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# Quarterly Technical Summary

# Educational Technology Program

15 March 1972

Prepared under Electronic Systems Division Contract F19628-70-C-0230 by

**Lincoln Laboratory**

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

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ABSTRACT

The full LTS-3 system was completed during this quarter. Five terminals have been delivered to Keesler Air Force Base where they will be used to support author checkout of lesson material prior to the inauguration of development testing in mid-April. Two terminals remain at the Laboratory to support instructional experimentation and component modification and development. Fourteen Electronics lessons and eleven Air Traffic Control lessons have been converted into fiche. This represents the bulk of the material needed for the Keesler Trial.

F.C. Frick
Program Manager

15 March 1972

Accepted for the Air Force
Joseph R. Waterman, Lt. Col., USAF
Chief, Lincoln Laboratory Project Office

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# EDUCATIONAL TECHNOLOGY PROGRAM

## I. EDUCATIONAL DEVELOPMENT PROGRAM FOR LTS

### A. System Software

The system program is located in one core box, 4096 12-bit words, of the PDP-8 computer. It consists of three parts of roughly equal size: the I/O routines to interface all external machinery, the time-sharing monitor and buffers to service five terminals, and the LTL (Lincoln Terminal Language) processor to call subroutines in the programs that interpret author logic. In the upper core box of the PDP-8 are resident about 3700 8-bit bytes of LTL code, which are called to control the display cycle, to interpret the author logic, and to respond individually to each student according to the author control logic for each frame. The author logic is contained in about 100 records on magnetic tape. These records are loaded dynamically on demand into five buffers, one per student, that fill the remainder of the PDP-8 upper core.

There are still minor flaws in this system, but they are of little overall significance in the operation of the system. No system bugs that cause a nonrecoverable error for one terminal or all of them have occurred in the most recent four weeks of operation.

### B. Software Correction and Recovery Procedures

The LTS is tolerant of certain faults in either the hardware (e.g., the microfiche to which the student is being transferred is missing) or the software (e.g., the frame to which the student should be transferred next is unspecified in the author logic). These faults not only produce messages that inform both the student and the system monitor of the condition, but also trigger a program sequence that restores prefault conditions.

Until author logic is revised so that it is entirely free of faults, an author can modify the logic for a frame from the LTS keyboard. These temporary modifications allow him to check other facets of the lesson before the logic is submitted for revision.

### C. Operation of Keesler Trial

The design of the field trial at Keesler Air Force Base has been completed. Conduct of the Keesler Trial will begin in mid-April for Basic Electronics and 1 May in Air Traffic Control. Each course area covers about one week of normal classroom instruction. The current operation is reserved for program debugging and for finding major flaws in the lesson logic that might seriously impede student progress. As soon as this is completed, four students in each course will begin each week to learn on the system. The onset of the Air Traffic Control is delayed two weeks more than Electronics because substantial changes have recently been made in the course content requirements. A new lesson must be added. The Trial will run for thirteen weeks in each area so that data on learning performance of about fifty students per course will be obtained.

### D. Data Analysis

The data gathered during the Trial can be conveniently divided into three classes – On-Line, Off-Line, and School Performance information.

On-Line data will consist of (1) the records gathered and printed automatically by the computer, and (2) quizzes given between lessons. Both kinds of data are intended to show the instructor whether the student is making satisfactory progress, or, if he is not, where the trouble lies. The computer record is produced on a teletype immediately after the student finishes a lesson as defined by the author. The first effort will be to gather data from a number of students and average them to provide typical lesson performance profiles. The results will be validated by correlating them with the quiz results: presumably, the areas where the student spends the most time will be reflected in errors on the post-lesson quiz. If so, individual performance records can be used to assess student progress, and the time spent administering quizzes can be saved. Averaged data will be useful in identifying weak portions of the lesson material.

Off-Line data will consist of individual, frame-by-frame records of student performance which will be recorded on magnetic tape. They can be analyzed when the field trial is complete to answer a variety of detailed questions about the behavior of the students, e.g., the frequency of use of features such as the HELP, REPEAT, BACK/FORTH scan options, and other features.

School Performance information will be gathered from each student at the end of his week of training. It consists of a test covering all the material and a survey of his attitudes about working on the system. The test results will be compared with those for a control group that receives regular instruction. These data comprise the main results of the Keesler Trial. The overall hypothesis is that LTS-3 will provide at least as effective instruction as the classrooms, in substantially less time. It is also expected that most students will prefer this mode of instruction over conventional classrooms or self-paced instruction with conventional materials. Since the Terminal combines the display advantages of quality audio/visual instruction, the sophistication of CAI response interpretation, and the time saving associated with individual pacing, there is strong reason to expect good results.

