STUDY OF DATA ENTRY REQUIREMENTS AT MARSHALL SPACE FLIGHT COMPUTATION CENTER

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UNIVERSITY OF TENNESSEE COMPUTING CENTER

THE UNIVERSITY OF TENNESSEE
Knoxville, Tennessee

FINAL REPORT

Study of Data Entry Requirements at Marshall Space Flight Computation Center

Supported by NAS8-30879

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PREFACE

This report was prepared by members of the staff of the Computing Center of the University of Tennessee at Knoxville, Tennessee. Dr. Gordon R. Sherman, Director of the University of Tennessee Computing Center (UTCC) was the Project Director. Mr. Donald Broach, Research Associate at UTCC, was the Chief Investigator. Other members of the UTCC staff who worked on the project were Miss Martha Bowen, Associate Director of UTCC, Mr. Hubert Dunsmore, Supervisor, Computing for Administration UTCC, and Mrs. Virginia Patterson, Research Associate at UTCC.

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INTRODUCTION

There can be ,o doubt that one of the most important and exciting subjects in modern computing is that of data entry technology. This is particularly true for large scale computing environments. It is well recognized that improvements in the applications and in the cost efficiencies of using modern computer resources are very promising in that broad and complicated and frustrating area which lies between the data generating activities and the computer processing of that data. The computer industry is finally picking up momentum in efforts to move away from the entrenched punch card oriented procedures which have been so predominant in the early stages of the computer revolution. New data entry technology is one of the most talked of and written about subjects in modern computer journals and magazines and seminars all over the world. Some experts are predicting a near absence of punched card usage by the early 1980's. The next generation of computer systems will undoubtedly have designed characteristics which will provide for (and assume) large scale direct data entry into devices online to the computer. This will, of course, cause some growing and adjustment pains for all types of computer personnel. The effect upon keypunch operators is relatively easy to understand. There will be an impact, of course, but in thinking the matter through, one can visualize the changes which will come to the nature of the work which is now called key punching. The programmers, including systems programmers, systems analysts and applied programmers, will also alter their established work habits to cope with and take better advantage of the new technology. But mainly, and most important, the users, the data and computer work generators will also be effected, and it will be all for the better. They will be much closer to the computer. Computer users, if given the opportunity to learn and to experience new techniques of data entry, will gain a great deal by producing much more work at lower cost from their computer resource. But the learning process for the users will take some time to grow and be successful, and those installations which realize this fact and make timely and intelligent plans for it will benefit the most from the forthcoming improvements in computer and computer communication and data entry technology.

The basic conclusions described in this report rest heavily on the conclusions outlined above. Large scale computing centers can obtain almost immediate advantages by upgrading their current card oriented operations into newer and currently available technology: but, in our estimation, the biggest payoffs will come with the acquisitions and implementations of the computer systems of the 1980's. Computing is a large, complicated and extensive activity which involves and depends upon many, many people of varying abilities and motivations and who are accustomed (perhaps entrenched) in traditional methods. In order to move up and out and into a position to best take advantage of the power which the online, direct data entry computer systems of the 1980's will offer, large scale computer service centers should proceed with well planned conversions to key-to-disk entry systems as soon as economically feasible. They should do what they can as soon as they can to move away from punched cards and to condition their computer community, users, keypunch operators, et al, to the changes which are coming.

II. Overview of MSFC's Data Entry Operations in Relation to a Possible Changeover

The point should be made initially that, based on both field observation and interviews, the data entry requirements for MSFC management and engineering support data processing are currently being fulfilled satisfactorily. However, even without assuming an increase in data volume, there exist two possible changes which could lead towards an optimization of the total data entry system.

One of these changes that could greatly increase the efficiency of data entry at MSFC is in the area of redesign of documents. From close observation, it appears that many documents have been designed for something other than a keypunch source. Redesign of these documents, under the direction of a person appointed as a "document coordinator," would certainly result in increased data throughput. This, by the way, is a condition which seems to prevail at many large computer installations - MSFC is by no means unique in suffering badly designed documents from a keypunch point of view.

Another existing problem in the present data entry system is the division of the bulk of the keypunch pool into two buildings. This situation makes job scheduling and other supervisory duties unnecessarily complicated for the single supervisor. In addition, the design of any of the recent data entry devices, which have central controllers, to meet this split keypool situation is more complex than would be needed if all machines were in a single location.

Other remarks in this section of the report would probably be somewhat clarified if prefaced by a brief summary of the data volume statistics supplied to us by MSFC. These figures were supplied as representing a "typical" week's work.

Building #	Records Per Week	Operator Hrs/Week	Avg. # Records/Day	Avg. # Operator Hrs/Day	# of Keystations Needed*
4471 (Keypunch)	52,359	201	10,472	40.2	7
4471 (Key/Tape)	21,971	92	4,394	18.4	3
4471 (Total)	74,330	293	14,866	58.6	10
4485 (Keypunch)	74,041	396	15,000	79.5	14
TOTAL (4471 4485)	148,371	689	29,866	138.1	24 (approx.)

* Based on 6 working hours/operator/day.

In addition, the following basic observations were made concerning the present data entry system:

(1) There are ten operators in Building 4471 and ten in Building 4485. Also, we were informed that there are four operators in the Computations Lab, Building 4463, which should be included in this study.

(2) Four Honeywell Key-to-Tape stations are being used by the operators in 4471. They are being used to process approximately one-third of the workload of that building.

(3) To insure data accuracy, all work is re-keyed for verification.

(4) An approximation of the operator time wasted due to clerical work involving complicated source documents was set at 20% to 30%.

An information gathering study must not only clarify the existing situation but also attempt to ascertain trends. For this reason, it was of major importance to learn that the volume of data entered and processed has been monotonically increasing for the past few years. In fact, from current projections, estimates are that data entry volume will double by 1979. At some time during this increase, a point will probably be reached at which it will be far more efficient to upgrade the data entry hardware to new technology rather than to simply expand the present system. This will probably entail some type of direct entry procedure. In the meantime, there are logical intermediary steps which can and should be taken.

There exist several reasons to upgrade currently installed data entry hardware. One of them, of course, is the threat of being unable to accommodate an evergrowing data volume. Another reason is roughly the following: The replacement of card keypunches by a more sophisticated electronic data entry system involves much more than simple hardware replacement. The new functions, inherent in more advanced data entry hardware, must be considered. The keypunch pool will no longer be a place where coded forms are dropped off, the data punched onto cards and then dispatched to the Computer Center. Instead of being merely a keypunch shop, it will become a more generalized data preparation center. The implications are that, even with no increase in the data volume, gains from the standpoint of accuracy and efficiency may well make a data entry system change cost effective.

