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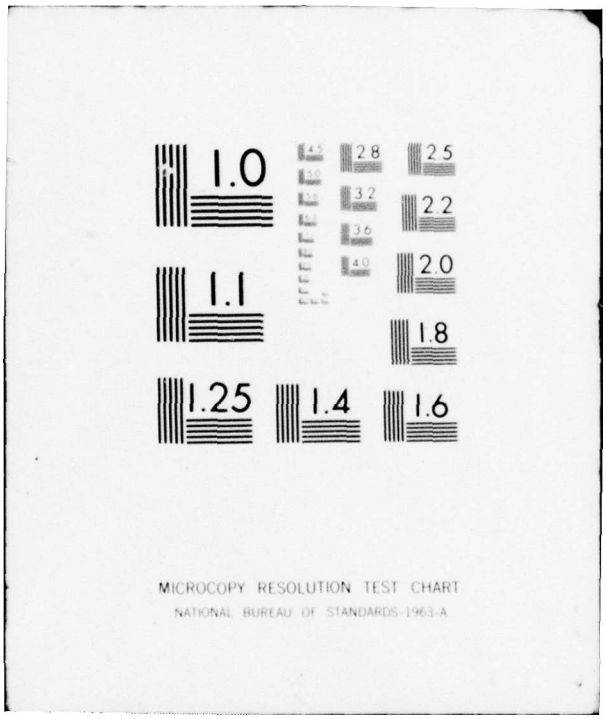
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RADC-TR-77-378
Final Technical Report
December 1977

FEASIBILITY TEST OF LOGOSCAN SYSTEM

Charles E. Byrne
John C. Byrne

Logos Development Corporation

Approved for public release; distribution unlimited.

ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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The report documents results of a two-month test of LOGOSCAN System to establish its applicability as an OCR device in the Russian text input processing. All design objectives of the System have been met in its prototype version. Most of the OCR problems encountered during the test are directly traceable to hardware limitations. Problems of this nature can be easily eliminated by transferring the LOGOSCAN recognition logic to a new hardware environment within the current state-of-the-art.

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1.0 Objective: Testing and evaluation of the Logoscan optical character reader recognition software. Government-supplied Russian typeset text was used throughout.

2.0 Conclusion: A recognition accuracy of better than 98% at a throughput rate of three characters per second was achieved during this test using previous generation equipment. The Logoscan software subsystem incorporated into current generation equipment will have an estimated accuracy rate of from 99% to 99.9% with a throughput rate of from 30 to 50 characters per second. These ranges depend upon the typeset text to be scanned, viz., the better the input quality, the higher the rates.

3.0 Technical Problems: All technical problems encountered during this test period were hardware related, viz., low resolution of the read head, paper skewing in the paper transport, and slow response time of the read head electronics as alternating black and white sections of the page being scanned move by the read head.

4.0 General Methodology: The tests were conducted in as nearly an operational environment as possible, consistent with hardware limitations. Numeric signatures of the test font were acquired as defined in Appendix B of the final report. These signatures were refined by analysis of closely matching characters, and the text re-scanned to determine improvements in recognition accuracy. It was necessary to slow the paper transport feed rollers to a minimum speed in order to overcome the slow response time of read head electronics.

A general survey of available optical scanners was conducted, using the following criteria:

1) cost
2) resolution
3) method of paper transport
4) availability
5) maintenance

5.0 Technical Results: The test confirmed the operational capability of Logoscan recognition algorithms, even in this non-optimum hardware environment. A system called Logoscan II, incorporating an ECRM/4400 (ECRM, Inc., Bedford, Mass.) as a raw video source and paper transport, with a Data General S130 (Data General, Southboro, Mass.) for execution of both normal and micro-code instructions, can be configured, thus increasing recognition accuracy to between 99.0 and 99.9%. Throughput rates would be from 30 to 50 characters per second. These figures are dependent upon the input text quality.

EVALUATION

The objective of this two-month testing effort consisted in establishing the applicability of LOGOSCAN System as an OCR device for conversion of Russian typeset text to computer processable format. The test was undertaken in semi-operational environment to verify the following performance characteristics: scanning speeds; output quality in terms of error/rejection rates; font acquisition as a by-product of a normal scanning operation; recognition and separation of touching characters, and acceptance of original test as well as reproductions for direct scanning.

The System is now implemented in its prototype version on COMPUSCAN 170 and NOVA 1200 with 12K memory and magnetic tape output. To meet the design objectives of the System, the designers have bypassed the original vendor-supplied logic and introduced the company's own recognition logic based on auto-correlation techniques. Instead of comparing the scanned character against a reference alphabet, using the traditional cross-correlation techniques, the System generates a numeric signature expressing the shape of the character. Consequently, matching of the input character against a reference alphabet is based on its numeric signature. The reference alphabet is independent of point size because recognition is based on shape analysis.

The test has confirmed the capabilities of the System, as indicated above, under constraints imposed by the present hardware configuration. OCR problems encountered during the test have been traced almost exclusively to hardware limitations. Problems of this nature can be easily eliminated by implementing the LOGOSCAN recognition logic as firmware in a microprogrammed mini- or, alternatively, microprocessor, compatible with the laser scanner componentry within the current state-of-the-art.

Zbigniew L. Pankowicz

ZBIGNIEW L. PANKOWICZ
Project Engineer

A. LOGOSCAN PERFORMANCE DURING TEST PERIOD

1. The Russian text:

АВТОМАТИЗИРОВАННЫЕ
СИСТЕМЫ УПРАВЛЕНИЯ
ШТАБОВ И ВОЕННЫХ
УЧРЕЖДЕНИЙ

has been used throughout this feasibility test, including the demonstration to government personnel on 30 August 1977. The Appendix contains illustrations of text scanned at that demonstration.

2. As presently configured, the Logoscan System correctly recognizes characters in the above font with better than 98% accuracy at a rate of three characters per second. Figure A-4 illustrates the distribution of unrecognized characters on page 101 of the above text. These errors are primarily attributable to hardware limitations, viz., low resolution of the read head and dynamic skewing of the text page due to variable roller pressure in the paper transport.

It is significant that a group of two characters, viz.,

Н И

of the 33 characters in this font account for a third of all recognition errors. Figure A-5 defines the effect of higher resolution on these two characters. It is the thin center bar connecting the vertical side of these characters which at low resolution sometimes causes the recognition system to break them. Special test can be introduced when the resulting narrow characters are encountered. However, capturing that thin bar via finer resolution is the better way.

Overall cost/effectiveness of the present level of performance cannot be considered due to the age of the system's components. Most are no longer manufactured and cannot be maintained.

The software subsystem, which gives Logoscan its unique capability, is directly transferable to present generation equipment.

3. New font acquisition, as demonstrated at the 30 August meeting, is normally a two man-day, machine-assisted operation. Figures B-1 through B-7 are examples of the system/operator exchange required.

4. The above Russian text was photographically enlarged, thus increasing the point size from 5 to 6, and scanned using the same reference alphabet.

5. Touching characters in a printed text are normally the result of wear, chips, or hairlines on the original type (see Figure A-6). The Logoscan system had no difficulty separating such characters in this font; for example, see Figure A-7.

6. Xerox copies of the original text page have proven to be the normal form of input to the scanner. Such copies have two advantages over the original page: 1) there is a sharper contrast between light and dark areas, and 2) the reflective characteristic of OCR bond paper used in the copies is superior to paper of the above Russian text.

7. The first-generation copy used during this feasibility test has proven adequate in maintaining an error rate of less than 2%. The new hardware configuration defined in the following will enable Logoscan II to reduce this rate to between .1% and 1.0%, depending on the quality of the original page.

8. As noted above, on 30 August 1977 a demonstration involving all of these seven points was conducted at the Logos offices in Middletown, New York. Government-selected test material was used throughout.

B. OPTIMIZATION OF LOGOSCAN II

1. Hardware:

There are two primary hardware considerations in an OCR system which is to do direct print reading, viz.,

a) What the read head "sees":

Obviously it is expected to see the characters on the printed page, but how it sees them both in terms of clarity and detail will determine the quality of data presented to the software subsystem. Clarity is a function of both focus and signal-to-noise ratio at the read head, while detail is a function of its resolution capability.

