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ABSTRACT

Work during the past quarter at the Lincoln Laboratory--a research center at the Massachusetts Institute of Technology which is supported by the Air Force--has emphasized improvements in software and mechanical devices for accessing microfiche files through the Lincoln Terminal System (LTS). Design and development work has been done on a cam-driven fiche selector and on the problem of mechanically induced scratches on fiche envelopes. Research and development work in alternate reader design and microfiche photography is also described. (DGC)

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Educational Technology Program

15 December 1974

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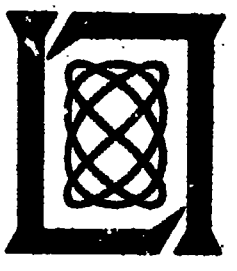

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Eugene C. Raabe

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

EDUCATIONAL TECHNOLOGY PROGRAM

QUARTERLY TECHNICAL SUMMARY TO THE AIR FORCE SYSTEMS COMMAND

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ABSTRACT

Work during the past quarter has emphasized improvements in system software and other author support systems. In addition, the cam-driven fiche selector has been undergoing cycle testing and investigation of the problem of envelope scratching has been initiated. An alternative reader has been designed and is being fabricated.

15 December 1974

F. C. Frick
Program Manager

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EDUCATIONAL TECHNOLOGY PROGRAM

I. INTRODUCTION

Work being done under the sponsorship of the Air Force Communications Service (AFCS), the National Science Foundation, and the U.S. Bureau of Mines has directed attention to the needs of lesson authors and the problems of lesson development. Software and procedures which should benefit the entire community of users have been developed during the quarter. In addition, attention has been given to the fiche production system and steps taken to improve this facility.

In the hardware area, attention has been focused on the problem of envelope scratches, an investigation that has been facilitated by the cam-driven fiche selector and its associated processor. A new audio reader has been designed, as an alternative to the microscope reader, and currently is being fabricated.

II. LTS SUPPORT SYSTEMS DEVELOPMENT

During the past quarter, emphasis has shifted from computer programming to authoring of lesson materials. A considerable effort has gone into writing materials for authors and developing procedures. A scheme has been worked out, for example, for handling fiche materials that is prototypical of one for full-scale production. An author submits materials for conversion to fiche to the production center and the originals and fiche copies are returned when an order is complete. Only master photo images are kept on file at the production site, providing a means for dealing with change orders. Otherwise, the system is totally decentralized in that the author is solely responsible for fiche layouts, revision sequencing, and frame contents. The documentation of author procedures is another on-going activity. It is intended that all instructions and procedures for writing lessons and operating the lesson checkout and student performance analysis facilities will eventually be on the Lincoln Terminal System (LTS). The goal is for the LTS to be a turnkey operation, not only for students but for authors of lesson materials as well.

Work continues on the development of lesson materials on digital system engineering and mine safety under contracts with the National Science Foundation and the U.S. Bureau of Mines, respectively. Author program documentation and new features of the software system developed under these contracts will benefit others as well. Although the terminal itself is a stand-alone machine, there is a concerted effort to develop programs, facilities, and lesson materials that serve the whole community of users. For example, an electronics lesson developed and written for LTS-3 by the Air Force (Keesler School for Applied Aerospace Sciences) is being converted to the LTS-3S machine under auspices of the Bureau of Mines.

III. AFCS MAINTENANCE MANAGEMENT SYSTEM

Work has continued on the design of a field experiment to determine the effectiveness of the LTS for maintenance management. The effort at present is divided between adapting existing maintenance procedures for the AN/TRC-97A mobile radio set to LTS, the design of new author programs, and the conversion of an LTS-3 terminal to stand-alone operation. The terminal will be installed at Robins AFB next March when a field evaluation of the concept will be conducted in cooperation with the 5th Mobile Communications Group, AFCS.

The LTS concept centers around inputting, via the LTS keyboard, values of system parameters observed in the course of preventive maintenance. The record thus obtained is used to direct appropriate diagnostic, alignment and trouble-shooting procedures, and serves as a cumulative record of system and subsystem performance. These records also establish a means for determining necessary logistic support or design improvement.