There is another strong reason to upgrade the data entry operations. During the course of a major system change, there will be more people to consider than just the keypunch supervisors and operators with respect to their interacting with and implementing the change. It is vital that the mainframe programmer and everyone else involved with the data handling be familiarized with the new system operation from the very beginning. The supervisor and mainframe programmer should be encouraged to work together on input record layouts. Because the data entry system is capable of reformatting keyed data and performing checks, balancing, editing, etc., programmers will be able to shortcut their programming efforts while also giving the operators a faster and easier way to key input data. Since this entire changeover operation will be lengthy and involve new procedures for many people, there are major advantages to starting implementations very soon. Progress should be planned to be carried out in stages. The recommendations of this report are such that, if carried out, there will be an adequate period between the current card oriented data entry system and a direct entry system which will undoubtedly be economically available in the early 1980's.

As stated above, upgrading a data entry system may well be cost effective even if the present installation is functioning adequately. One approach that would aid in justifying a transition from standard keypunch equipment to a key-to-disk system is by a type of functional analysis. During such an analysis, an attempt is made to isolate any process which may be made more efficient or even eliminated by the proposed system change. For example, there are several obvious areas in MSFC's present DE system that could be identified in a functional analysis.

(1) The problem of source documents which are difficult to keypunch from were alluded to earlier. The only way to solve the influent document problems with the present system is a time-consuming and costly redesign of the documents. However, most key-to-disk systems provide a reformatting option with which the data entry format may be designed to meet the desires of the key operator. After the data has been entered, it may then be reformatted to meet the specifications of the processing program.

(2) Available data entry equipment can provide an array of verification techniques (check digit, cross footing, table lookup) which could allow the elimination of the key verify operation. If one is uneasy about eliminating key verification, both manual and machine verifications can be run in parallel; as confidence increases, redundant keying can be decreased.

(3) Most key-to-disk systems can provide supportive functions such as batching and logging in source documents, preparing batch totals, and monitoring work in progress.

(4) In a typical data entry shop, the personnel turnover rate is as high as 50% yearly, so the training procedures and their costs are worth investigating. Most of the present vendors of key-to-disk equipment provide a five to ten day comprehensive training course initially which has, in most cases, been adequate.

(5) A number of conflicting estimates have been made regarding the cost of correcting an error in data entry as opposed to correcting the error which reaches the mainframe computer.

However, the majority of experts agree that the errors which reach the mainframe will be 10 to 100 times the cost of an error detected within the data entry shop. All of the recent key-to-disk systems offer the ability to edit data. The extent and flexibility of the edit routines vary extensively both within and among vendors. At one end of the scale would be the system that performs only the simple verification type of data checks. These basic checks are performed in the foreground concurrently with the data entry. When an error is located, either a flag is set on this record or the incorrect record is displayed on a CRT screen for immediate correction. At the more sophisticated end of the scale, editing is done in the background mode under the direction of a user-written COBOL-type editing program. This type of routine could approach the extent and sophistication of the current mainframe edits. Clearly, cost savings can be obtained by minimizing mainframe edit programs through one of these types of preprocessor edits performed in the data entry shop.

At this point, a brief summary of a typical data entry system conversion might be helpful.[1] A large manufacturing firm, located in the northeastern part of the U. S., began converting from keypunch machines to key-to-disk equipment in 1971. Altogether, 85 IBM keypunch/verifier devices were replaced by seven Inforex shared processors and 56 keystations. Eight major departments of this company input source data for key-to-disk preparation. A total of 500 data formats are required to serve the needs of

[1]"'Card Crunch,' Noise Impelled Change to Key-to-Disk," A Computer World Special Report, October, 1974.

these departments, which support jobs with cycles varying from daily to annual. After two years of operations, with the key-to-disk equipment processing three million records monthly, the company reported data throughput has improved approximately 22%.

According to the firm's manager of computer operations, system throughput as well as group efficiency and accuracy reports are available without interrupting the work flow. It was also mentioned that the new system allowed the training period to be shortened, with improved accuracy, and greater throughput and less document handling than with keypunching. Operators and supervisors reported that the systems are much quieter, and they found people can key faster and setup times can be minimized. To summarize the results of this particular systems change is a quote from the manager:

> "The daily data entry operations have helped simplify and improve the control of our data input and our expediting function is more efficient and effective. So when we look at a 22% increase in data throughput with the key-to-disk equipment, we are really looking at faster reporting, more precise control, and more efficient short and long-term operations."

The results of the changeover, as given in the above abbreviated case study, were substantiated by visits made to two Knoxville, Tennessee business firms. That is, both firms reported a 20% to 30% throughput increase with fewer stations than in the keypunch system. One of these companies, Knoxville Computing Center, replaced their Univac keypunches with an eighteen station Entrex key-to-disk system. At the time of our visit, three of the stations were remote, being located in various businesses in East Tennessee. The data entry supervisor informed us that there had been a 20% increase in productivity which resulted in reducing the operator staff by three.

Before presenting the overview of existing approaches to data entry, it should be emphasized that all recommendations contained in this report pertain to the central keypunch pools. The keypunch machines that are scattered about in the various departments for use primarily by the professional programmer staff and many others who do much of their own programming, form a unique and vital function that, at present, should remain as is.

III. Survey of Existing Approaches to Data Entry

In the first stages of this research project, the central problem to be answered concerned the determination of the appropriate category of data entry device for MSFC. The device types from which this selection was made consisted of:

(1) Card punches and verifiers

(2) Keyboard to paper tape devices

(3) MICR readers

(4) Mark readers

(5) Optical character recognition (OCR) devices

(6) Industrial data collection devices

(7) Point of sale (POS) devices

(8) Voice response systems

(9) Interactive remote terminals

(10) Keyboard to tape/disk devices

Clearly, without drastically changing the overall data processing environment at MSFC, the only truly applicable categories are (1), (5), (9) and (10). Each of these possible selections will be briefly discussed.

Certainly the most common form of data entry device in use today is still the keypunch machine that produces the 80-column punched card. At this time, it would not be wholly accurate to dismiss the punched card as obsolete. There are still many data entry environments for which the keypunch is a wise choice. The following characteristics of such an environment would seem to favor keypunches; (1) need for only a small number of stations; (2) need for a relatively small number of program formats, say no more than about 10; (3) ability to work effectively with 80-character records; (4) availability of strong editing in the central computer; (5) acceptability of subsequent discovery of errors by the central computer rather than early discovery in the data entry process; (6) absence of a need for rapid and systematic search of the recorded data records; (7) absence of a need for immediate print-outs; (8) absence of any outstanding personnel disciplinary problems.

Upon careful reflection, it seems that the MSFC data entry situation is on the "borderline" in terms of several of the above characteristics. In particular, characteristics (1), (2), and (3) are very rapidly becoming obsolete in terms of adequately describing MSFC's operation. Most of the other statements above will indicate some change away from keypunches within the near future due to the data volume increase referred to earlier in this report. It appears that the answer to whether an installation that is coping at present with a keypunch shop should make a hardware change would best be answered with a word of caution. Future growth and future proliferation of job complexity should be carefully assessed before deciding upon the punched card medium.

