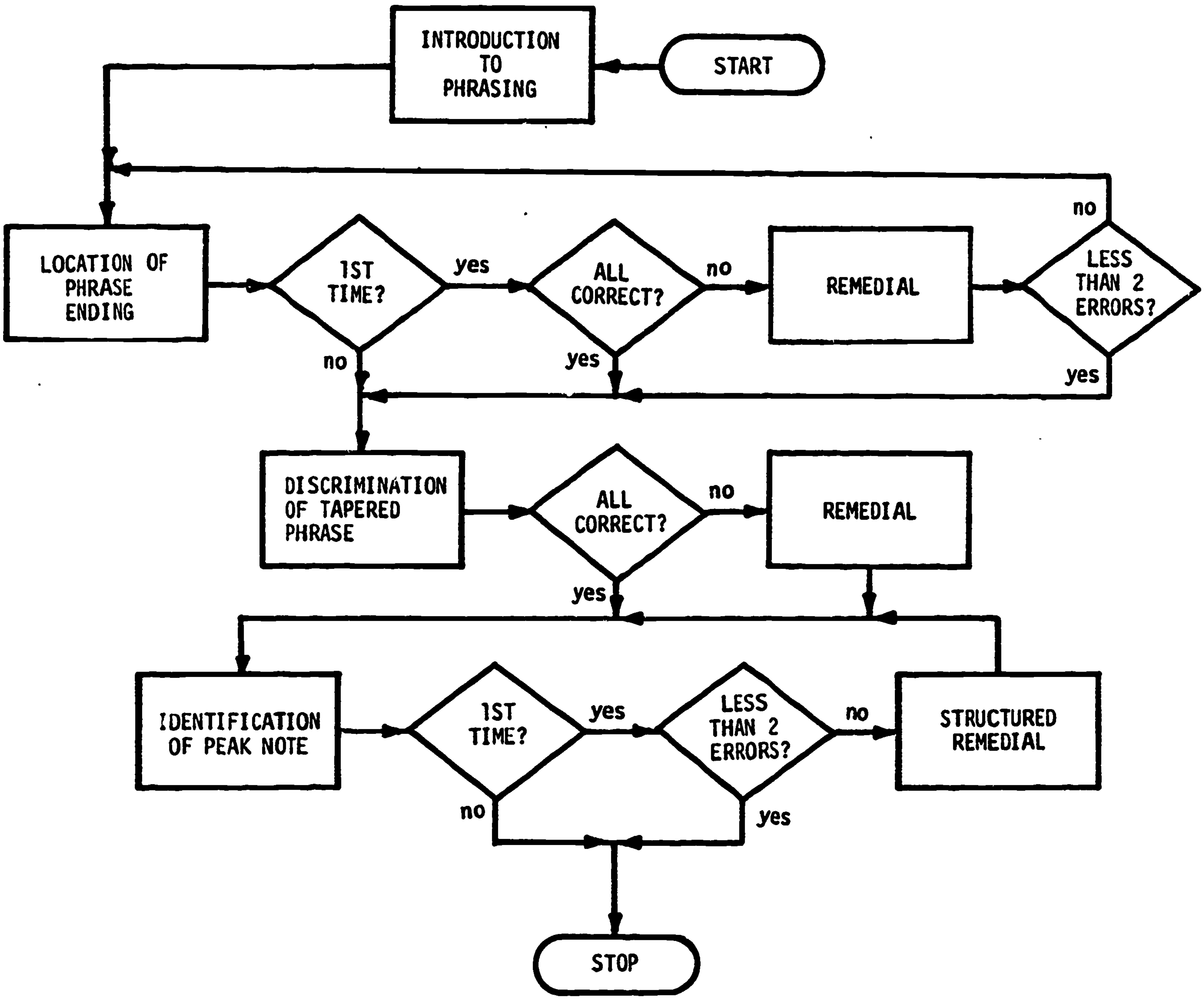
DATE:

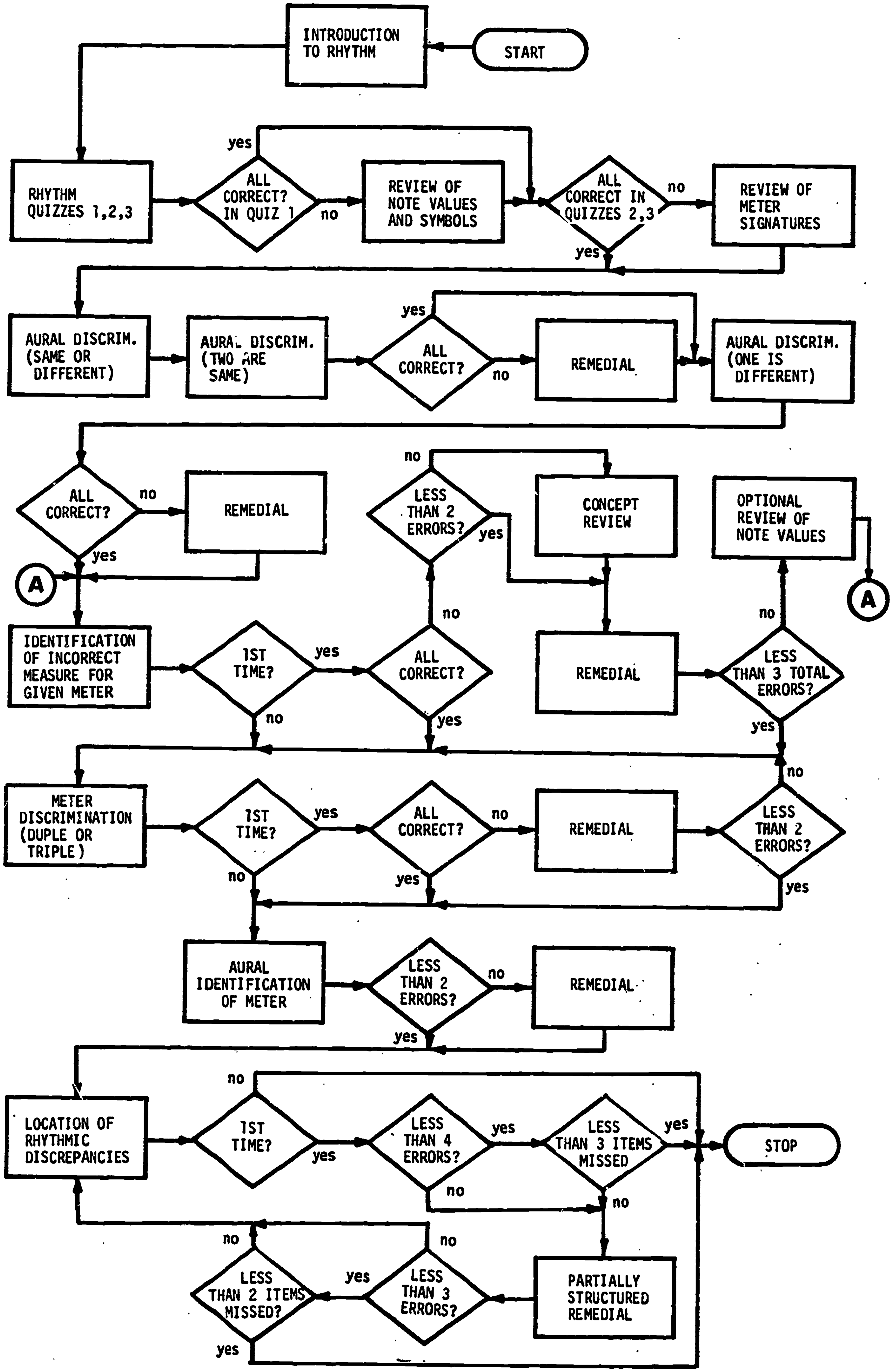
May, 1968

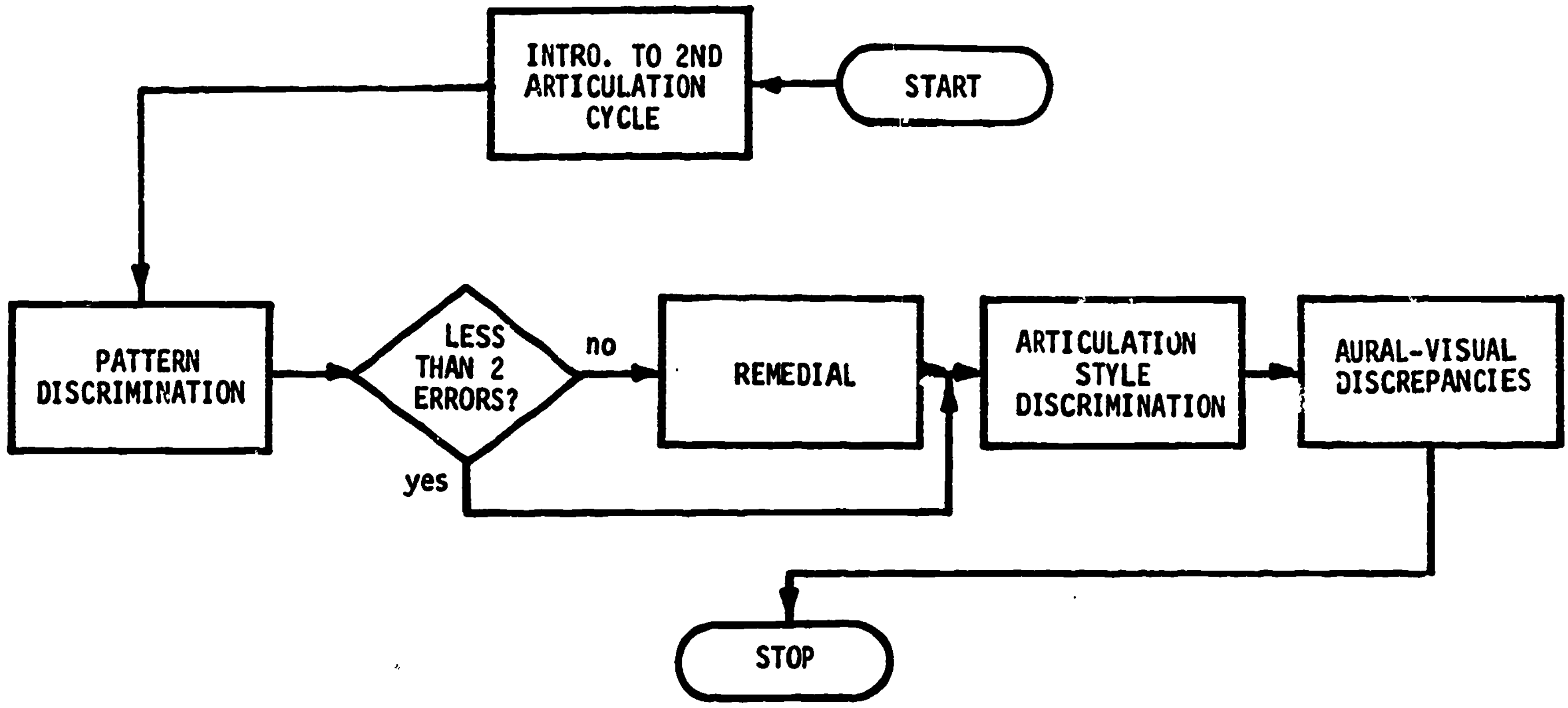
APPENDIX B

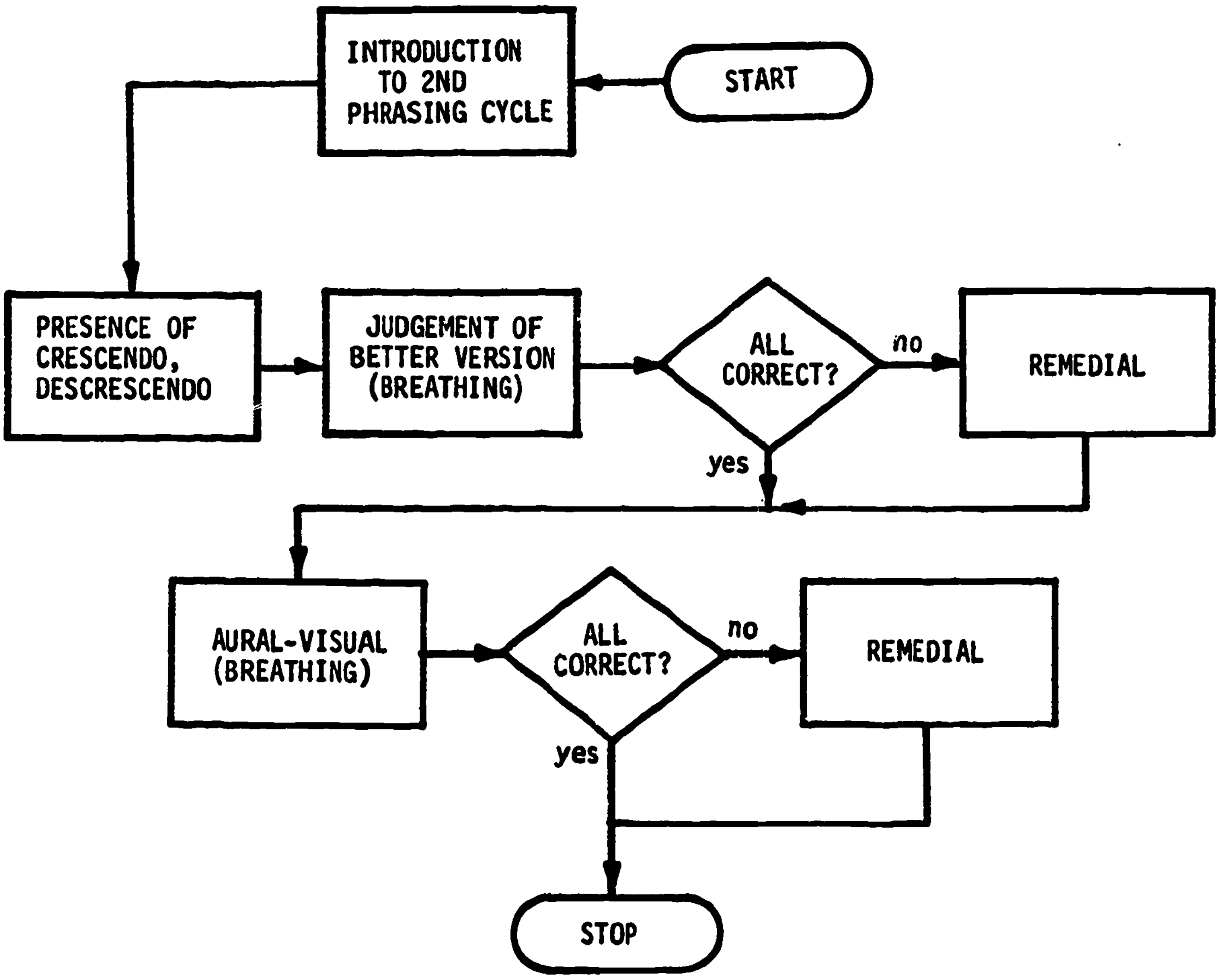
Flowcharts

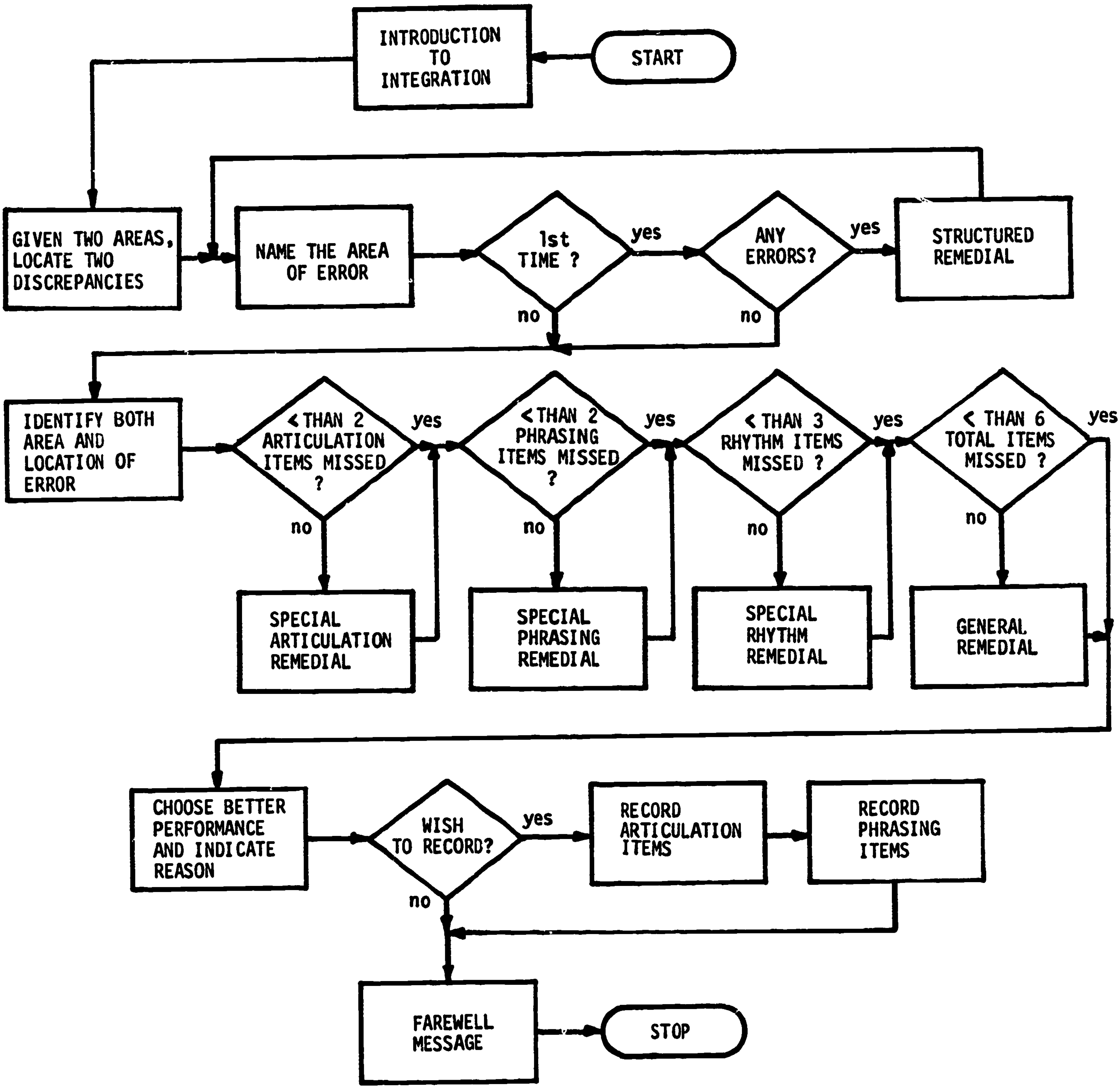

START
INTRO. TO ARTICULATION PATTERNS
AURAL DISCRIM. (SAME OR DIFFERENT)