Our recent demonstration was conducted using equipment in which the light source is a standard projector lamp of 150W with optic fibers delivering light to the page being scanned. This is inherently a low signal-to-noise subsystem. The effective resolution capability of its 60 fiber optic read head is 6.5 mils.

The equipment to be used in Logoscan II, as detailed in Section 3, improves the data quality in both of the above categories. Its light source is a laser, and its effective resolution is 4 mils. This figure can be reduced to 3 mils via relatively simple lens and gear chain modifications.

b) How the page to be read is presented to the read head:

Although a purely mechanical operation, the manner in which a page is presented to the read head is of considerable significance to a direct print reading OCR system. This is due to a characteristic of printed text, viz., ascenders and descenders such as the Russian Б and Д, plus a density of seven or more lines to the inch. Any initial paper skew or dynamic skew, as the page moves through the transport, compounds the line separation problem.

Logoscan II hardware will hold both the read head and the page stationary during a single scan. Subsequent movement of the page along its axis does not introduce dynamic skewing.

Appendix C contains examples of certain technical problems, and character variations encountered during this test period.

2. Software:

The basic recognition power of the Logoscan software subsystem has been proven during this feasibility test in an area where neither masking technique nor feature extraction has proven adequate. These latter two techniques, although highly successful when used on controlled fonts such as that produced by monospaced typewriters, cannot perform in the presence of touching or broken characters, missing or weak strokes, hairlines, ascenders, descenders, or varying line thickness, all of which can occur within the same font, often within the same printed book. This is especially true when scanning Cyrillic font with its fine tails and curls.

Sections of Logoscan II logic will be implemented in micro-code.

3. Configuration of Logoscan II:

Logoscan II will be implemented on the following equipment configuration:

Unit	Function
ECRM/4400	read head, paper transport
DG/8611H	character recognition
DG/8615	character recognition
DG/6021	magnetic tape, output
DG/6045	magnetic disk, reference alphabet store
DG/6041	printer, reference alphabet acquisition
DG/6052	CRT terminal, reference alphabet acquisition, file editing
DG/6042	terminal, Logoscan control, file editing
DG/6013 & DG/4012A	reader/punch, program and data I/O

4. Logoscan II Performance Characteristics:

Logoscan II will have the following performance characteristics:

a) A recognition rate of 30 to 50 characters per second. This rate is font dependent and is related to the quality of the input text, viz., the better the quality, the higher the rate.

b) An error rate of .1% to 1%. As above, this rate is also related to the quality of the input text.

c) It will accept Xerox copies of the original text.

d) Output will be on industrial standard 800 bpi magnetic tape in any format required.

e) A new font can be acquired and stored on disk for later recall. This man/machine operation requires approximately two man-days to acquire an accurate font. It is then usable for any book printed in that font, independent of type size.

f) The system will be capable (in its non-scan mode) of editing English language text files, and outputting corrected text via its printer or its magnetic tape unit.

APPENDIX A

RUSSIAN INPUT DICTIONARY

(Lower Case)

а - A	к - K	х - X
б - B	л - L	ц - Q
в - V	м - M	ч - C
г - G	н - N	ш - W
д - D	о - O	щ - 5
е - E	п - P	ъ - 7
ё - 8	р - R	ь - 6
ж - j	с - S	ы - Y
з - z	т - T	э - 3
и - i	у - U	ю - H
й - 1	ф - F	я - 4

SPECIAL SYMBOLS FOR CAPITALS AND NUMBERS

Russian	English	Special DG ASC II Codes
В	V	#
О	O	@
Н	N	*
А	A	0
У	U	%
Ш	W	↑
С	S	←
Е	E	<
Ц	Q	-
1	1	+
3	3	!
5	5	$

FIGURE A-1

состава оборудования, совершенствование математического обеспечения.

НСОУ (рис. 29) включает один основной командный центр ВС в здании министерства обороны, один запасный (подземный) командный центр вблизи Вашингтона и несколько воздушных командных пунктов (оборудовано пять самолетов ЕС-135, один из которых постоянно находится в 15-минутной готовности к вылету).

Национальная система оперативного управления ВС США находится в ведении министерства обороны и во взаимодействии с другими системами позволяет президенту, министру обороны и комитету начальников штабов управлять вооруженными силами в любых условиях мирного и военного времени.

Система дает возможность с помощью различных средств связи и вычислительной техники осуществлять сбор, накопление и обновление политической и военной информаций, информации о состоянии вооруженных сил США, союзников и вероятных противников, включая данные о расположении войск, степенях их готовности, боевых возможностях, уязвимости и т. д., поступающей от Центрального разведывательного управления, госдепартамента, агентства национальной безопасности, различных органов министерства обороны, объединенных и специальных командований ВС.

На конкретных центрах и пунктах национальной системы оперативного управления текущая обстановка и необходимые для должностных лиц справки и донесения отображаются на различных экранах, электронно-лучевых трубках, люминесцентных табло, выдаются на печать. Время с момента запроса данных до их отображения (на основном командном центре) составляет около 15 *сек.*

Технические средства командных центров и пунктов НСОУ позволяют производить необходимые расчеты для определения оптимальных вариантов боевых действий вооруженных сил, и в первую очередь ударных ядерных сил, доводить принятые решения до штабов видов вооруженных сил, объединенных и специальных командований, объединенных управлений министерства обороны и агентства национальной безопасности. Время прохождения команд и распоряжений от командного центра НСОУ до окопечных пунктов составляет 5—7 *мин.*

FIGURE A-2

SOSTAVA OBORUDOVANI4, SOVERWENSTVOVANIE MATEMATICE-
SKOGOOBESPECENI4.

*+0% (RIS. 9) VKLHCAET ODIN OSNOWNOI KOMANDNYI
CENTR #+ V ZDANII MINISTERSTVA OBORONY, ODIN ZANAS-
NYI (PODZEMNYI) KOMANDNYI CENTR VBLIZI #AWINGTONA
I NESKOL6KO VOZDUWNYX KOMANDNYX PUNKTOV (OBORUDOVA-
NO P4T6 SAMOLETOV <+-+$$, ODIN IZ KOTORYX POSTO4NNO
IAXODITS4 V +$-MINUTIOI GOTOWNOSTI K VYLETU).

*AQIOIAL6NA4 SISTEMA OPERATIWNOGO UPRWLENI4 #+
+T0 NAXODITS4 V VEDENII MIIISTERSTVA OBORONY I VO
WAIMODEISTVII S DRUGIMI SISTEMAMI POZVOL4ET PREZI-
DENTU, MINISTRUOBORONY I KOMITETUIAAL6NIKOVWTABOV
U-WAVL4T6VOORUJENNYMISILAMI VLHBYXUSLOVI4X MIR-
NOGOI VOENNOGOVREMENI.

+ISTEMA DAET VOZMOJNOST6 S POMO56H RAZLICNYX
SREDSTV SV4ZI I WYCISLITL6NOI TEXNIKI OSU5ESTVL4T6
SBOR- NAKOPLENIE I OBNOVLENIE POLITICESKPI I VOENNOI
INFORMAQII- INFORMAQII O SOSTO4NII VOORUJENNYX SIL
+F-SOHENIKOAVERO4TNYXPROTIWNIKOV-VKLHCA4 DAN-
NYE O RASPOLOJENII VOISK, STEPEN4X IX GOTOWNOSTI, BOE-
WYX VOZMOJNOST4X, U4ZVIMOSTI I T. D., POSTUPAH5EI OT
-EITRAL6NOGO RAZVEDYVATEL6NOGO UPRAVLENI4, GOSDEPAR
TAMENTA, AGENTSTVA NAQIONAL6NOI BEZOPASNOSTI, RAZLIC-
NYX ORGANOV MINISTERSTVA OBORONY, OB7EDINENNYX I SPE-
QIAL6NYXKOMANDOVANII #+.

*+A KONKRETNYX CENTRAX I PUNKTAX NAQIONAA6NOI SI
STEMY OPERATIWNOGO UPRAVLENI4 TEKUSA4 OBSTANOWKA I
NEOBXODIMYE DL4 DOLJIOSTIYX LIC SPRAWKI I DONESENI4
OTOBRAJAHTS4 NA RAZLICNYX 3KRANAX, 3LEKTRONNO-LUCE-
WYX TRUBKAX, LOMINESCENTNYX TABLO, VYDAHTS4 NA PE-
CAT6. #REM4 S MOMENTA ZAPROSA DANIYX DO IX OTOBRAJE
NI4 (NA OSNOWNOM KOMANDNOM CENTRE) SOSTAVL4ET OKOLO
+$)(%.