Optical character Recognition (OCR) Devices read printed or handwritten alphanumeric information from special-size documents, journal tapes and standard pages. The information is then either recorded on magnetic tape (off-line mode) or transferred directly into a computer system for processing (on-line mode). Such devices have been in use since the early 1960's, yet only about 2,000 computer installations currently use OCR equipment. In many application areas, such as retail merchandising operations, utility bill processing, and any other application involving a turnaround document originally prepared by the computer's high-speed printer, the OCR can be a highly suitable device for direct data entry. The data read by such devices is also legible by humans.

The use of OCR equipment, although very attractive in terms of optimizing data entry throughput, is not at present recommended to MSFC for several reasons:

(1) The initial change in source documents would be comprehensive, time-consuming, and costly.

(2) The type fonts that can be read by most units have been limited to a few highly stylized fonts.

(3) Reliability with OCR equipment has not always been satisfactory, often resulting in high reject rates.

(4) Compared to other new data entry equipment, the cost is relatively high.

However, it should definitely be kept in mind that given present efforts by OCR manufacturers, the criticisms (2), (3), and (4) above could be corrected within the next few years. At this time, if for no other reason than cost, the data volume at MSFC does not seem to justify scanning. The state of the art in data entry has just not reached this attempt by OCR developers to eliminate one more human interface.

The concept of the interactive remote terminal as a data entry device involves four distinct system elements:

(1) A keyboard, located at some distance from a central computer system, for entering alphanumeric data.

(2) A data communications network to transmit this data between the remotely located terminal and the central computer.

(3) A central computer to receive, preprocess, and store (usually on disk files) the data entered from many remote locations.

(4) A typewriter or CRT display screen at the remote location to receive responses and directions as output from the central computer.

Thus, the interactive remote terminal is an on-line input/output device designed for the two-way transmission of data with a central computer.

In terms of MSFC's application, the interactive remote terminal would be used as a keyboard data entry device, with the Univac 1108 performing control, editing, verifying, and storing functions, in addition to acknowledging that the data has been successfully entered. This possible system was discussed at great length during the May 12th visit to MSFC by two UTCC researchers. The discussion was prompted when Mr. John Kearney of MSFC discussed the possibility of the gradual movement of data entry back to those areas that are creating the source data. Several problems inherent in the use of interactive remote terminals came to the surface during this discussion.

One of the first problems which was identified was simply the general feeling that, in a certain sense, it is "safer" to have the data keying operating physically separate from the 1108 system itself. One of the MSFC representatives said that he felt uneasy about having key operators working interactively with files on the 1108. Perhaps the best explanation for this expressed uneasy feeling is couched in the basic nature of interactive terminals themselves. That is, the interactive remote terminal can not only enter data, but can also receive immediately, or in "real time," the computer's response in the form of meaningful output data. This inquiry and response usage can be used in any application requiring an immediate response to a "status" query, such as in inventory control, credit, and reservations systems. Such usage, since it involves applicational processing of the entered data, together with an output data response, represents more than a pure data entry system. It involves online data entry plus real-time processing.

If, and when, the initial processes of the data entry procedures at MSFC begin to shift toward the origin of the data, there will commence to exist a real possibility that interactive remote terminals connected to the 1108 mainframe will become an important alternative. That is, if data is entered at the source by people knowledgeable concerning the content of the information, then there would exist a condition whereby users could interact with the data files on the 1108 with advantage. To achieve this situation would require extensive restructuring of MSFC's data entry environment. A central pool containing twenty or so key operators would have to be converted to "information analysts" located at the various origins of source data.

Another more obvious problem to consider with online interactive terminals is "down" time on the 1108. A member of the systems group pointed out that the 1108 goes down one time in every 15 hours on the average (these down times are typically very short - just long enough to get a dump). Although this figure is quite acceptable for a mainframe, data gathered by UTCC on key-to-disk systems indicates much less down time than this due to both fewer "crashes" and less service time required before the key-to-disk system is back up. Thus, one major detrimental factor in using online interactive terminals for data entry is the potentially disastrous situation of twenty idle key operators and ever mounting data during mainframe down time. It might be noted here that future mainframes with greater reliability will decrease the importance of this factor.

The existing facts concerning interactive terminals in relation to the present environment at MSFC tends to indicate that for the near future some other system more similar to existing procedures would be best. Just as with the OCR equipment, it should not be ruled out that in terms of long range plans, a gradual movement towards an environment in which data is captured at the source by knowledgeable "information analysts" might be advantageous. But at least for the rest of this decade, it seems to be the consensus of the research group at UTCC that the system type to be discussed next would best optimize the present DE system with the least disruption in the work flow.

The key-to-disk systems available today have a common minicomputer processor and disk storage facility shared among several keystations. Nearly always, the primary output of such a system is industry - compatible 7 - or 9-track magnetic tape with recorded densities ranging from 200 to 1,600 bpi. The tapes are written from data records stored on the common disk pack drive, which serves as an intermediate storage medium. Data records on the disk can also be transmitted directly to the central computer over a communications line, the use of this form of output is increasing.

Key-to-disk configurations have no universal set of configuration rules, but a typical installation might consist of: (1) at least four keystations utilizing either a CRT or panel display; (2) a supervisory station which may be a teletypewriter, a special console, or even a standard keystation that is converted to supervisory use by keying in a special pass code; (3) one or more shared disk drives; (4) one or more tape drives; and (5) quite often a line printer. The common denominator of this class of systems, however, is the subjection of all system operations, especially formatting and manipulation of keyed data, to processor control.

The central processor normally exercises program control at three different levels. One is control over system operations and functions; these are managed by a body of executive programs. They include utilities that operate the various system components, such as the CRT displays, functioning of the keyboard, multiplexing of the keystations to the shared components, operation of the peripheral devices, etc. A second level of programming formats, edits, and performs tests on incoming data as it is being keyed. Many keying errors and discrepancies in the data are discovered at this time. Programs responsible for such functions are often said to be in the foreground partition. The third software control level performs operations upon data records already stored in the disk pack. End-of-batch balancing is an outstanding example of an editing check that can be applied at this time. Programs of this class are often said to be in the background partition.

Format programs generally reside in disk storage and are placed in the main processor memory as summoned by the keystation operator. Any particular format can be accessed and used by any number of operators concurrently. Often, a string of format programs is associated with a particular job or batch, and the system automatically links or chains each successive format upon completion of a preceding record. The number of such levels ranges from four up to thirty or more for different systems. This feature allows the operator to key source material continuously without any concern for the appropriate format.