Most of the procedures for the AN/TRC-97 are straightforward from the standpoint of the LTS software. There is a reasonably linear flow with decision points involving alignment, fault location, or test equipment procedures. The existing operating system is adequate and the set of author programs is sufficient. There are, however, four performance measurement procedures that will require new, carefully designed author programs. Each of these procedures consists of putting the AN/TRC-97 into an appropriate configuration and attaching various pieces of test equipment. Measurements are then taken by moving a probe or switch to a series of points or settings. These measurements are to be entered into the LTS. Since the measurements are gathered in rather rapid sequence, it is clearly desirable to enter the measurements within the context of a single LTS frame. This in turn presents problems of staying in phase and assuring an ability to examine and edit inputs. In other words, it is essential that no confusion be introduced by the nature of the LTS interaction. Several schemes are being investigated to facilitate this input process and attention is being given to producing a set of programs with some general utility to support this or similar procedures.

The necessary work for conversion of the fourth LTS-3 terminal for stand-alone operation has been completed. At present, the terminal is operable in manual mode and is being aligned and adjusted in accordance with the procedures specified in the LTS-3S Technical Manual. This activity will be followed by cycle tests under self-processor control to establish operational readiness. A portable maintenance kit is being assembled for deployment with the equipment during field tests.

IV. LTS HARDWARE DEVELOPMENT

Checkout and characterization of the cam-driven fiche selector have been completed. The associated self-processor interface has been tested and all fiche manipulation functions are now being cycle tested. In conjunction with the cycle tests, fiche and envelope scratch tests have been initiated to determine the source of the scratches and to evaluate possible solutions to this problem. A new audio reader, based on a Rohlix drive, has been designed and presently is being fabricated. This reader has general application in either the LTS-4 or LTS-3S systems.

A critical review of the fiche production system has been undertaken and techniques and guidelines have been established for reproduction of mixed continuous-tone photographs, text, and line drawing originals.

A. Cam-Driven Fiche Selector

Work has been completed on the checkout and characterization of the cam-driven fiche selector. The system has been interfaced with a SIM 4-02 processor to allow processor-controlled operation of the fiche manipulator. The monitor I/O routines developed for the LTS-3S system have been modified to accommodate the control requirements of the LTS-4. The major changes involved the reformatting of the row position control signals and the accommodation of a frame change complete signal. The row position control signals are now presented to the system in a sign plus relative magnitude format rather than the absolute value of the row coordinate as required by the LTS-3S system.

A simple cycle test program has been written and the fiche and frame select mechanisms of the breadboard system shown in Fig. 1 presently are being tested under processor control. The test is organized such that 4 fiche are selected in sequence and all 12 frames are accessed for each fiche selection. To date, approximately 4400 fiche selections have been completed and the performance of the electrical and mechanical systems has been satisfactory. Failures can generally be categorized as minor and have been overcome by simple mechanical adjustments.

A list of the operational sequences required for fiche and frame selection and the associated elapsed times are shown in Table I. The sequence begins by assuming a student response has evoked a frame located on another fiche. The first series of commands describes the ejection of the fiche presently in the reader plane and it is assumed that the present frame corresponds to the fully extended position of the fiche. The total time to eject a fiche is 2.7 sec while the time to position a new fiche in the reader plane at row zero is 1.9 sec. The time to select a frame is approximately 1 sec. The fiche and frame positioning times represent approximately a 1-sec improvement over those experienced in the LTS-3S system.

B. Envelope Scratch Tests

One of the problems of the cassette system is the fact that the Mylar envelopes which are used to transport fiche from the cassette to the reader plane are susceptible to scratching. The scratches become evident as impulse noise in the audio channel and as dark lines on the video display. Some preliminary tests of the envelopes were conducted in the Spring of 1973 and the results indicated that the envelopes attenuated the illumination and degraded the signal-to-noise ratio by 6 to 12 dB. The LTS-4 development program was discontinued in FY 74 to permit development of the LTS-3S stand-alone system. The recent cycle tests of the cam-driven fiche selector presented the first reliable means for continuing the envelope scratch tests. With computer-controlled tests, noticeable scratches have been found on all envelopes after less than 100 retrieval cycles. Tests have been conducted with portions of the system disassembled to isolate the source of the scratches. It appears that scratches occur when the moving fiche rubs against the leading edge of adjacent fiche. This problem is amplified when the fiche buckle as they are engaged by the edge rollers upon entrance and exit from the cassette. Separating stripes 0.030-inch thick have been added to the envelopes between image areas. Various configurations of these stripes are being tested and, in general, it appears that the scratching is reduced but not eliminated.