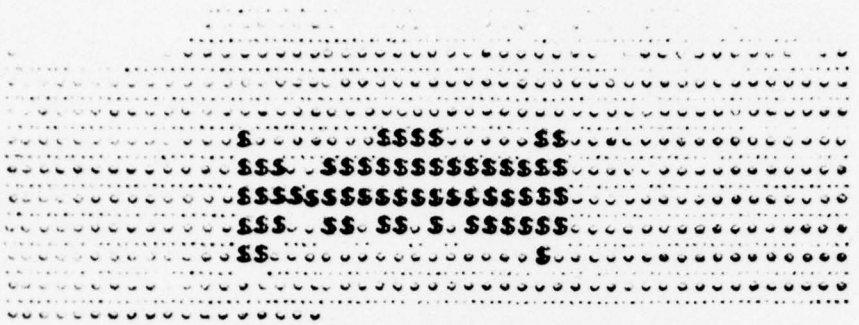
'EXNICESKIE SREDSTVA KOMAIDNYX CENTROV I PUNKTOV
*+0% POZVOL4HT. PROIZVODIT6 NEOBXODIMYE RASCETY DL4
OPREDELENI4 OPTIMAL6NYX VARIANTOV BOEVYX DEISTVII
VOORUJENNYX SIL, I V PERVUH OCEREL6 UDARNYX 4DERNYX
SIL-DOVODIT6PRIN4TYE RENENI4 DO WTABOV VIDOV VOORU-
JENNYXSIL, OB7EDINENNYXI SPECIAL6NYXKOM+NDOVANVI,
OB7EDINENNYXUPRAVLEKII MINISTERSTVA OBORONYI AGENT
STVA NAQIONAL6NOI BEZOPASNOSTI. #REM4 PROXOJDENI4
KOMANDI RASPOR4JENII TKOMANDNOGO CENTRV *+-0% DO
OKONECIYX PUNKTOV SOSTAVL4--:;%.

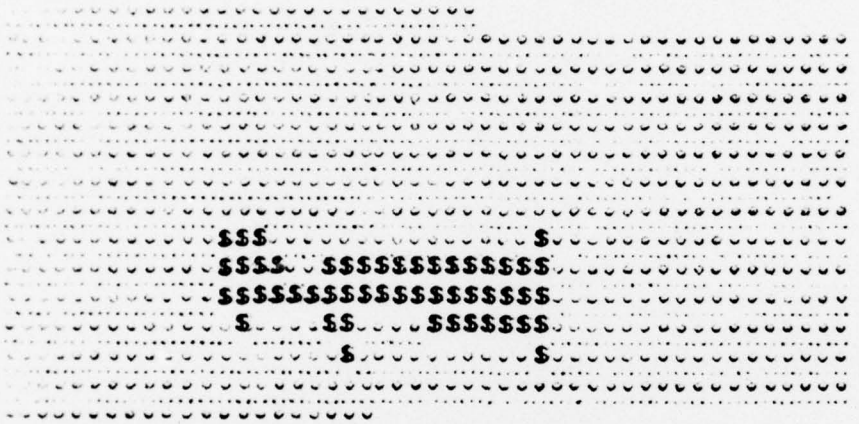
FIGURE A-3

CHARACTER (lower case)	No. of errors
П	1
Н	10
А	3
Ч	1
Е	3
О	2
В	1
И	2
Л	1
Д	1
Ш	1
Т	1
(upper case)	
Ш	1
А	1

Unrecognized characters on page 101.