Format programs can be specified in great detail and with considerable latitude. There is no difficulty about defining alpha fields, numeric fields, must-enter fields, duplication fields, skip fields, must-fill fields, and right-and-left-justified fields. Fields can also be specified "must verify." Such fields will be recalled from the disk pack during verification, but other fields will be passed over. In addition, range checking, table lookups, zero balancing, and crossfooting are available on many systems. It has been found that with the proper use of a combination of the above validation and edit checks, there becomes a reduced need for formal verification. That is why, in the more advanced systems, the occasional critical field that must be verified is specially designated in the format program.

As touched upon earlier, there exists one function of most key-to-disk systems that may be particularly applicable at MSFC. This is the reformatting capability. Reformatting allows the operators to key data from source documents in exactly the same order as presented, and then restructures entered data into computer-acceptable format on tape under user-defined and disk-stored program controls. Reformatting may also "explode" packed records into desired record length as they are written to tape. MSFC's problem of "difficult-to-punch from" source documents could be greatly alleviated by this reformatting. MSFC's keypunch supervisor's estimate of 20% to 30% wasted time due to complicated documents indicates that the use of reformatting might result in a productivity increase somewhat greater than the typically reported increase of approximately 20% when a conversion from keypunches to key-to-disk is performed.

The supervisor directs and monitors the operation of the entire system. Through the supervisory keyboard, communication is maintained with all system components. Supervisory duties include assigning job and batch numbers, distributing tasks to the operators, designing new format programs, writing data records to magnetic tapes, calling for system printout, and others. Also, the supervisor can request operator statistics. These statistics typically consist of operator identification, batch identification, operator start and stop times, number of keyed records, number of source document errors that had been bypassed, number of operator keystrokes, and the operational mode of activity. Users report high acceptance of the statistics by keystation operators, as they evidently feel that the impersonal nature of these statistics protects them from any personal bias on the part of the supervisor.

Mention should be given to the recent trend toward editor languages. These languages which are usually simplified versions of COBOL, RPG, or BASIC, give users the capability to modify the system programming without vendor assistance in accordance with their own special editing and validation needs. Exactly what editing procedures are needed would have to be determined. Then the capabilities of prospective systems would be compared with the users' needs, along with cost considerations and provisions for future upgrades.

IV. Summary Descriptions and Recommended Systems

Drawing from the preceding discussion of several existing approaches to data entry, the recommended appropriate alternative for MSFC, at least for the rest of this decade, is to install a member of the key-to-disk family. With this conclusion in mind, UTCC began the task of collecting data on the many different key-to-disk products. The objective was to identify several systems which satisfied tha following condition: (1) ability to meet MSFC's present needs; (2) ability to easily expand as MSFC's data volume grows; and (3) ability to perform data validation tasks (i.e., something beyond direct emulation of the card punch functions).

Given the decision that key-to-disk is the most viable alternative, the next step is to determine the appropriate level of sophistication for the recommended system. Complexity of key-to-disk operations range from a simple card punch emulation to "full blown" maxi-edit data entry, validation, and verification techniques. Based on discussions with various members of MSFC's programming staff, the key-to-disk systems recommended will possess a level of data editing capability that should allow the operator to "clean-up" those errors she is most able to correct or flag errors she is not sure how to correct. The specific editing capabilities are discussed in the system summaries which follow. For more specific hardware and software capabilities, refer to the tables in the Appendix of this report. In addition, if further information is required concerning the many available options, consult the material supplied by the manufacturer that has been submitted with this report.

(1) The Computer Machinery Corporation has recommended two (2) CMC-5 Key Processing Systems. This proposed duplexed CMC-5 System configuration is presented in the following table:

CMC-5 Key Processing System

Model and Description	Quantity	Lease Price
CMC-5; system programs, teleprinter, supervisory console, system controller, CMC 271 Disk Unit, CMC 231 Magnetic Tape Unit	2	$1,197
CMC 103 Keystations	24	1,865
CMC 118 Keystation desks	24	202
CMC 923 Multiple Format Groups	2	105
CMC 912 Reformatting	2	105
CMC 924 Data Validation	2	260
CMC 723 Extended Performance Module	2	158
TOTAL	58	$3,892

* Based on a 1-year lease.

The basic CMC-5 system includes from one to sixteen keystations; a supervisory console housing a small (8K) general-purpose computer, magnetic disk unit and magnetic tape unit, and a freestanding teleprinter. This basic configuration can be expanded to include a 132-column line printer for high-speed printouts of batch and tape listings and supervisory reports. Also, a TeleBatch data communications system can be added to enable a remote CMC-5 system to communicate with another Key Processing system or with a mainframe computer.

The CMS 103 keystation is a desk-top CRT display unit with detached keyboard. The unit displays 128 characters arranged in four lines of 32 characters each. Of the 128 displayable characters, 16 are constantly in use to display the following: column number, field number, operating mode (read, write, verify, program entry or program select), record format level, auto skip/dup on or off, auto-balance status, and text messages indicating current record number or conditions such as verify miscompare, rewrite, backspace verify and batch limit. The keyboard layout is similar to that of the IBM 64-character 29 Card Punch, except that control keys are used in place of switches. Keystations may be up to 1,000 feet from the controller.

As the heart of each Key Processing system, the supervisory console houses the system minicomputer, the system disk drive, various control circuits, the supervisory control panel, and a magnetic tape drive. Adjacent to this console is the supervisory printer (a Teletype Model 33 ASR). It consists of a keyboard, printer, paper tape punch, and tape reader mounted in a free-standing floor console. The teleprinter is used to enter commands to the system and to print status reports.

The central processor used in the CMC-5 system is a modified DEC PDP-8. The computer operates in a partitioned environment. Input data is processed in real time in the foreground partition. Lower priority tasks, such as listing reports on the teleprinter and transfer of records from disk to tape are performed in the background. Controllers for operating the tape and disk drives must interface the processor. The processor has a 1.2 microsecond cycle time, a 12-bit word length, and 8K words of core memory.

A CMC 271 magnetic disk unit in the lower drawer of the supervisory console stores the system programs, files, and libraries, and serves as temporary storage for batch data. As keyed data is received from the computer, the system allocates storage area automatically and dynamically, track by track, on an as-needed basis. This data is recorded on both surfaces of an IBM 2315-type removable disk cartridge. Storage capacity is 18,000, 112-character records and 100 record formats. This library capacity can be increased to 480 main/alternate (single) formats. In addition, multiple format groups, each with up to eight format levels, can be defined. An indicator on the supervisory control panel signals when 75% of the available capacity has been filled. A system interlock automatically inhibits further keying, without loss of data, when storage consumption exceeds 99.9%.