C. Alternate Reader Design

An alternate reader employing a Rohlix drive has been designed and is being fabricated. This reader, which is shown in Fig. 2, has been configured to occupy the same bell housing as the rotating microscope reader. The basic difference between the two readers is the fact that the rotating microscope reader inserts a pin in the center of the spiral for fine positioning, while the alternate reader accomplishes fine positioning by means of the closed-loop servo system developed for the LTS-3S system. The alternate reader will not require that the fiche be punched during production, will operate in the horizontal plane, and can be used as an alternative to the present LTS-3S reader. The reader acquires and tracks a spiral magnified 5.6X at the image plane by driving the Rohlix linear actuator radially (as a function of the photodiode detected error signal) as the turntable rotates.

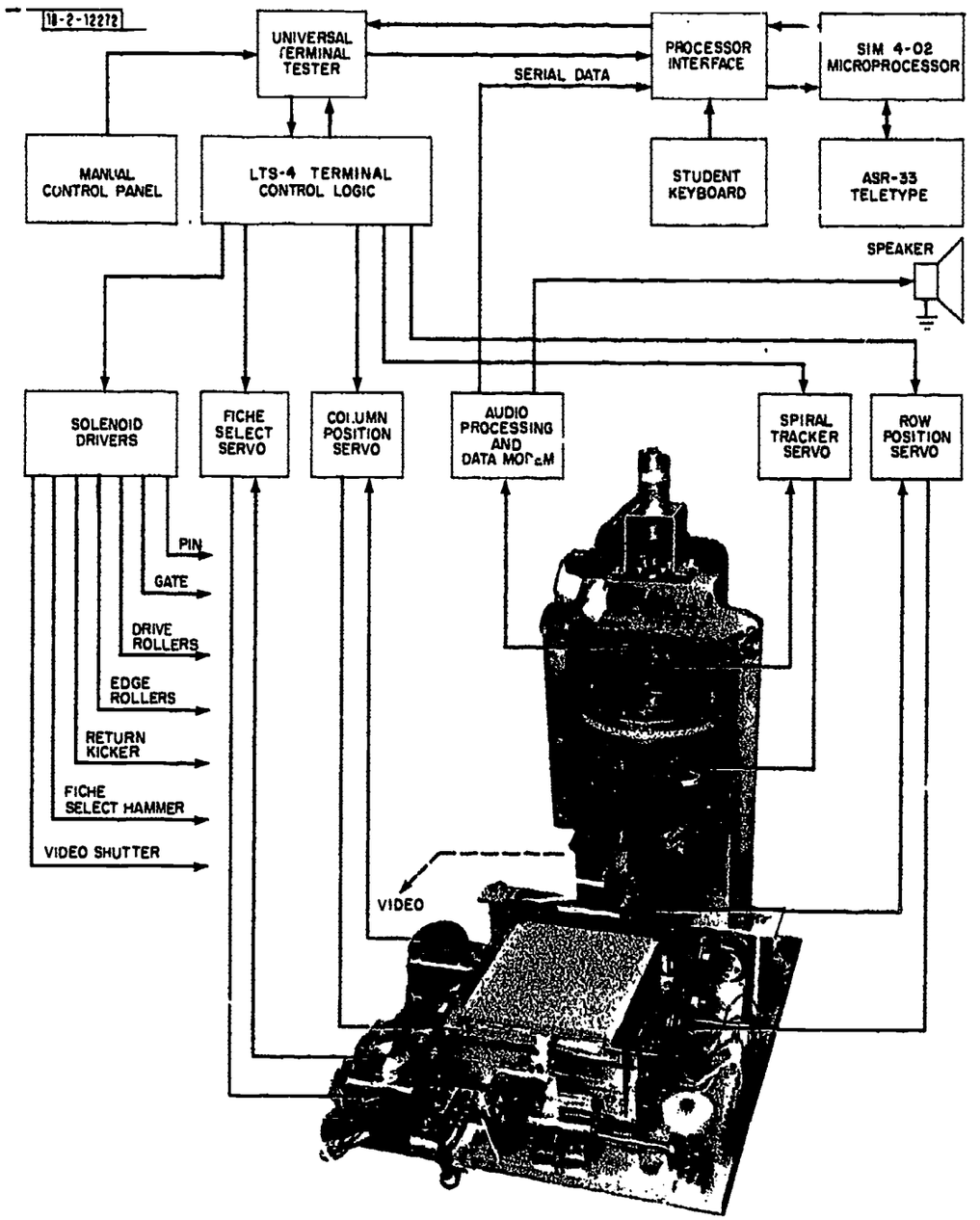

Fig. 1. Cam-driven fiche selector/reader.