FIGURE A-4

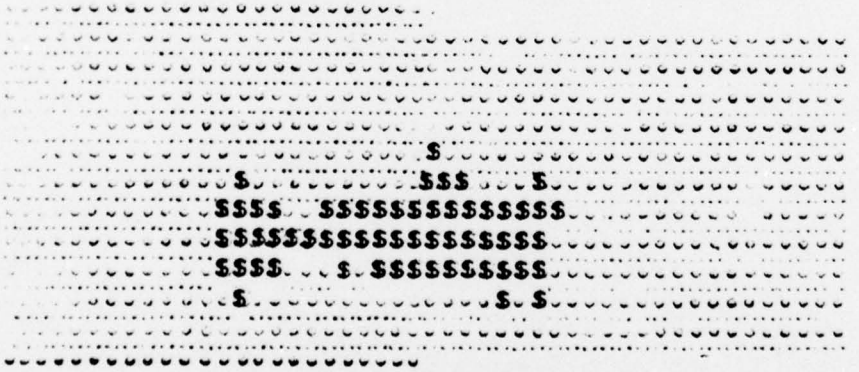


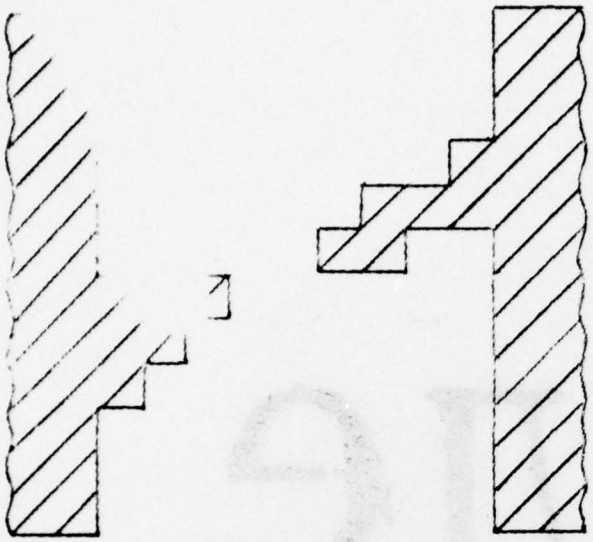


CHARACTER

H

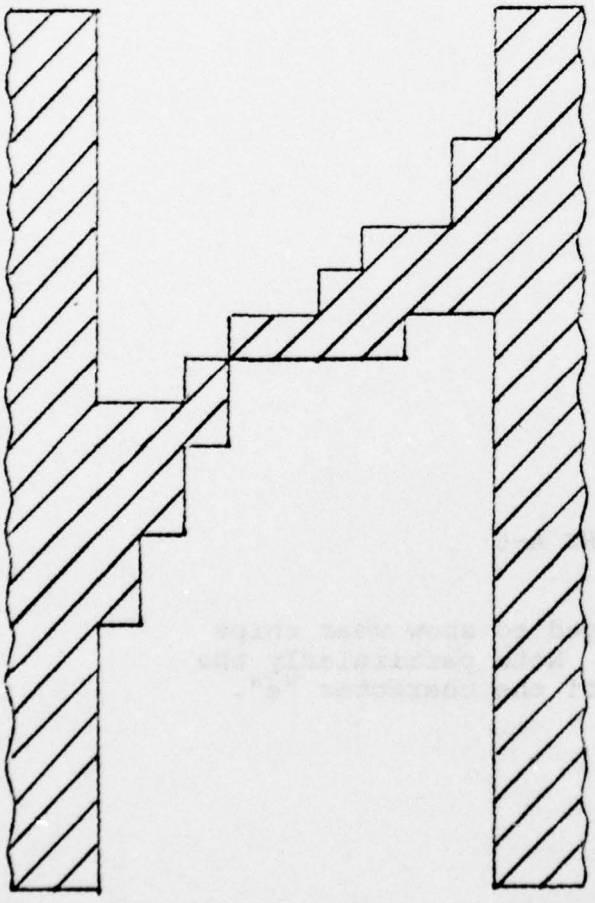
SEEN AS
TWO
SEPARATE
CHARACTERS





EFFECT OF INCREASED
VERTICAL RESOLUTION
ON WEAK STROKES

RUSSIAN CHARACTER И
WITH WEAK CENTER STROKE
AS SEEN WITH 6.5 MIL
VERTICAL RESOLUTION

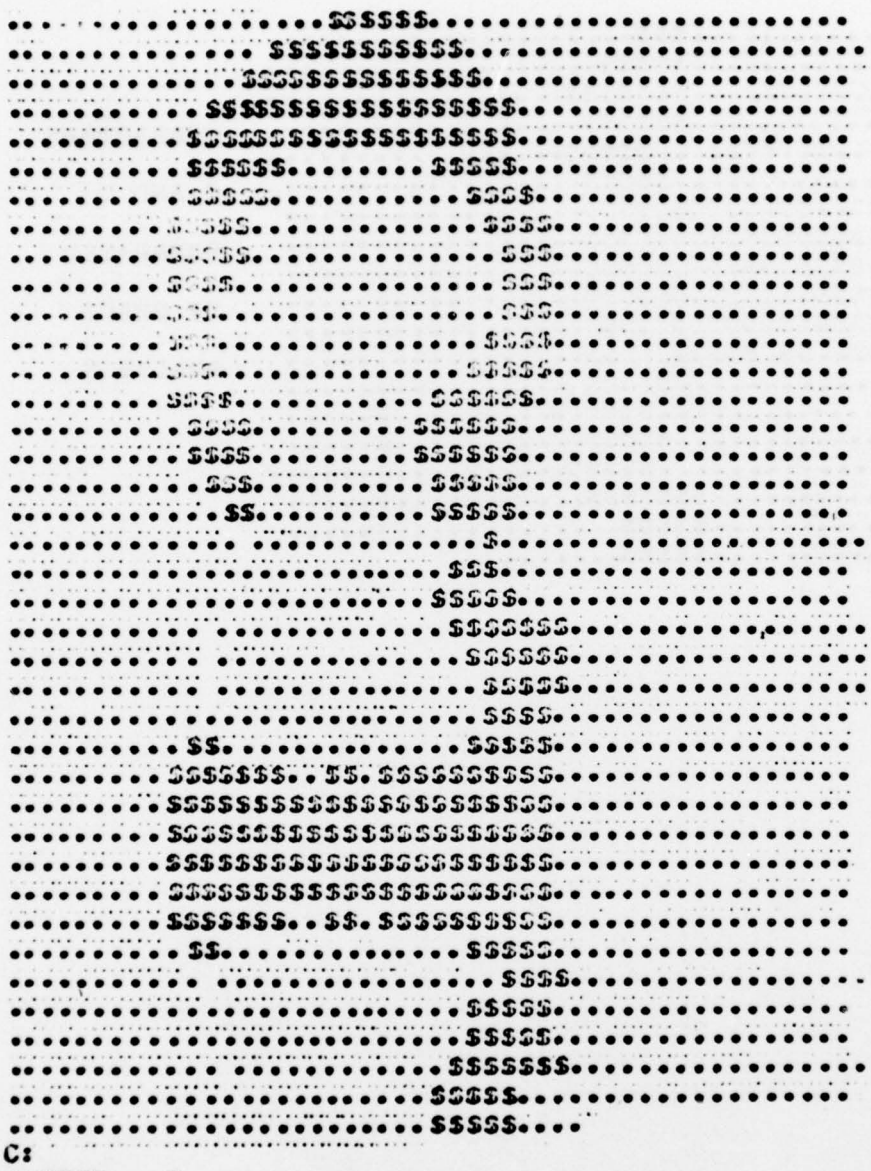


SAME CHARACTER
WHEN SEEN WITH
4 MIL RESOLUTION

FIGURE A-5B

FIGURE A-6

Portion of text enlarged to show wear chips and holes in strokes. Note particularly the hairline to the left of the character "e".



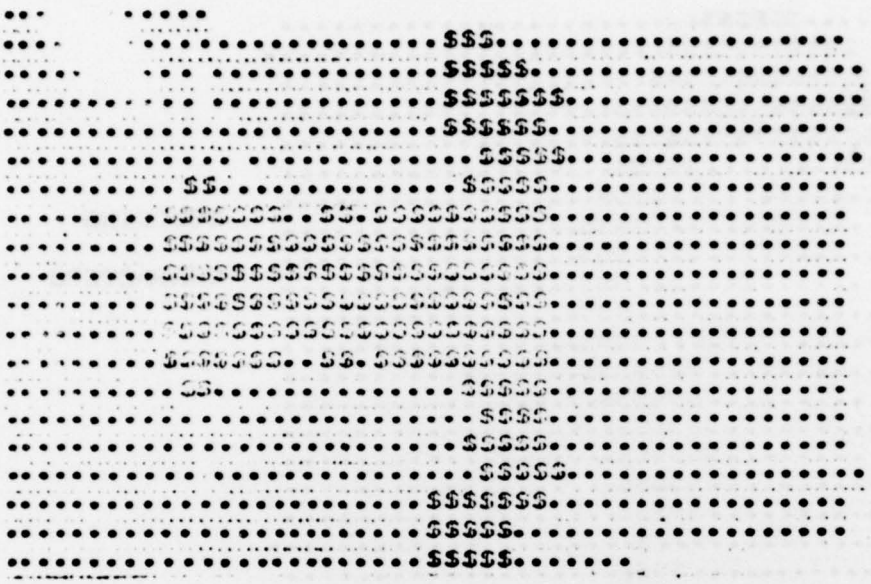
TOUCHING

CHARACTERS

```
C:
LETTER = S
NO. ALREADY = 01

C: Y
```

FIGURE A-7A



CHARACTERS C AND T SEPARATED BY SHAPE ANALYSIS

FIGURE A-7B

APPENDIX B

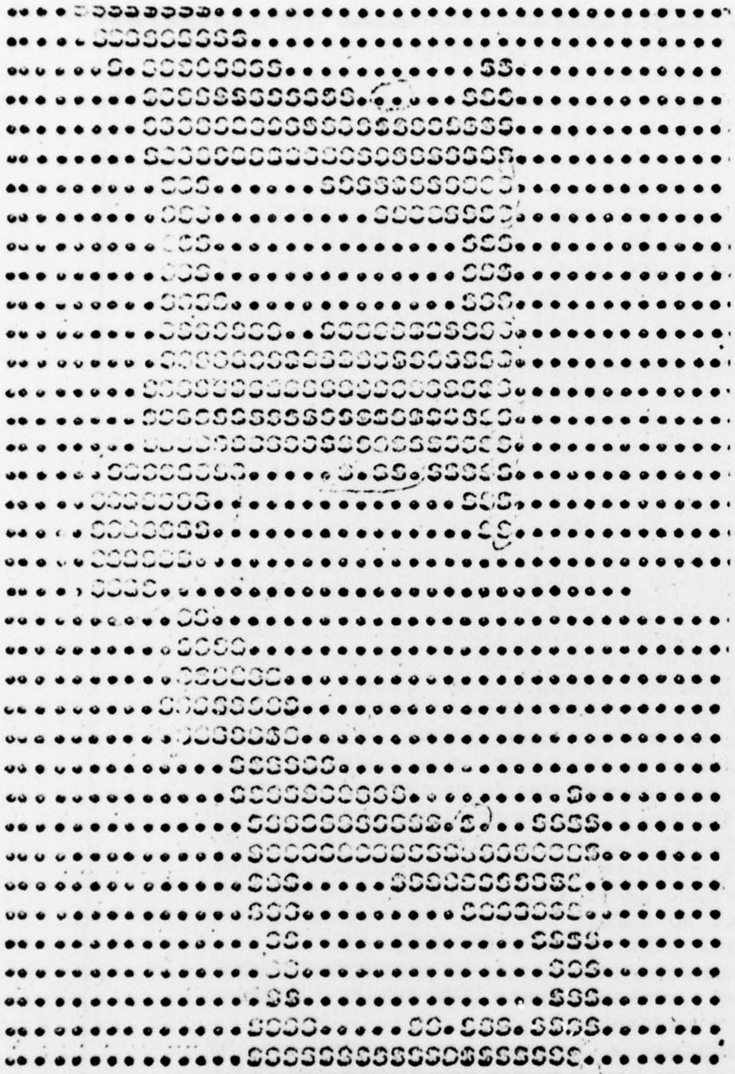
деляется назначением трубки. Планировалось увеличить диаметр трубок с 48 до 75 *см*. Первые трубки типа «Характрон» широко применялись в американской системе ПВО «Сейдж». Трубки использовались в качестве индикаторов воздушной обстановки в определенном районе. На экранах трубок отображались все цели и их характеристики в виде так называемого «формуляра цели», состоящего из девяти различных знаков. Центр группы знаков формуляра занимал на экране положение, соответствующее положению цели в данный момент, и перемещался в соответствии с движением самолета, направление полета которого определялось вектором. В печати сообщалось, что экран трубки позволяет отображать информацию о нескольких сотнях воздушных целей *.