Completed batches of data are transferred from the disk to a magnetic tape unit in the upper drawer of the supervisory console. The tape unit can also be used to read input files to disk for subsequent updating. The CMC-5 system accommodates any one of five models of tape units so that users have a choice of tracks, densities, speeds and reel sizes. These include 7-track units with densities of 556/800 bpi and 9-track units with densities of 800 and 1,600 bpi. Read/write speeds range from 12½ to 25 ips.

All data entered into Key Processing systems is under format control. Format control defines each field by length and by type of content as it structures multilevel format groups. It also specifies fields to be automatically skipped, duplicated or right justified. Formats can be entered into the format library via a keystation or the teleprinter. Operating modes are: (1) write, (2) verify, (3) correction - enables operator to insert a new character or field at the indicated (i.e. flagged) position, (4) search - batches can be searched by record identifier or by key identifier field contact, (5) Batch Append/Record Insert - enables records to be added at the end of or inserted within the batch, (6) display - used to view the desired data, and (7) format entry.

To verify data, two different keystations may enter and verify the same batch concurrently. The write operator must stay at least one record ahead of the verify operator. An interlock prevents the write operator from interfering with the record being verified. A verify operator need correct only the erroneous data, not the entire record. Other automatic data verification and validation functions provided by the CMC-5 system are auto-balancing, check digit, crossfooting, balancing, totaling, field qualification, and value and range checking.* The first two of these checks are performed as the data is entered, while the rest are performed after a batch is closed but before it is transferred to tape. Records are retrieved from disk during data validation and processed according to the test sequence. Results of the tests are printed out by the teleprinter or a line printer. Flags are inserted in records found to be in error to allow easy retrieval and correction by the verify operator.

CMC's TeleBatch software supports data communications between two CMC-5's or between a CMC-5 and a mainframe computer. The CMC-5 is equipped

* Refer to vendor-supplied material submitted with this report for definitions of editing terms.

with a Binary Synchronous Communications Controller. TeleBatch emulates the IBM 2780 Data Transmission Terminal, uses EBCDIC, and observes BSC protocol. Data can be communicated over the dial-up switched network or dedicated lines at rates from 1,800 to 4,800 baud. An optional feature boosts the transfer rate to 19,200 baud. The user must furnish modems for all communications line interfaces, as well as hardware and software for any telecommunications functions performed by the mainframe operator.

A high-speed line printer may be added to the CMC-5 system. It can drive either an 80-column printer, the CMC 761, or a 132-column printer, the CMC 762. They can be used concurrently with keying operations. Rated speeds are 356 lines per minute for the CMC 761 and 245 lines per minute for the CMC 762.

(2) The <u>Data 100 Corporation</u> has recommended the following Keybatch III configuration:

Keybatch III

Model	Description	Quantity	Lease Price
74-104	Terminal Control Unit	3	$ 741
4521	Keybatch Expansion Chasis	3	663
4772	Keystation	24	1,224
4779	Keystation Tables	24	240
74-202	Magnetic Tape Unit	3	618
4120	Mag Tape Adaptor	3	231
74-502	Disk Unit	3	720
4150	Disk Adaptor	3	129
4543	Compare and Branch	3	135
4544	Output Reformatting	3	135
TOTAL			$4,836*

* Based on a 1-year lease.

The Keybatch III system includes from one to nine keystations, a Model 74 (32K) controller, a magnetic tape unit, and a magnetic disk unit. This system is somewhat different in origin than the other system in that it was developed from Data 100's family of remote batch entry stations. As a result, Keybatch III is a Model 74 terminal that can operate either as a data entry system or a remote batch terminal, but not both concurrently.

The keystation is a keyboard/display unit with a 9-inch (diagonal measurement) screen; a work table is available as an option. The unit displays any of 64 EBCDIC - compatible characters arranged in 8 lines of 32 characters each, totaling 256 characters. The keyboard is available in keypunch or typewriter style. The keystation operates locally within 1,000 feet of the controller and may have remote operation over a communications facility.

Supervisory functions, performed from a keystation, include the access or transfer of information directories; the entry, alteration, or transfer of user-written record formats; the request of status reports on the system, operator, or batch; the transfer of disk-resident job batches to magnetic tape or the communications line; and the deletion of a data batch from the system. The supervisor can also initiate system save/restore functions with respect to data batches or record formats and can perform utility functions such as systems recovery for power failure.

The Model 74 terminal controller is the control element of the Keybatch III system. This general-purpose programmed controller is a variable-length instruction, byte-oriented controller that contains the memory, register, and internal logic units required for terminal control program execution. The memory capacity is 32,768 words of storage. In addition, the controller contains a direct memory access channel that provides a separate path directly to memory, a byte I/O channel that can accommodate a variety of peripheral equipment, and operator control panels that provide for operator control of the terminal operations.

The cartridge disk drive (supplied by Wange) is a free-standing unit consisting of a top-loaded removable disk cartridge, a fixed disk, and an integral controller and is available with a storage capacity of 2.5 or 5.0 million bytes. The data transfer rate is 312,500 bytes/second.

Keybatch provides five operating modes: Entry, Re-entry, Verify, Search, and Audit. The Entry mode permits the operator to open and create new batches, while the Re-entry mode permits entry into an existing batch to add to or alter its contents. Verify permits key verification of existing records residing on disks. Search finds records by record number or identify key. The Audit mode permits records to be examined that are flagged during entry.

Keybatch organizes data into field lengths of up to 99 characters, keyed record lengths of up to 128 characters, and output record lengths of up to 256 characters. Data entry and validation are performed under the control of input and table format, respectively. The transfer of disk-resident data to magnetic tape (or printer) or communications facility is performed under control of output formatting. Auxiliary input formats control the entry of batch and table data from punched cards, magnetic tape, or a communications line. The Keybatch system can accommodate as many as 999 record formats for each of the four format categories - an aggregate of 3,996 formats. Any of up to 99 different formats within each category can be manually or automatically linked.

Additional software includes Extended Editing, Compare and Branch, and Output Reformatting. The Extended Editing feature provides 14-digit accumulation for arithmetic computations such as batch balancing, cross-footing, and logical testing; arithmetic functions include addition, subtraction, multiplication, and division. This feature also permits editing, clearing, or incrementing the contents of an accumulation; preparing and using tables of legal or illegal values or range sets for data validation; table look-up operations in which table values can be retrieved and automatically entered into a data record; and check-digit calculation for verification. The Compare and Branch feature (used in conjunction with the Extended feature) permits positive or negative branching to another field in a format, depending on the condition of one of the 26 available indicators or 15 accumulators. The Output Reformatting feature permits user-written auxiliary input formats for entering data recorded on punched cards, magnetic tape, or received from a communications line to create new data batches.

Keybatch III may communicate with the 1108, but then data entry and data transmission to the host computer are non-concurrent. However, Keybatch III may be upgraded to Keybatch II with the addition of a Model 78 terminal control unit and this system does enable simultaneous data entry and transmission. Keybatch also supports the standard peripherals for the Model 74 terminal. These include a 300 or 4-0 line/minute, 80-, 120- or 132-column printer and a 300 or 450 card/minute card reader.