TABLE I

FICHE/FRAME SELECT SEQUENCE

FICHE SELECT COMMAND	
Extract positioning pin	
Open film gate	
Close drive rollers	
Sense fiche clear of gate	2.7 sec
Engage edge rollers	
Time-out slew into cassette	
Command column servo to column 1	
Activate return kicker	
FICHE EJECT COMPLETE RESPONSE	
Enable fiche select servo	
Time-out selection	
Activate select hammer	
Slew fiche into gate	
Detect fiche entering gate	1.9 sec
Release edge rollers	
Detect encounter with first row position	
Stop drive rollers	
FICHE SELECT COMPLETE RESPONSE	
FRAME SELECT COMMAND	
Enable row and column servos	
Drive row and column to coarse positions	1 ± 0.35 sec
Detect row null	
Stop drive rollers	
Detect column null	
Stop column drive	
FRAME SELECT COMPLETE RESPONSE	
Release drive rollers	
Insert positioning pin	0.22 sec
Close film gate	
FRAME CHANGE COMPLETE RESPONSE	
Enable tracker servo	
AUDIO ON/DATA ENABLE COMMAND	
Detect north mark	
Start track	
Transfer data	
Play audio	0 – 28 sec

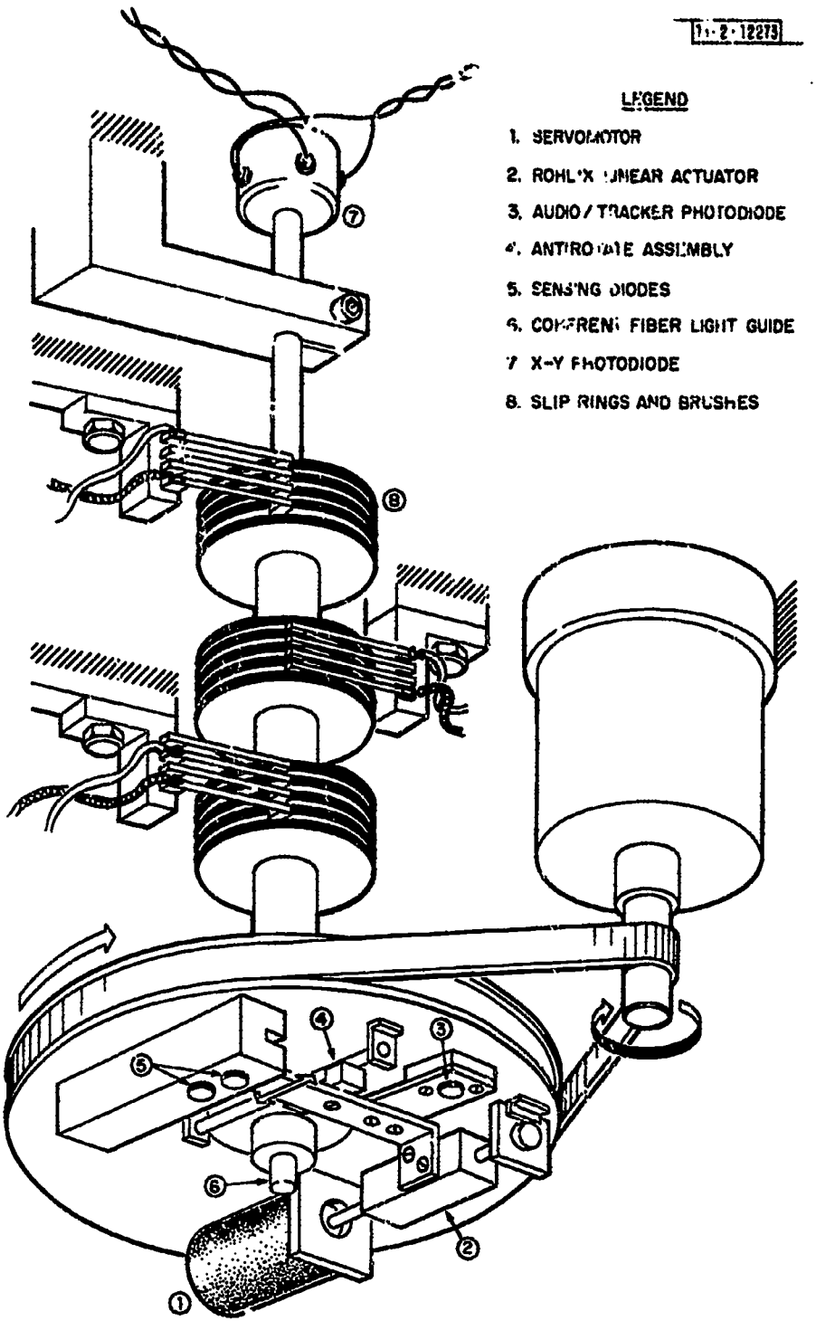

Fig. 2. Alternate reader configuration.