AURAL DISCRIM. (WHICH TWO ARE SAME)
1ST TIME?
yes
no
LESS THAN 2 ERRORS?
STRUCTURED REMEDIAL
AURAL DISCRIM. (WHICH ONE DIFFERENT)
PARTIALLY STRUCTURED REMEDIAL
2 OF FINAL 3 RIGHT?
VISUAL DISCRIM. (LOCATE DISCREP.)
ANY ERRORS?
REMEDIAL
AURAL DISCRIM. ARTIC. PATTERN IDENTIFICATION
PATTERN REVIEW: REMEDIAL
AURAL-VISUAL DISCRIMINATION (LOCATE DISCREP.)
LESS THAN 4 ERRORS?
INTRO. TO ARTIC. STYLES; STACCATO, UNMARKED, PORTATO
AURAL DISCRIM. (IDENTIFY STYLE)
LESS THAN 3 ERRORS?
STOP


INTRODUCTION TO PHRASING
START
LOCATION OF PHRASE ENDING
1ST TIME?
yes
no
ALL CORRECT?
no
yes
REMEDIAL
LESS THAN 2 ERRORS?
no
yes
DISCRIMINATION OF TAPERED PHRASE
ALL CORRECT?
no
yes
REMEDIAL
IDENTIFICATION OF PEAK NOTE
1ST TIME?
yes
no
LESS THAN 2 ERRORS?
no
yes
STRUCTURED REMEDIAL
STOP