(3) Entrex, Inc. has recommended the Entrex System 480 for MSFC's current operation. A possible configuration follows:

Entrex System 480

Model	Description	Quantity	Lease Price
4011	Control Group CPU to 64K bytes Disk Drive 2.4 MB Tape Drive	1	$1,197
111	Data Scopes 029	24	2,184
410	Operator Analysis	1	N/C
TOTAL			$3,381*

*Based on a 1-year lease, GSA approved, so must add approximately 10% to make equivalent comparisons to other companies.

System 480 includes a minicomputer (65k bytes), one to four cartridge disk drives, one to four magnetic tape drives, and up to 32 Data Scope keystations. The central control group, consisting of a processor, one disk drive, and one tape drive is contained in a single cabinet. Each additional tape drive is contained in a separate cabinet, which can also accommodate one or two additional disk drives.

Each keystation is a CRT display unit that contains a typewriter - or keypunch-style (IBM 29 format) keyboard. Both keyboards include 17 function keys for system-designated functions. The typewriter-style keyboard also includes a 10-key numeric pad to the right of the main keygroup. The keyboards can generate any of 64 characters. Typewriter and keypunch-style keyboards can be mixed on System 480. Keystations display up to 480 characters arranged in 12 lines of 40 characters each. The top line of the display is reserved for system status, while the second line is reserved for error messages. Each keystation can be located up to 1,000 feet from the central control group. Remote keystations can be added via a communications option.

Any number of keystations can simultaneously serve as supervisory stations. A keystation is converted to a supervisory role by keying a confidential pass-code, thus preventing access to supervisory functions by unauthorized personnel. Supervisory functions include: (1) managing disk-resident record batches, (2) conducting input and output batch operations, (3) conducting utility operations, (4) maintaining system libraries, and (5) conducting system operations.

The central processor is similar to the Data General Nova, with a 1.2-microsecond cycle time and a 16-bit word length. The maximum main storage capacity is 65k bytes for System 480. Power failure detection and automatic restart features are included.

The disk drive is a Diablo System Model 31. This is a single-disk unit that utilizes both disk surfaces and provides 2.4 million bytes of storage. Additional modules of disk storage may be configured for a maximum of 9.6 million bytes of intermediate storage. Model 31 has fixed read/write heads that retract automatically upon power failure. Disk space is assigned dynamically; that is, requests for space are queued so that data records can be located optimally on the disks.

The magnetic tape drives for the System 480 are made by Pertic or Wangco; these units write formatted, validated data on 0.5 inch IBM compatible 7- or 9- track tape. The density of the 7-track tape is 556 and/or 800 bpi; parity can be odd or even. For 9-track tape, the density is 800 and/or 1,600 bpi with odd parity. Reading and writing occur at 25 ips.

System operation is controlled by a comprehensive set of integrated programs and routines designed to facilitate all operator and supervisor functions. Data entry and verification operations are controlled by input formats which contain programmed editing functions and validity checks. Editing functions, performed automatically as data is keyed, combine conventional keypunch functions such as field duplicate and skip with more sophisticated functions such as the mandatory entry of data into a field and the mandatory completion of a field.

A comprehensive set of validity checking features helps to insure the accuracy of keyed data. Besides alphabetic and numeric-only field restrictions, these include range checking, check digit generation and checking, value table checking, ascendance checking, and batch balancing. Two parameter-driven check digit algorithms are supplied with the standard software; up to 15 different algorithms can be implemented and active simultaneously. Validation checking can also be performed on data entered from a communication facility or other input media. In addition, Entrex provides a COBOL-like language, called Editor, that gives users the capability to generate application programs for the manipulation and formatted output of data. The full language is standard with System 480.

Entrex System 480 has five operating modes:

(1) Data Entry - Data is keyed into the system under control of an input record format that defines fields and specific editing and validity checks to be applied. Keying errors are corrected or flagged for later correction as they occur. It should be noted that on this system the input record size is unlimited.

(2) Data Verification - In typical operations, key verification is conditionally performed on fields that contain operator-corrected errors or that are found to be out of balance as

the result of a zero balancing operation. Scan verification, the visual verification of fields, is often satisfactory for fields that have been validated.

(3) Data Validation - Editing and validation checks are applied to data read from input media or received from the communication facility.

(4) Data Examination - Allows the operator to access an identified disk-resident batch and display each record in either a forward or backward direction.

(5) Data Updating - Periodic batch updating can be performed in this mode.

Communications from a remote keystation to the Entrex 480 Controller is asynchronous in the half-duplex mode at 1200 byte/second. Each remote keystation adapter includes an Entrex-supplied modem. Also, the Entrex system may communicate with a mainframe host computer and is 2780/3780 compatible, transmitting from 2000-9600 baud. A Data Access Arrangement (DAA) is required between the Entrex system and a modem produced by a non-Bell manufacturer. Finally, System 480 may be field expanded to System 580 featuring disk capacity to 29MB, ISAM capabilities and selective tape input. The 480 may also be field expanded through the use of optional features such as a 300 LPM line printer and additional tape and disk drives.

(4) The description to be made next of the <u>Inforex System</u> necessitates a preliminary comment. The profile of a typical Inforex user differs somewhat from that of adherents to other key-to-disk systems. Mainly, the Inforex user wants his data entry system to perform appreciably less editing and validation than managers of large systems prefer, and he is satisfied

with basic reformatting prior to writing to tape or none at all. In fact, the Inforex user prefers to leave most editing and error detection to mainframe programs instead of to the minicomputer processor. For this reason, the system initially proposed by Inforex, two Inforex 1302 systems, is not directly comparable to the other manufacturers presented. In particular, the CMC-5 system would need to have the Reformatting Data Validation, and Extended Performance Module options deleted; and the Entrex 480 system would need to be degraded to their 280 system before valid cost comparisons could be made with Inforex. In the case of Data 100, even the removal of Compare and Branch and Output Reformatting would leave it at a more sophisticated software level than the proposed Inforex 1302 system. Therefore, while stating quite clearly that Inforex recommended a 1302 system, UTCC felt that to accurately compare costs, all proposed system should represent approximately the same level of complexity. As a result, the system description below will be of an Inforex 1303-II.[2]

Inforex 1303-II

Model	Description	Quantity	Lease Price
1303-2	Control Unit: Processor, disk drive and tape drive	2	$1,740
2901	Keystations	24	1,560
	Reformatting	2	80
	Expanded Tape Processing	2	80
	Blocking	2	80
	TOTAL		$3,540*

* Based on a 1-year lease.

[2]It should be noted that slight changes in proposed system designs were also made to the other manufacturers to facilitate inter-manufacturer comparisons. MSFC may wish to refer directly to the original proposals supplied with this report.