D. Belt-Driven Fiche Selector

The parts for the belt-driven fiche selector and its associated cassette tilting mechanism have been received. Some assembly of parts has been completed but this work has been delayed in favor of completing the alternate reader design and conducting envelope scratch tests. The advantage of the cassette tilting mechanism is the fact that it minimizes the angle at which fiche enter the edge rollers. This effect has been synthesized in the envelope tests carried out on the cam-driven system by positioning test fiche close to the center of the cassette.

E. Microfiche Photography

A critical review of the fiche production system has been undertaken in anticipation of an increased requirement for the production of continuous-tone photographs on LTS fiche. The LTS fiche production places some unusual requirements on the copy technique, since each fiche stores both visual images and audio tracks. The photographic process used must yield high resolution, low noise (fine grain) audio tracks and good reproduction of both continuous-tone graphic material and line drawings. This combination of requirements leads one to use a halftone (screen) process for the visual material. Since it is not desirable to screen line drawings, reproduction of mixed continuous-tone and line drawing originals is best done by pasting the screened print onto the page with its associated print or line drawings and then copying.

The microfiche image is reduced 20 times from the original, so the resolution requirement on the fiche is 20 times as great as that of the original. Standard halftone screens are 133 lines per inch and 65 lines per inch for full-sized work. These translate to 105 lines per millimeter (lpm) and 51 lpm, respectively, on the fiche. This actually is a minimum requirement which relates to the case where white and black dots are of equal area on the screened print. Faithful reproduction of highlights and shadows, where the screen dot size may be of the order of 10 percent of the local area, requires a resolution about twice that of midtones.

In the LTS fiche production facility, original resolution must be maintained in three basic steps which are shown in Fig. 3 as: (1) the 2.3X reduction of the original graphic material by the copy camera, (2) the (8.7X) reduction by the step and repeat camera, and (3) the contact printing process. The limitations of each step are discussed below:

(1) Copy Camera:– This camera, a recent purchase, uses an f/16 fixed aperture lens with an 8.25-inch focal length. Resolving a dot of 10 percent area on a 133-line screen at the 2.3X reduction (where image size is 3.7 × 4.8 inches) point requires a resolution of 684 lines per inch. The lens to film plane spacing in this camera must be held to ±20 mils to achieve this performance. This positioning can be achieved with the aid of low-power microscope observation of the ground glass backplate. It was determined that using the manufacturer's instructions for setting the focus was inadequate for our needs.

(2) Step and Repeat Camera:– Resolution limit on test patterns copied onto minicard film with this camera is of the order of 160 lpm. This is not adequate for reproducing a good tonal range microfiche image from 133-line-per-inch originals. It is adequate for 65-line originals.

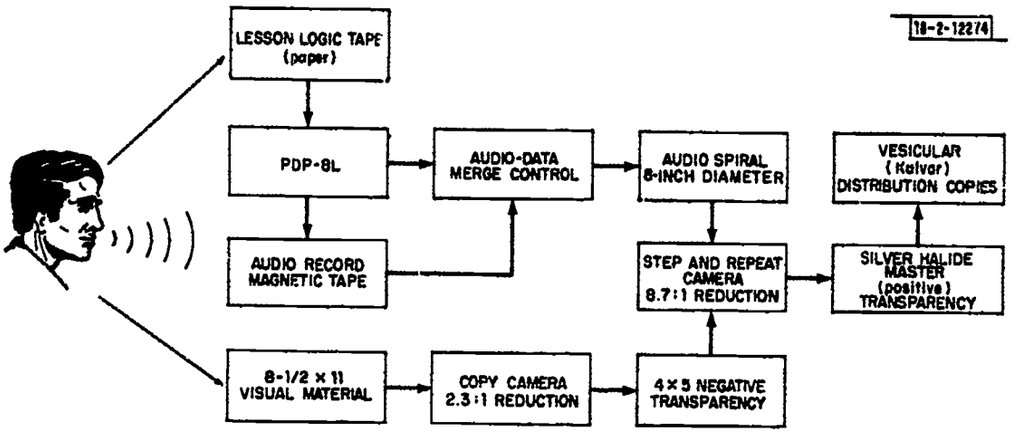

Fig. 3. Fiche production facility.