## II. HARDWARE DEVELOPMENT

The full LTS-3 system was completed during this quarter. Approximately three months of system shakedown tests were conducted prior to shipment to KAFB. The five-terminal system is installed and operating at KAFB, and has supported USAF Author Lesson checkout since early March 1972.

### A. Terminal Design

The final LTS-3 units were delivered for system tests. Late modifications were incorporated into the earlier machines, so that all seven machines are now identical. Modifications, in addition to those described in earlier Educational Technology Quarterly Technical Summaries, included redesign of the film gate to ensure reliable operation; replacement of unstable potentiometers in the original Image Systems circuitry for adjusting time delays associated with the "load" and "view" functions; replacement of the original audio and tracking diode sensor assembly with an improved version produced by the Lincoln Laboratory Microelectronics Group; installation of switching to permit separate operation of electronics, light source, and audio turntable; and provision for automatic fiche selector push-button release to avoid interference with fiche selection in computer control.

## B. Audio System Performance

### 1. Compensated Audio Transfer Function

The audio is pre-emphasized (Fig. 1) before being recorded on film to compensate for the audio reader lens and slit plus the film copy process MTF. Overall audio system frequency response is shown in Fig. 2. The channel response is flat to within ±2 dB from 0.3 to 3.0 kHz.

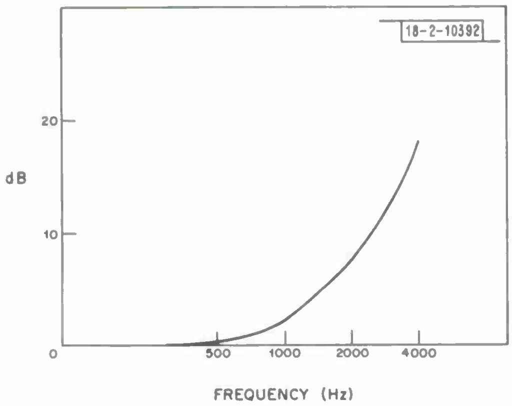



Fig. 1. LTS-3 pre-emphasis frequency response.

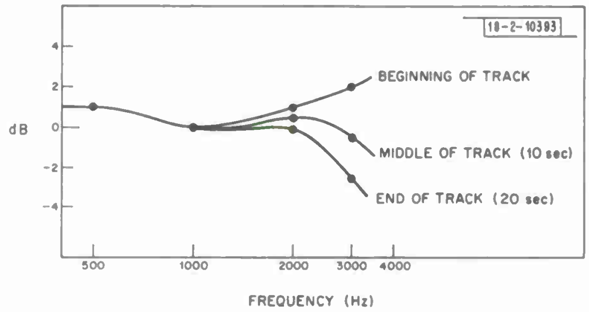



Fig. 2. LTS-3 compensated frequency response.

### 2. Signal to Noise (S/N)

There are three sources of noise in the audio system: the front end noise due to the diode shot noise and amplifier; the film noise (which is the main source of background noise) due to the granularity of the film; and impulse noise, which is subjectively the most annoying source of noise, and is due to dust, lint, and scratches on the film. Table I lists the S/N ratios for the various sources of noise. CRT traces of typical channel background noise plus impulse noise are shown in Figs. 3(a) and (b). Figure 3(a) shows approximately a 100-msec sample of background noise plus impulses, and Fig. 3(b) shows an expanded view of a single impulse. The number of impulses whose peak amplitude was 15 dB above the average magnitude of the background noise was found to be on the average of 25 per second. The impulses are typically 300 μsec in duration and 15 percent of the peak-to-peak audio signal amplitude.

TABLE I

S/N RATIOS FOR VARIOUS SOURCES

| Noise Source | S/N Ratio (dB) |
|---|---|
| Front end noise | 50 |
| Grain noise | 37 |
| Impulse noise | 27 |

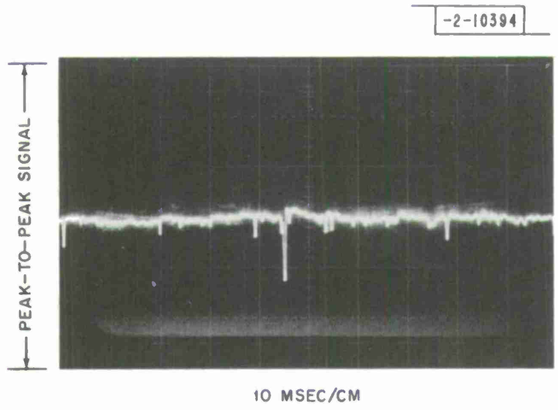



Fig. 3(a). Typical impulse noise.