START
INTRODUCTION TO RHYTHM
RHYTHM QUIZZES 1,2,3
ALL CORRECT? IN QUIZ 1
yes
no
REVIEW OF NOTE VALUES AND SYMBOLS
ALL CORRECT IN QUIZZES 2,3
no
yes
REVIEW OF METER SIGNATURES
AURAL DISCRIM. (SAME OR DIFFERENT)
AURAL DISCRIM. (TWO ARE SAME)
ALL CORRECT?
yes
no
REMEDIAL
AURAL DISCRIM. (ONE IS DIFFERENT)
ALL CORRECT?
no
yes
REMEDIAL
A
LESS THAN 2 ERRORS?
no
yes
CONCEPT REVIEW
OPTIONAL REVIEW OF NOTE VALUES
A
IDENTIFICATION OF INCORRECT MEASURE FOR GIVEN METER
1ST TIME?
yes
no
ALL CORRECT?
no
yes
REMEDIAL
LESS THAN 3 TOTAL ERRORS?
no
yes
METER DISCRIMINATION (DUPLE OR TRIPLE)
1ST TIME?
yes
no
ALL CORRECT?
no
yes
REMEDIAL
LESS THAN 2 ERRORS?
no
yes
AURAL IDENTIFICATION OF METER
LESS THAN 2 ERRORS?
no
yes
REMEDIAL
LOCATION OF RHYTHMIC DISCREPANCIES
1ST TIME?
no
yes
LESS THAN 4 ERRORS?
yes
no
LESS THAN 3 ITEMS MISSED
yes
no
STOP
PARTIALLY STRUCTURED REMEDIAL
LESS THAN 3 ERRORS?
yes
no
LESS THAN 2 ITEMS MISSED?
no
yes


INTRO. TO 2ND ARTICULATION CYCLE
START
PATTERN DISCRIMINATION
LESS THAN 2 ERRORS?
no
yes
REMEDIAL
ARTICULATION STYLE DISCRIMINATION
AURAL-VISUAL DISCREPANCIES
STOP


INTRODUCTION TO 2ND PHRASING CYCLE
START
PRESENCE OF CRESCENDO, DESCRESCENDO
JUDGEMENT OF BETTER VERSION (BREATHING)
ALL CORRECT?
no
yes
REMEDIAL
AURAL-VISUAL (BREATHING)
ALL CORRECT?
no
yes
REMEDIAL
STOP



INTRODUCTION TO INTEGRATION
START
GIVEN TWO AREAS, LOCATE TWO DISCREPANCIES
NAME THE AREA OF ERROR
1st TIME ?
yes
no
ANY ERRORS?
yes
no
STRUCTURED REMEDIAL
IDENTIFY BOTH AREA AND LOCATION OF ERROR
< THAN 2 ARTICULATION ITEMS MISSED ?
yes
no
SPECIAL ARTICULATION REMEDIAL
< THAN 2 PHRASING ITEMS MISSED ?
yes
no
SPECIAL PHRASING REMEDIAL
< THAN 3 RHYTHM ITEMS MISSED ?
yes
no
SPECIAL RHYTHM REMEDIAL
< THAN 6 TOTAL ITEMS MISSED ?
yes
no
GENERAL REMEDIAL
CHOOSE BETTER PERFORMANCE AND INDICATE REASON
WISH TO RECORD?
yes
no
RECORD ARTICULATION ITEMS
RECORD PHRASING ITEMS
FAREWELL MESSAGE
STOP

Number of Items
for Categories in Flowchart

CAI Task	No. of Items per Category
Articulation	
Introduction to Articulation Patterns	1
Aural Discrimination (same or different)	4
Aural Discrimination (which two same)	8
Remedial	6
Aural Discrimination (which one different)	6
Remedial	6
Visual Discrimination (locate discrepancy)	2
Remedial	4
Aural Discrimination of Articulation Pattern Identification	8
Remedial	6
Aural-Visual Discrimination (locate discrepancy)	9
Remedial	4
Aural Discrimination (identify style)	5
Remedial	
Phrasing	
Location of Phrase Ending	4
Remedial	4
Discrimination of Tapered Phrase	5
Remedial	3
Identification of Peak Note	5
Remedial	3
Rhythm	
Rhythm Quiz 1	4
Rhythm Quiz 2	11
Review of Note Values and Symbols	6
Review of Meter Signatures	4
Aural Discrimination (same or different)	4
Aural Discrimination (two are same)	4
Remedial	4
Aural Discrimination (one is different)	4
Remedial	4
Identification of Incorrect Measure for Given Meter	4
Remedial	4
Meter Discrimination (duple or triple)	4
Remedial	2
Aural Identification of Meter	6
Remedial	3
Location of Rhythmic Discrepancies	6
Remedial	5

Number of Items for Categories in Flowchart (Cont.)