В последние годы английская фирма ИКЛ разработала устройство отображения настольного типа на электронно-лучевой трубке индивидуального пользования (тип 7181). Принцип работы этого устройства аналогичен принципу действия «Характрона», однако знаки на экране трубки формируются путем проектирования отдельных точек, из которых составляется нужный знак. Это осуществляется с помощью двух матриц: одной 10×7 точек — для формирования прописных знаков и другой 14×5 точек — для формирования строчных знаков. Размер отверстия для точки на матрице равен 0,3 *мм*. При индикации соседние точки на вертикальных линиях соединяются в одно целое. Размер знаков на экране составляет 3,4 *мм* по высоте и 2,3 *мм* по ширине. Экран этого устройства имеет размер 264×175 *мм*.

На экране может отображаться 96 различных знаков. Емкость экрана составляет около 2000 знаков (25 строк по 80 знаков в строке).

Кроме отображения информации, выдаваемой из ЭВМ, это устройство используется как настольный пульт для ввода данных в машину. В этом случае устройство оснащается специальной клавиатурой, позволяющей на-

FIGURE B-1

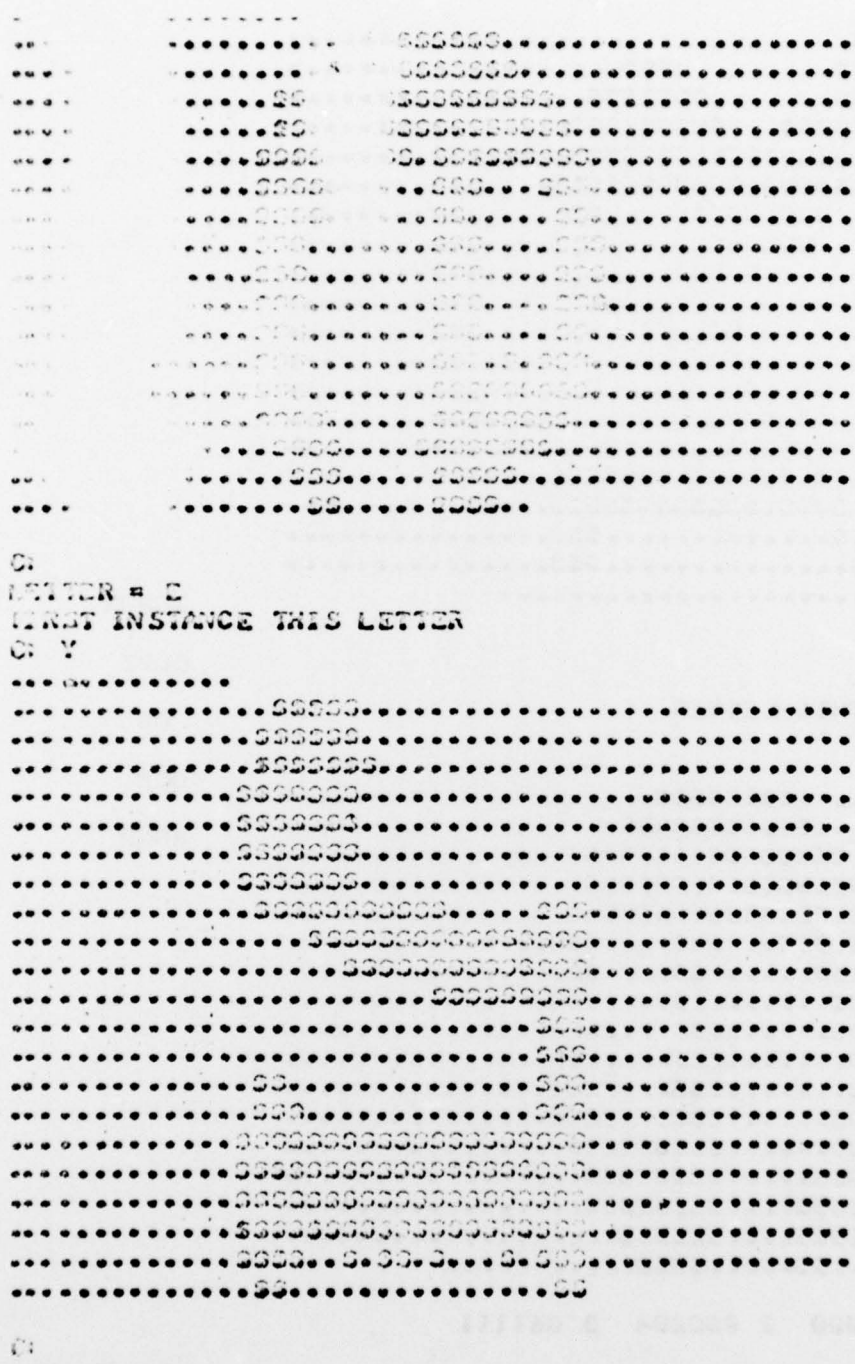


```
73 27570
0 023013   1 000000   2 000002   3 061111
40P

C:
LETTER = D
FIRST INSTANCE THIS LETTER
C: Y
```

"DEVELOPING" A REFERENCE ALPHABET

TTY output corresponds to the image seen by the read head. The system looks for a line, tests the first character for positioning, and rescans the line as necessary. Each character is processed to form a numeric signature, and the system allows the operator to identify it. The number of occurrences of each character are recorded. At the operator's option, a particular character may be stored or ignored. Note the number of variations (circled).