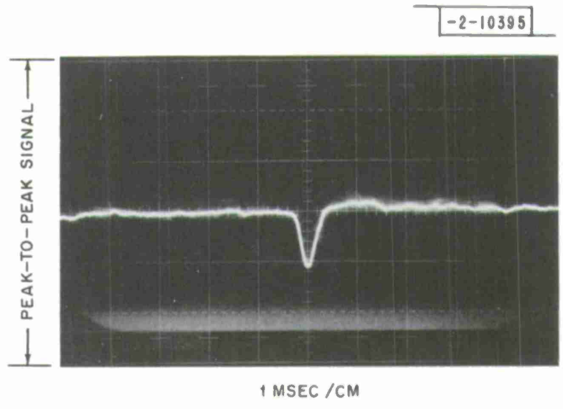



Fig. 3(b). Typical impulse.

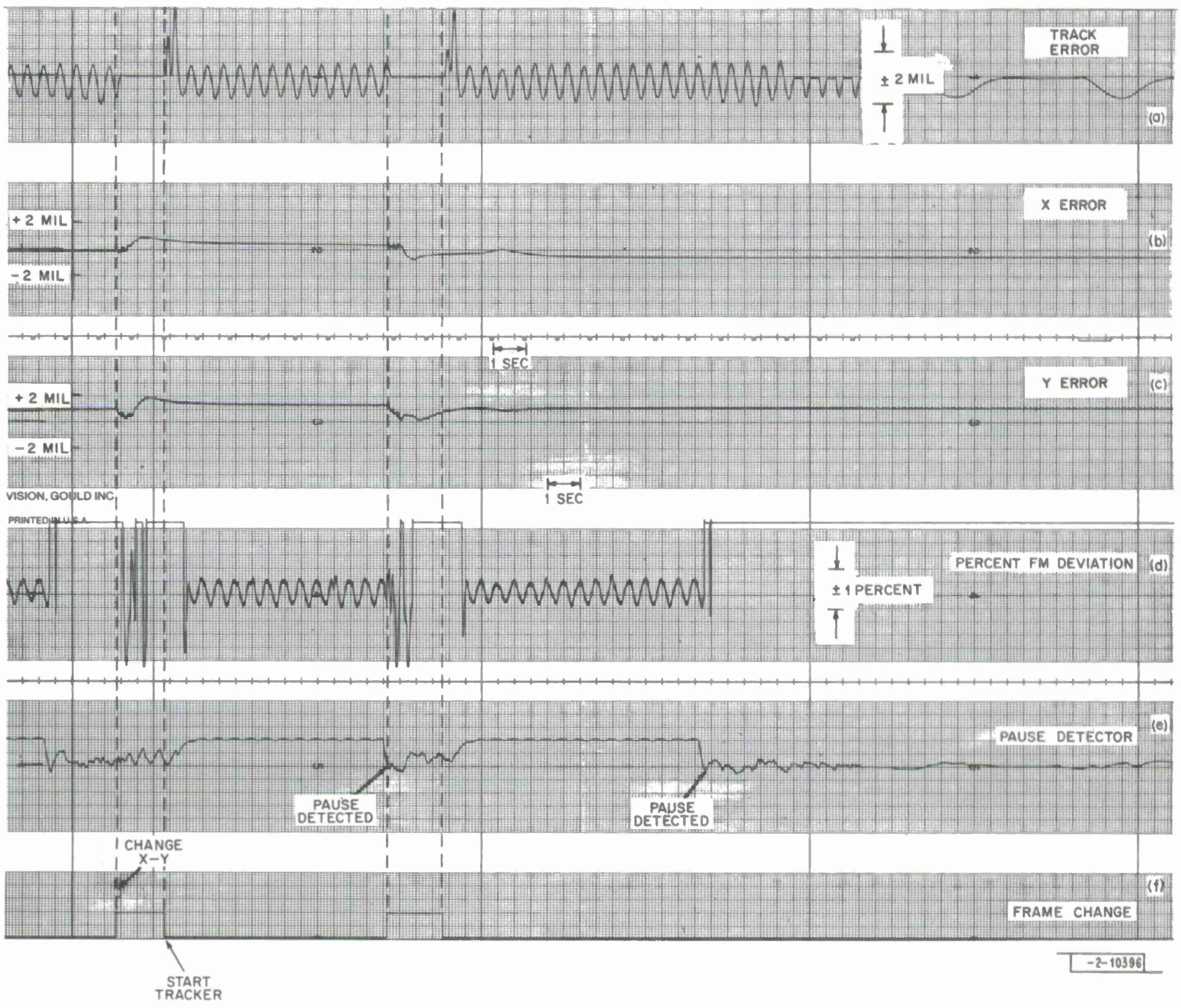



Fig. 4(a-f). Dynamic performance: LTS-3.

### 3. Distortion

Distortion was measured for a peak sine wave at 1 kHz. The second harmonic distortion was found to be 7 percent. The third harmonic distortion was 2.5 percent.