CAI Task	No. of Items per Category
Articulation	
Pattern Discrimination	8
Remedial	4
Articulation Style Discrimination	7
Aural-Visual Discrepancies	9
Phrasing	
Presence of Crescendo, Decrescendo	5
Judgment of Better Version (breathing)	4
Remedial	3
Aural-Visual (breathing)	5
Remedial	2
Integrated	
Given Two Areas, Locate Two Discrepancies:	
Name the Area of Error	5
Remedial	3
Identify Both Area and Location of Error	11
Special Articulation Remedial	5
Special Phrasing Remedial	4
Special Rhythm Remedial	3
General Remedial	
Choose Better Performance and Indicate Reason	14
Judging and Recording	
Record Articulation Items:	
Criterion	8
Remedial	6
Advanced	6
Record Phrasing Items	8
	297

APPENDIX C

Extract From A Course Listing

EXTRACT FROM A COURSE LISTING

```
CLAR8*E
   1  PR   *E
   2  FPO  17*E
   3  DT   0,5+/2,0+/32,5+/(A)RE THESE THE SAME OF DIFFERENT (/*E
   4  DT   8,5+/2,8+/27,5+/+, (S)AME          +, (D)IFFERENT*E
   5  DT   13,16+/2,13+/24,16+/+, (R)EPEAT*E
   6  AUP  AB10 238,0+/34*E
   7  EPP  300+/QU3*E
   8  NX   *E
   9  DT   16,5+/2,16+/32,5+/(P)ERHAPS YOU SHOULD LISTEN AGAIN.*E
  10  PA   40*E
  11  DE   16+/2*E
  12  BR   RE*E
  13  CAP  4,7,3,4+/CC*E
  14  DT   16,5+/2,16+/10+/(V)ERY GOOD.*E
  15  PA   30*E
  16  DE   0+/32*E
  17  WAP  4,7,3,20+/DF*E
  18  DT   16,5+/4,16+/36,5+/(N)O, THEY WERE THE SAME.  (L)ISTEN*C*IAGAIN
           AND LOOK AT THE EXAMPLE.*E
  19  PA   50*E
  20  DE   16+/6*E
  21  FP1  *E
  22  AUP  AB10 238,0+/34*E
  23  FPO  *E
  24  WAP  4,12,3,15+/LA*E
  25  AUP  AB10 238,0+/34*E
  26  UN   UU*E
  27  DT   16,5+/4,16+/37,0+/(T)OUCH THE PEN TO ONE OF *C*ITHE LIGHTED
           AREAS.*E
  28  PA   50*E
  29  DE   16+/4*E
CLAR11*E
   1  PRR  *E
   2  DE   0+/32
   3  LD   0+/S2*E
   4  DT   0,5+/4,0+/40,0+/(N)OW WE WILL CHANGE THE PROCEDURE*C*ISLIGHTLY.
           (I)N THE SETS OF THREE, LABELED*E
   5  DT   4,0+/2,4+/40,0+/A, B, AND C, TWO WILL SOUND EXACTLY*E
   6  DT   6,0+/4,6+/40,0+/ALIKE.  (Y)OU ARE ASKED TO NAME THE TWO*C*IWHICH
           SOUND THE (SAME).  (R)EMEMBER, THE*E
   7  DT   10,0+/4,10+/40,0+/ARTICULATION PATTERNS MUST BE EXACTLY*B*B*B*B*B*B
           (-------*C*I)ALIKE TO BE CONSIDERED THE SAME.*E
```

```
 8  DT  14,5+/6,14+/40,0+/(Y)OU MAY REPEAT THE TAPE IF YOU*C*IDESIRE
        BEFORE ANSWERING. (Y)OU MAY ALSO*C*IREPEAT THE TAPE AFTER YOU
        GIVE A CORRECT*E
 9  DT  20,0+/4,20+/40,0+/ANSWER. (T)HE NEXT ITEM WILL NOT APPEAR*C*
        IUNTIL YOU TOUCH THE PEN BY (GO).*E
10  PA  120*E
11  DT  27,5+/2,27+/35,5+/(P)RESS THE SPACE BAR TO CONTINUE.*E
12  EPI 30,37+/2,30+/1m37+/900+/1+*E
```

APPENDIX D

Instructional Display Planning Guide

Form X26-5608-0 (U/M 025)
Printed in U.S.A.