The Inforex Key Entry System consists of a control unit (24k bytes) and from one to sixteen CRT keystations. The control unit houses a processor, disk drive, and tape drive. The 1303-II employs a new vertical packaging with the processor control panel mounted above the tape drive.

The 2901 keystation consists of a desk with keyboard and CRT display. The keyboard layout is the same as that of the IBM 64-character 29 Card Punch, with a few additional keys. A 48-character subset can be switch-selected. A CRT screen that displays 128 characters in 4 lines of 32 characters each is situated behind the keyboard. The last three positions on the bottom line give the column count. When an error or system message must be presented, the screen goes blank, the error light on the keyboard flashes, and the keyboard locks electronically. Then the message appears. The maximum distance between keystation and controller is generally accepted to be 1,000 feet. However, using a line amplifier, it is possible to string control unit to keystation distances of 2,000 feet.

The typical designation of a particular station as the supervisor's station is not as formal as in the other key-to-disk systems. The supervisor can do her work from any station without the use of a password. The duties of the supervisor are essentially the same as those for other systems. Some of these duties are: the transfer of records to tape by identifying the job and the batches to be transferred; maintenance of system format libraries; when using an Inforex "linked" system, the supervisor can initiate data transfer from any disk unit or tape drive from one system to a tape or disk unit of a linked system; accessing the library containing operator statistics; and, if applicable, initiation and control of the communication process.

The control processor contains 24k bytes of read/write core memory. The processor is designed to permit overlapped jobs. Keystation to memory, memory to disk, and disk to tape operations can all proceed concurrently. Communications and disk-to-tape transfers, however, are mutually exclusive, but communications and printing can proceed with the other tasks mentioned. The processor includes a power-failure interrupt and recovery routine to allow convenient restarts in case of power failure. The larger memory of the 1303, as compared with the 1301/1302, provides space for holding multiple user programs (formats) resident in core, thus providing greater processor performance than the 1301/1302, which move the formats between disk and core for each data character entered.

The standard system disk drive incorporates both fixed-head and moving-head read/write assemblies. The fixed-head portion holds the variable program routines and information, while the moving-head portion holds the data records. The data portion of the disk holds about 16,000 125-character records. This capacity is adequate to hold about a half to a full day's output with a maximum configuration, depending on the amount of duplication, skipping, and spacing out through reformatting. To avoid the tendency to overload the disk when short records are stored, the system utilizes a packing technique. Two 60-character records can be fitted into the space nominally allotted for a 125-character record, or four 30-character records can be inserted into the same space. The reformatting feature can later reassemble these short records into longer ones and rearrange the field sequences if desired.

The 1303-II tape drive has a read/write speed of 45 ips. It is available in one of two formats: 9-track, 800 bpi or 9-track, 1600 bpi (extra cost). This tape drive accommodates 2400-foot reels.

Normally, as the operator keys in data, it is displayed on the CRT and transferred to a buffer in the memory section of the control unit. When the record is released, data is transferred from the memory buffer to the disk. On command from the keystation, data in batch form is transferred from the disk to magnetic tape. Control of data being keyed is by the conventional approach of defining a control format that identifies fields, and automatic operations such as skipping or duplicating, and any restrictions such as alphabetic or numeric only.

The flow of records within a system is controlled by job name and batch number. For each job, there can be up to eight program or format levels. These eight formats can be cascaded, or chained, automatically. Because the last three character positions are used for chaining instructions, the maximum record length is 976 characters. A batch number is assigned to the output from each keystation. A group of records belonging to the same batch are stored as a unit on disk.

The Inforex 1303-II offers the following editing features: table lookups, range checking, crossfooting, field boundary, balance totals, check digits, verification specified by field, must enter fields, must complete fields, left zero fill, and must fill fields. Other software features include operator statistics, reformatting, tape update, selective to disk, and tape validate procedures.

With the 1303-II either of two communications capabilities can be incorporated. These are the On-Line (called Binary Synchronous Communications or BSC) and the Off-Line (also called Infosync). The BSC feature allows the Inforex system to emulate on IBM 2780 under HASP or STAM as a remote job entry terminal or remote tape drive. The print and card punch functions of an IBM 2780 are not supported. Transmission for both communication methods is synchronous, half-duplex at 300 to 9600 bits/ second as determined by the attached modem. Infosync is intended for communications between two Inforex systems.

Upgrading the 1303-II to the Inforex 3300 series requires a modification to existing keystations or installation of new keystations as well as a change-out of control units.

The following table will serve as a concise means to compare cost across manufacturers as MSFC's data entry system expands.

Monthly Cost Per Keystation*

	Number of Keystations									
Company/Model	9	16	18	24	27	32	36	45	48	64
CMC/CMC-5	188	143	188	163	154	143	163	147	143	143
Data 100/ Keybatch III	186	202	186	202	186	202	186	186	202	202
Entrex/ System 480***	250	185	176	157	151	143	176	161	157	143
Inforex/ 1303-II	175	127	175	148	139	127	148	131	127	127

* Cost per keystation = [(# of keystations) (rental rate) + (# of controllers or central control groups) (rental rate) + (# of peripherals) (rental rate) + (software option) (rental rate)] / total # of keystations

***10% adjustment for GSA made on Entrex system

Several relevant facts should be considered while viewing the above table:

(1) The fact that Inforex is consistently lowest in price should

be tempered with the knowledge that its data validation and editing capabilities are not as extensive as the other systems.

(2) The CMC-5 system could easily be reduced to about the same cost of the Inforex 1303-II if the CMC Data Validation option is removed from the proposed system. This would still leave the CMC-5 system with similar editing capabilities to the 1303-II.

(3) The Entrex 480 system has both the most extensive editing capabilities, and it is able to support by far the most keystations.

(4) The Data 100 Keybatch III is the only system offering a Exec 8/Exec 11 feature for communicating with the Univac 1108. The other systems adhere to IBM BSC's standards emulating a 2780.

For additional information in comparing the systems, refer to the tables of the appendix of this report.