### 4. Incidental FM

Incidental FM is caused by variations in the effective radial velocity of the scanning diode. The principal source of FM is the offset of the audio spiral center. To a first-order approximation, the frequency deviation is proportional to the total radial offset. A radial offset of 0.004 inch will cause a peak FM deviation of 1 percent at the start of the audio track. A typical FM deviation measurement is shown in Fig. 4(d).

### 5. X-Y Acquisition

The X-Y acquisition system error signals are shown in Figs. 4(b) and (c). It takes little more than 1 sec from the time of a frame change command [see Fig. 4(f)] until the X-Y error signals reach steady state.

### 6. Tracker

The audio spiral tracker is given a track command on the falling edge of the frame change command. Typical track error signals are shown in Fig. 4(a). The tracker acquires the audio track in about 0.5 sec. There are two main sources of tracker error: the first is the varying gravitational force on the vertically mounted tracker, while the second is the X-Y radial offset. Each produces a 2-Hz variation in the error signal. These errors are independent and may add in phase or partially cancel one another.

### 7. Pause Detection

An FM discriminator is used to detect cue tones and the end-of-audio signal which are sent to the computer. These low-rate data signals are coded as a shift in frequency from 200 to 220 Hz. The discriminator output is shown in Fig. 4(e).

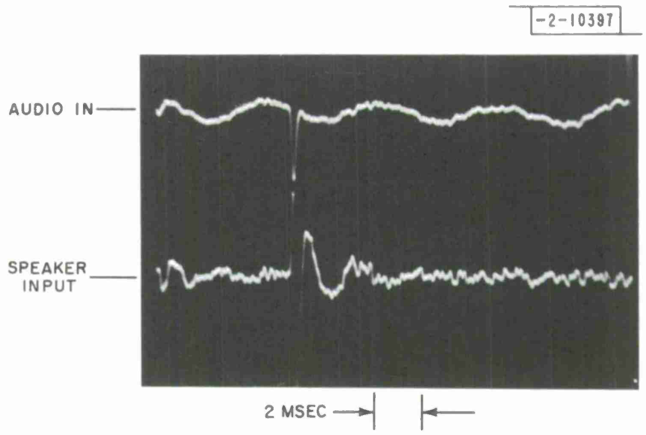
### 8. Impulse Canceller

An impulse noise canceller has been implemented which erases impulse noise during periods of silence in the audio message, when the impulses are most objectionable. When high-level speech is present, no attempt is made to eliminate the impulses since they are partially masked by the speech. Figure 5(a) shows typical channel operation without the impulse noise canceller; Fig. 5(b) shows the same channel with the canceller. The input channel in both cases shows an impulse superimposed on the 200-Hz side tone. The output signal has been high-pass filtered to suppress the 200-Hz signal. Without impulse cancellation, an impulse is present at the output causing a pop on the speaker. With the impulse canceller, only background noise is present.

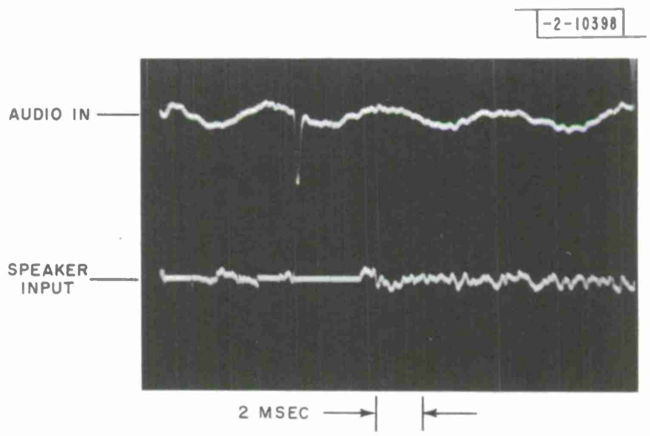
## C. Fiche Production

During this quarter, the bulk of the author material was converted into fiche. Specifically, fourteen Electronics lessons, eleven Air Traffic Control lessons, a lesson on the use of the Author Recording Facility, and a lesson on the use of the LTS-3 Keyboard were produced.

The Fiche Production facility has produced 2000 master visual negatives, 2700 master spiral sound tracks, 75 master half-tone negatives, and 400 master fiche. The higher number of spiral masters reflects the extensive development work (still on-going) to provide the highest possible audio quality to the student. Approximately 7500 copy fiche, for use in the student terminals, have been processed commercially.




(a) Without impulse canceller.




(b) With impulse canceller.

Fig. 5(a-b). Impulse eraser waveforms.

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13. ABSTRACT

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| Lincoln Training System (LTS) | computer-aided instruction |