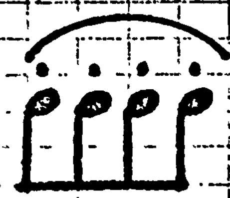
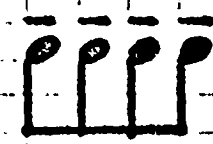
You should recall the earlier work with articulation styles:

Staccato (much separation between tones)

unmarked (some separation)

portato (almost no separation)

As you recall, staccato notes are marked: 

Portato notes are marked  or 

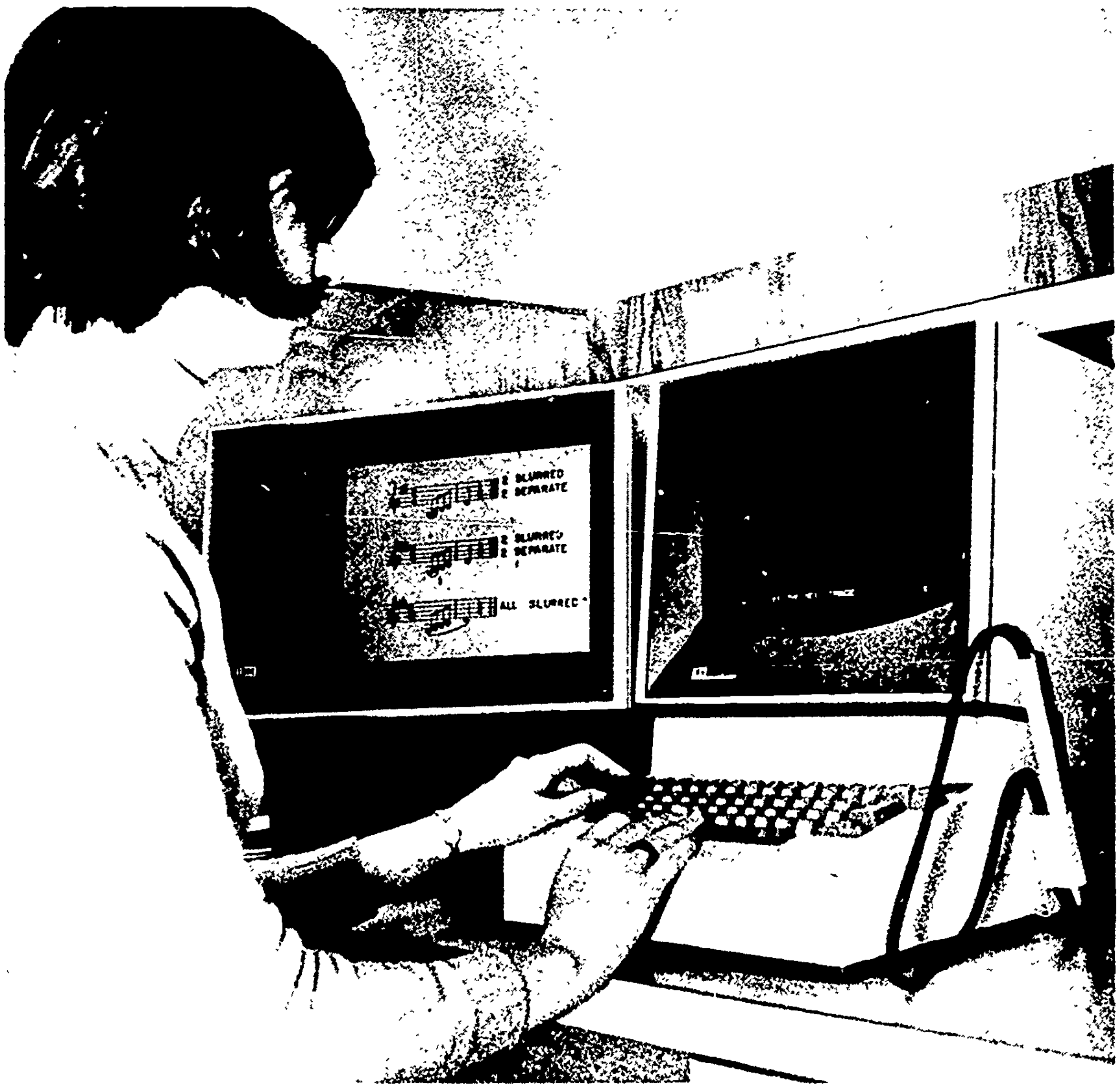
Press the space bar to continue.

APPENDIX E

Pictures

Picture Below: Investigator Observing On-Line Instructional Session

Picture Below: Programer Revising Course Material at the Instructional Station



Picture Below: Monitor Starting Off-Line Instructional Session

Picture Below: Student Using Off-Line Equipment