XEROX

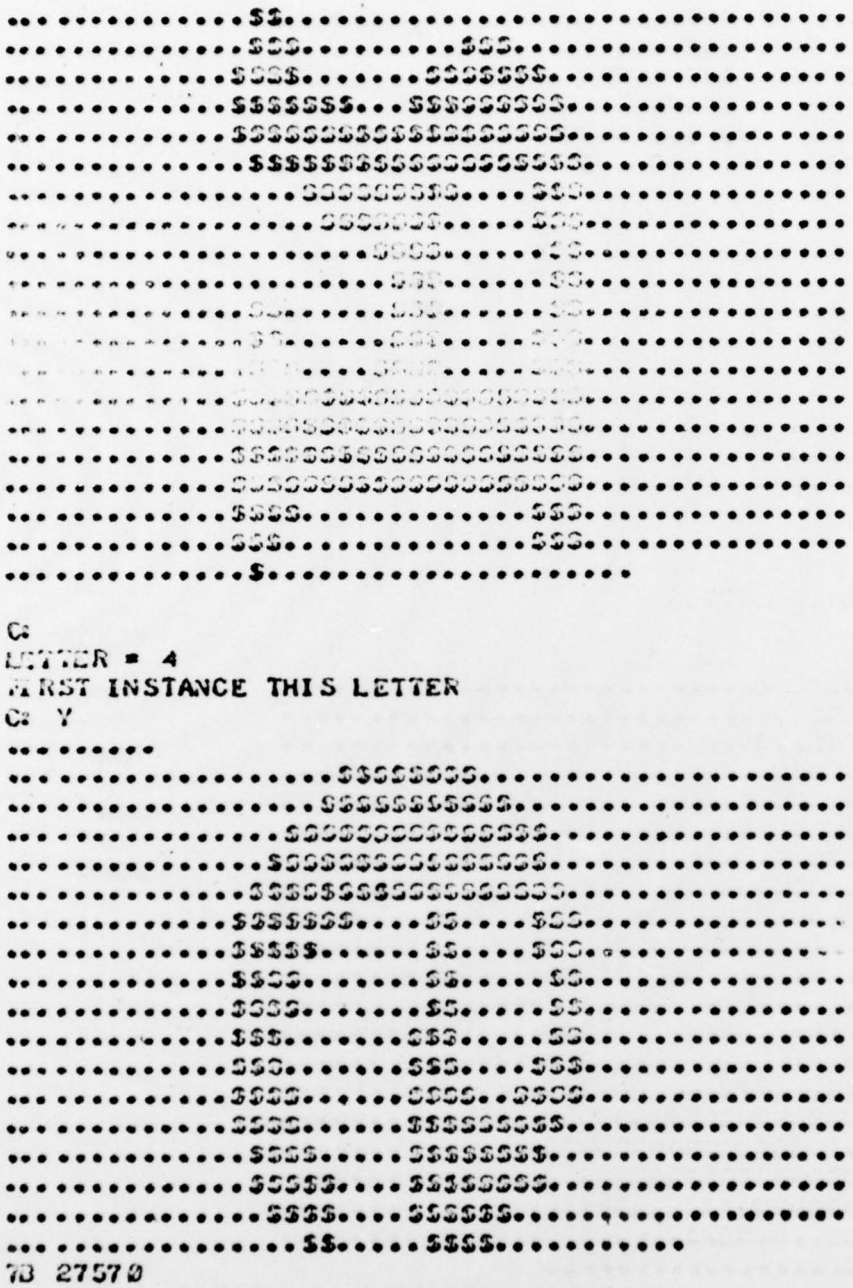
COPY

ON

OCR

BOND

FIGURE B-3



XEROX COPY ON OCR BOND

```
C:
LETTER = 4
FIRST INSTANCE THIS LETTER
C: Y
```



```
78 27570
0 023013  1 000000  2 000004  3 061111
78P

C:
LETTER = E
NO. ALREADY = 01
C: Y
```

SECOND OCCURENCE OF THIS LETTER

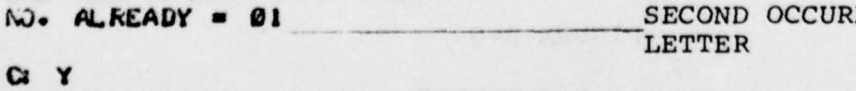
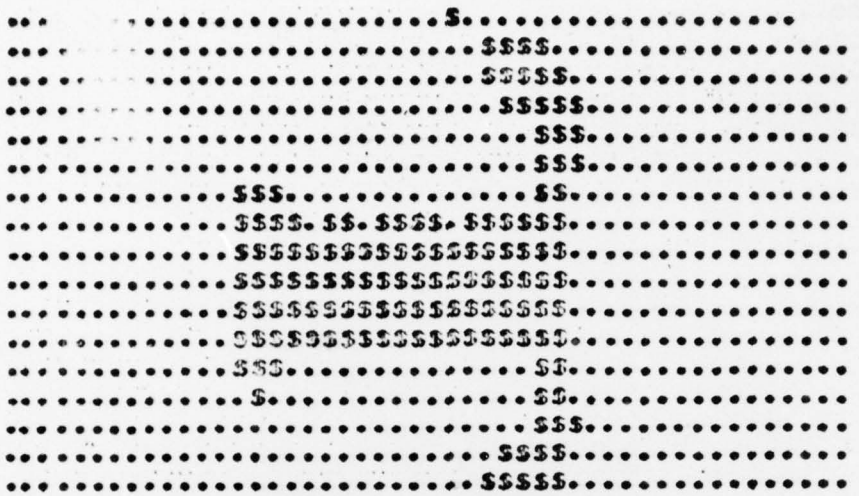
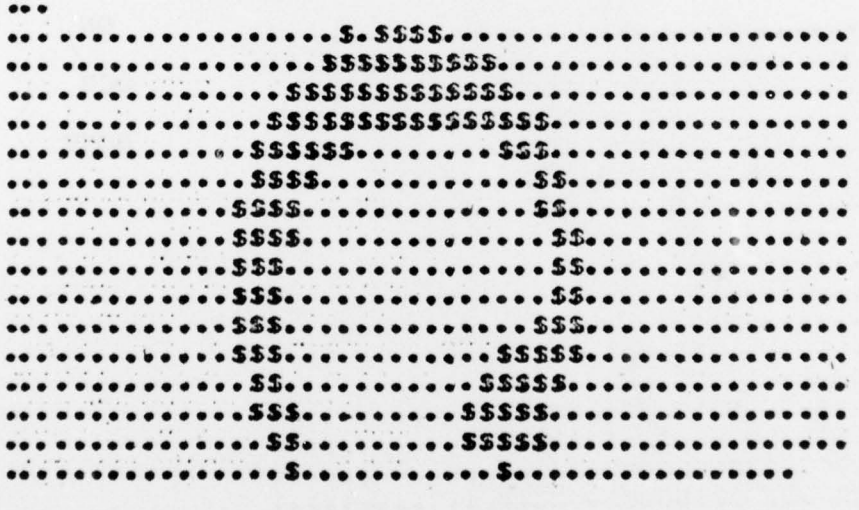


FIGURE B-4



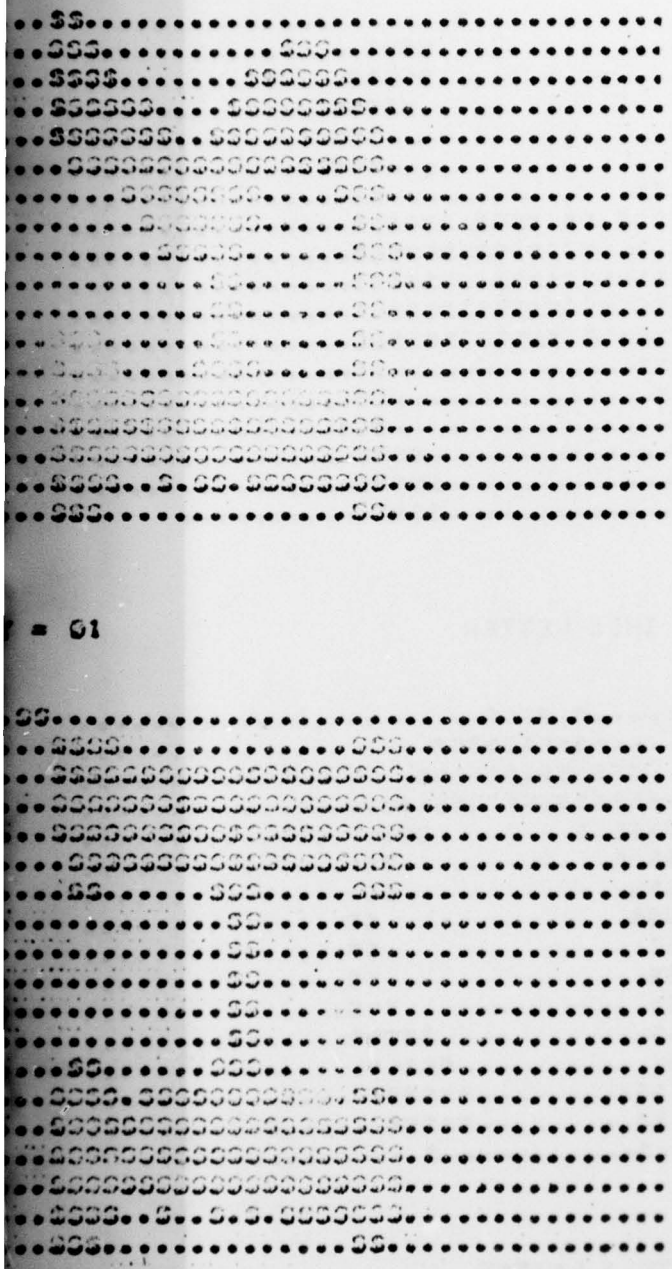
XEROX COPY ON OCR BOND

```
C:
LETTER = T
FIRST INSTANCE THIS LETTER
C: Y
```



```
C:
LETTER = S
FIRST INSTANCE THIS LETTER
C: Y
```