With these monthly costs per keystation in mind, it is possible to cost-justify the purchase of a key-to-disk system in the following manner. MSFC informed UTCC that the monthly salary of a key operator, including fringe benefits, is approximately $580.00. Now, as mentioned previously, the information discovered in our research indicates that a cardpunch shop, upon conversion to a key-to-disk system, can expect a minimum increase in efficiency of 20%. From these figures, one can compare savings realized due to the resulting 20% decrease in staff with the average cost of the required key-to-disk system. This is done in the following table:

Cost-Justifying Purchase of Key-to-Disk System

No. of Operators Needed (Cardpunch)	No. of Operators Needed (key-to-disk)	Savings Realized Per Month	Approximate Systems Cost Per Month			
			CMC/ CMC-5	Data 100/ Keybatch III	Entrex/ System 480	Inforex/ 1303-II
11	9	$ 1,160	$ 1,692	$ 1,674	$ 2,250	$ 1,575
20	16	2,320	2,288	3,232	2,960	2,032
22	18	2,320	3,384	3,348	3,168	3,150
30	24	3,480	3,912	4,848	3,768	3,552
33	27	3,480	4,158	5,022	4,077	3,753
40	32	4,640	4,576	6,464	4,576	4,064
45	36	5,220	5,868	6,696	6,336	5,328
56	45	6,380	6,615	8,370	7,245	5,895
60	48	6,960	6,864	9,696	7,536	6,096
80	64	9,280	9,152	12,928	9,152	8,128

From the previous table, it can be seen that when only considering the 20% reduction in operator staff that one can expect when converting to key-to-disk, it is possible to cost justify for certain size data entry operations the purchase of this new equipment. Other considerations such as: (1) reduction in expenditures on punch cards; (2) less storage space required due to use of tapes instead of cards; and (3) fewer cycles of data between main computer and keying area due to the validation and editing techniques of key-to-disk systems would also contribute to savings with the key-to-disk system. For example, at present, MSFC produces about 120,000 punched cards per week (not including cards that must be repunched due to keying errors). At $2.00 per 1,000, this cost alone is $960.00 per month. It must be considered that the 120,000 cards/week figure is based on 20 operators. Assuming a linear relationship between number of key operators and number of cards produced, we can adjust the "Savings Realized" column of the previous table to reflect the additional savings due to reduced card cost. The following table is the result.

Cost-Justifying Purchase of Key-to-Disk System (Card Cost Included)

No. of Operators Needed (Cardpunch)	No. of Operators Needed (key-to-disk)	Savings Realized Per Month	Approximate Systems Cost Per Month			
			CMC/ CMC-5	Data 100/ Keybatch III	Entrex/ System 480	Inforex/ 1303-II
11	9	$ 1,688	$ 1,692	$ 1,674	$ 2,250	$ 1,575
20	16	3,280	2,288	3,232	2,960	2,032
22	18	3,376	3,384	3,348	3,168	3,150
30	24	4,920	3,912	4,848	3,768	3,552
33	27	5,064	4,158	5,022	4,077	3,753
40	32	6,560	4,576	6,464	4,576	4,064
45	36	7,380	5,868	6,696	6,336	5,328
56	45	9,068	6,615	8,370	7,245	5,895
60	48	9,840	6,864	9,696	7,536	6,096
80	64	13,120	9,152	12,928	9,152	8,128

This table clearly indicates the ability to cost justify the purchase of a key-to-disk system by MSFC on the predicted savings in personnel and cards alone.

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anies/ del	Maximum No. Of Active Keystations Per System	Core Memory of Controller	Disk Capacity	Tape Specifications	High Speed Printer	Keyboard	Display	Communications	Max. Distance From Local Keystation To Controller
5	16	12K bytes	2.2 million bits 18,000 112 char. records	7 trk at 556 or 800 bpi; 9 track at 800 or 1600 pbi	yes	Keypunch	4 lines of 32 chars.	CMC-5 to CMCS; IBM BSC, emulates 2780 for mainframe communications	1,000 feet
100/ atch	9	32K bytes	5.0 million bytes 38,200 80 char. records	9 trk at 800 bpi or 1600 bpi	yes,	Keypunch or Typewriter	8 lines of 32 chars.	uses Exec II/Exec 8 feature to comm. with 1108	1,000 feet
ex/ em 480	32	65K bytes	2.4 million bytes no redundant data stores so difficult to est. no. of records	7 trk at 556/ 800 bpi; 9 track at 800/ 1600 bpi	yes	Keypunch and/or typewriter	12 lines of 40 chars.	uses IBM BSC to comm. with a mainframe or another Entrex	1,000 feet
rex/ -II	16	24K bytes	2.2 million bytes 18,000 125 char records	9 trk at 800 or 1600 bpi	yes	Keypunch	4 lines of 32 chars.	uses IBM BSC to comm. with a mainframe or another 1303-II Acts as remote tape drive to mainframe	2,000 feet with line amplification

FOLDOUT FRAME

Appendix I: Hardware Features

Display	Communications	Max. Distance From Local Keystation To Controller	Max. No. Of Tapes Supported	Max. No. Of Disks Supported	Remote Keystations	No. of Systems In Field	Ability to Upgrade	Read/Write Tape Speeds
4 lines of 32 chars.	CMC-5 to CMCS; IBM BSC, emulates 2780 for mainframe communications	1,000 feet	2 (both same density)	2	No	2600 +	CMC-6 (New controller and disk)	12½ ips 25 ips (optional)
8 lines of 32 chars.	uses Exec II/Exec 8 feature to comm. with 1108	1,000 feet	1	1	Yes	175 (approx)	Keybatch II (several hardware changes)	25 ips for 800 bpi 12½ ips for 1600 bpi
12 lines of 40 chars.	uses IBM BSC to comm. with a mainframe or another Entrex	1,000 feet	4 (may have different trks and densities	4	Yes	1200 (approx)	System 580 (new disk needed)	25 ips
4 lines of 32 chars.	uses IBM BSC to comm. with a mainframe or another 1303-II Acts as remote tape drive to mainframe	2,000 feet with line amplification	1	1	No	3000 +	System 3300 (extensive hardware changes)	45 ips

FOLDOUT FRAME

2

Appendix II: Software Features

mpany/ Model	Max. Record Length On Input	No. of Format Levels	Automatic Chaining of Format Levels	Max. No. Of Formats In System	Tape to Disk Input	Tape Update In Place	End of Batch Background Editing	Operator Statistics	Batch System Sort
MC/ MC-5	112 chars.	8	Yes	399	Yes	No	Yes	Yes	No
ata 100/ eybatch II	128 chars.	99	Yes	999 (for each of 4 categories)	Yes	Yes	Yes	Yes	No
ntrex/ ystem 480	unlimited	10	Yes	unlimited	Yes	No	Yes	Yes	Yes
nforex/ 303 - II	125 chars.	8	Yes	192	Yes	Yes	No	Yes	No (can sort as you go from disk to tape)

FOLDOUT FRAME

Appendix II: Software Features

End of Batch Background Editing	Operator Statistics	Batch System Sort	Disk to Tape Concurrent with Data Entry	Communications to Mainframe Concurrent With Data Entry	Card Input	Reformatting
Yes	Yes	No	Yes	Yes (get degredation if sending from disk rather than tape)	No	Yes
Yes	Yes	No	Yes	No	Yes	Yes
Yes	Yes	Yes	Yes (1 station locked)	Yes	Yes	Yes
No	Yes	No (can sort as you go from disk to tape)	Yes	Yes (cannot transmit from mainframe to 1303-II tape)	No	Yes