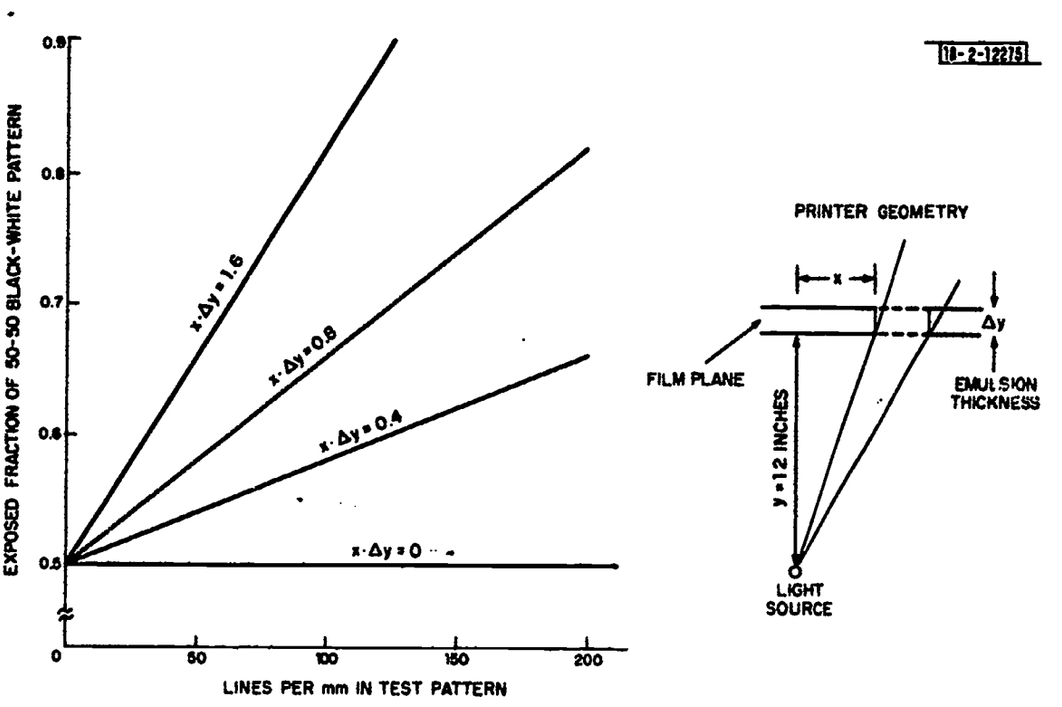

Fig. 4. Degradation in test pattern as a function of printer geometry and emulsion thickness.

(3) Printer:— The printer used to make Kalvar prints from the silver halide minicard masters is a major limit to our present system resolution. The unit uses a memory vapor light source, with an active area of about 1 × 3 inches, located 12 inches away from the vacuum print frame. Figure 4 indicates how lack of collimation in the source can affect resolution in the printing process. The figure shows the fraction of film exposed — in a linear dimension — when the test fiche uses a 50-50 black-white bar pattern. Parameters are film emulsion thickness and offset of the area observed in inches from a perpendicular to the most distant portion of the light source. The Kalvar emulsion is about 0.4 mils thick and offsets may be 4 inches or more. This means that with a 100-lpm test pattern, the exposed fraction will be 0.82 instead of the desired 0.5. The consequences of this spread is to wipe out black highlight dots in the screen pattern. At the same time, the distributed nature of the source tends to spread white dots in shadow areas so there is insufficient energy for exposure to occur. A loss occurs, therefore, at both ends of the gray scale, resulting in pictures with no detail in either highlights or shadows. For example, using the 100-lpm case with 0.4-mil emulsion thickness, one finds that with a source displaced 2 inches from the perpendicular to the film (using 12-inch film plane to light source distance), a 10-percent area dot becomes approximately a 3-percent area in the printing process. If the film area under consideration is displaced 4 inches from the light source (as some areas must be in our printer), the 10-percent dot is wiped out. Note that this corresponds closely to the situation which arises when a 133-line-per-inch screen is used on original material for that translates to 105 lpm on the microfiche.

Our review of fiche production equipment has allowed us to pinpoint in detail the performance and adjustment requirements at each step of the process. We have determined that our printer is an important limit to resolution in the existing system. Printer performance will be the subject of further study.

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