FIGURE B-5



XEROX

COPY

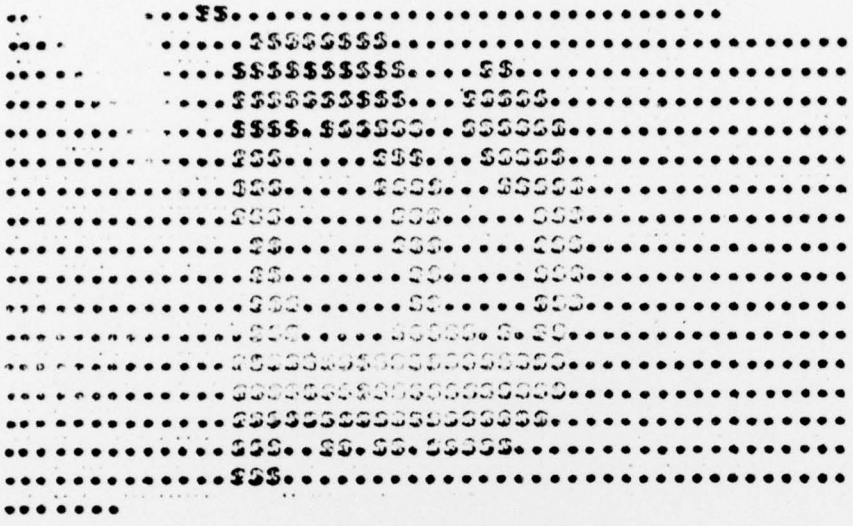
ON

OCR

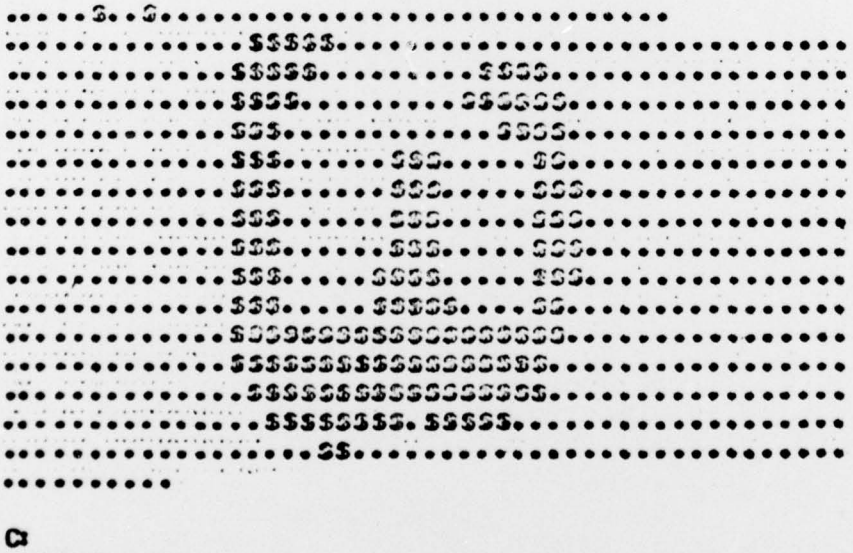
BOND

NCE THIS LETTER

FIGURE B-6



```
C:
LETTER = A
FIRST INSTANCE THIS LETTER
C: Y
```

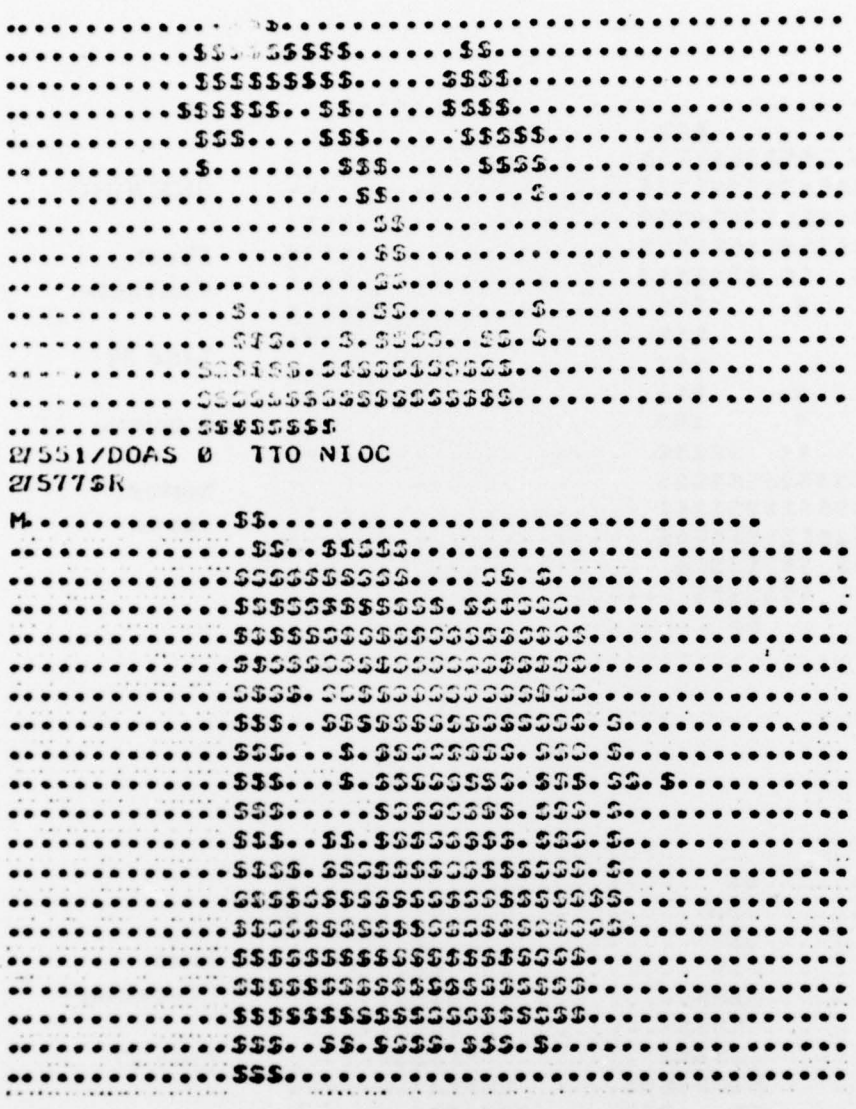


```
C:
LETTER = Z
FIRST INSTANCE THIS LETTER
C: Y
```

XEROX COPY ON OCR BOND

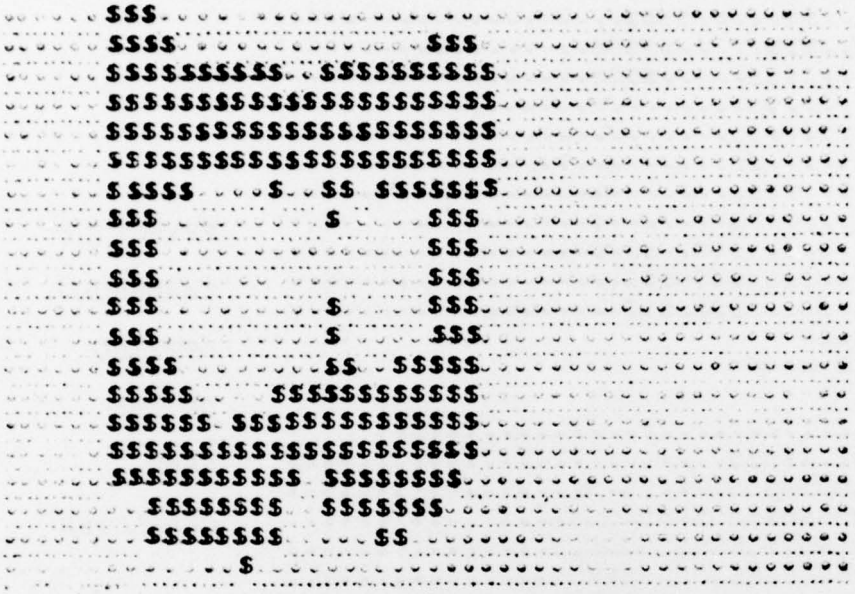
FIGURE B-7

APPENDIX C



EFFECT OF THRESHOLD SETTING ON THE SAME CHARACTER

FIGURE C-1



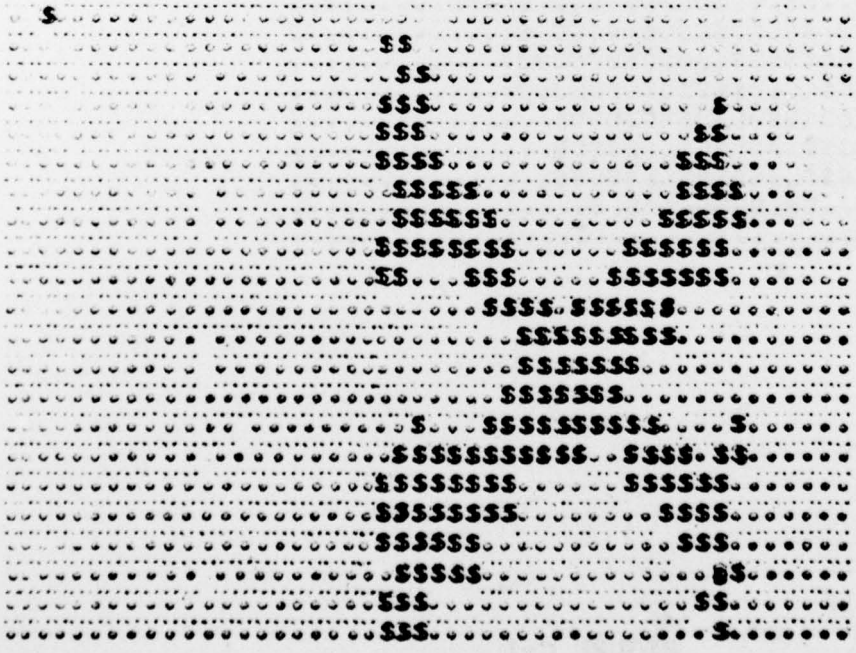
SKEWING

First Character

Line 37

6 points

bottom space

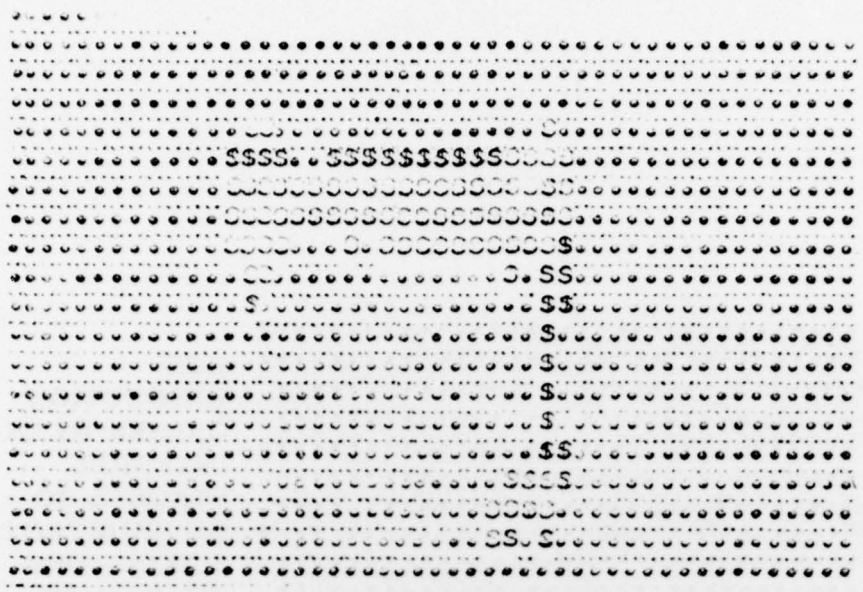


Last Character

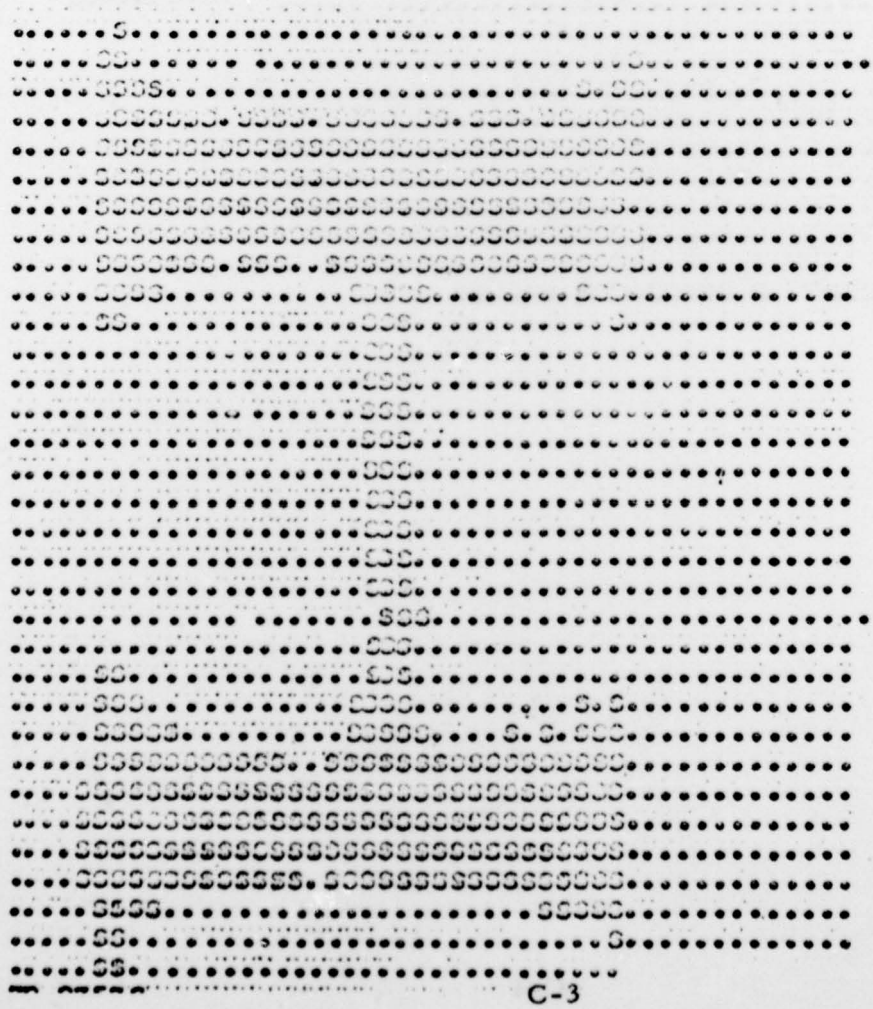
Line 37

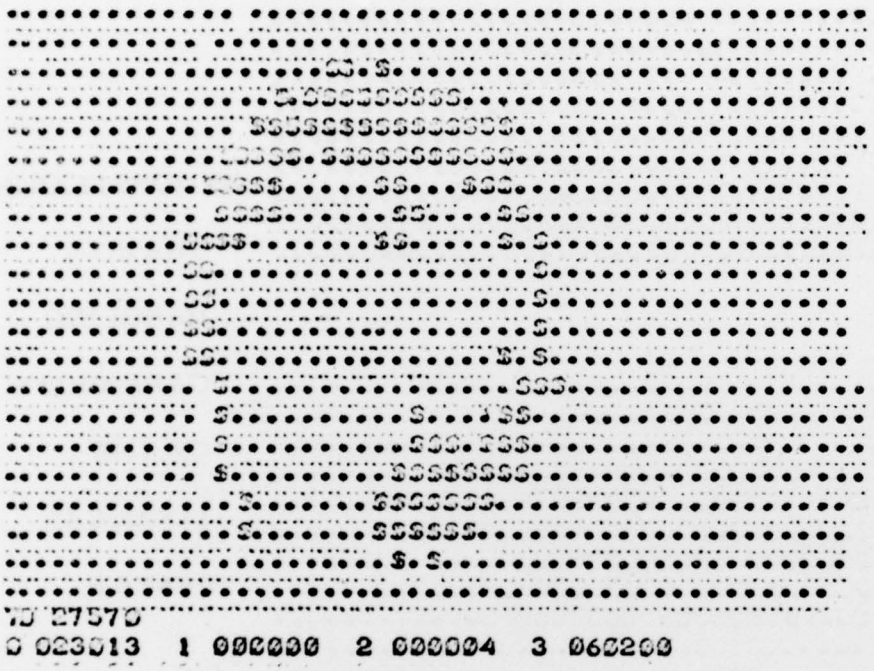
21 points

bottom space



DEMONSTRARING THE SIZE HANDLING CAPABILITY OF THE LOGOSCAN SYSTEM





LOW RESOLUTION CAUSES WEAK INTERIOR STROKES TO GO UNDETECTED, MAKING ONE CHARACTER LOOK LIKE ANOTHER.