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EARS, GEARS, SEARS, and Other Related Items
(Revised 8 April 1975)
(Revised 21 June 1977)

        The EARS printing system is available in CSL room 2077. The
EARS system may be accessed directly from any machine on the Ethernet.
ALTOs currently may access EARS via the program GEARS which is
described in this memo.   Access to EARS via MAXC is described in
another memo. The use of PUB with respect to EARS is also described in
another memo.

1. EARS

        EARS is a one page per second printing system consisting of an
Ethernet, Alto, RCG (Research Character Generator), and SLOT/7000. The
EARS system is designed to spool more than 1000 pages of output on its
disk and to print graphic art quality documents. Up to 190 individual
documents may be spooled simultaneously.

        EARS does no page composition.   Page composition is done by
other computers on the Ethernet. This approach distributes the
composition load, minimizes changes to the EARS system software, and
allows users to write their own special composition software. The
standard EARS File Format allows a user to get at all of the features
of EARS while also allowing simple pages to be easily composed.

        The EARS system will print multi-page documents   in portrait,
landscape, or mixed mode. The system is designed with the following
limits:

        1.   15k   characters/page (including directives)
        2.   512   text strings/page
        3.   128   characters/font
        4.   16   fonts/page
        5.   64   font sets/document
        6.   500   pages/document
        7.   32k   words of compressed font storage/font set
        8.   600k   words of guaranteed document storage space
                       on disk at connect time
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2. SEARS

SEARS is the subsystem that may be run on the ALTO named Palo to start the EARS system. Once EARS has been started, it displays various information about itself. There are two display areas on the ALTO screen. The first is a journal that records ethernet transactions and operator requests. The second records current system status such as "spooling", "printing", "call key operator", etc.

The printing system accepts the following keyboard commands from an operator:

P	print
B	backspace printer (5 pages)*
D	delete current file*
R	restart current file*
C	complete current file and halt
H	halt printer
S	spool input
N	no spooling
Q	quit
W	enable auto mode
Z	disable auto mode

*These commands only work when the printer is in the HALT state.

When SEARS is executed the system is initialized with both printing and spooling enabled. The quit command is the only reliable method to terminate EARS. (Booting the machine will merely cause a restart.)

If the status display area requests a key operator, the duplicator portion of EARS is probably jammed or out of paper. Follow the instructions posted near EARS to remedy this problem.
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3. GEARS

GEARS is an interim program that will compose text files and transmit them to EARS via the Ethernet. The EARS Alto is named Palo, and is host 3 on 35-Ethernet.

GEARS may be controlled with global switches, local switches, imbedded directives, and items in User.cm. In the simplest case, you would type GEARS, followed by any number of text file names. Each file will be printed in the default fixed pitch font and will receive appropriate headings.

If the default conditions are not acceptable, all of the capabilities of the system may be accessed via the switches and directives. I believe the global switches are self-explanatory--if not, try one. (See Summary of Commands.)

GEARS searches User.cm for a [HARDCOPY] section to set some parameters. Currently the network address of an EARS format printer and the 'Printed by' string on the break page can be set from User.cm. Here is an example:

    [HARDCOPY]
    EARS: Palo
    PRINTEDBY: "SDD - $"

'$' in the PRINTEDBY string is special: it means insert the Username (from the OS) in place of the $ character. The default string for PRINTEDBY is "$".

EARS font selection is quite flexible. Ears has two font concepts: A font and a font set. A font is an arbitrary collection of up to 128 distinct characters while a font set is a group of up to 16 fonts.

Normally a user will select a font from the default set. This font set is maintained by EARS and does not reside on each user's disk. Rather a directory for this font set is on each user's disk and is named DEFAULT.ED. A program named FEARS will list the fonts in DEFAULT.ED by name and by number. A new default font may be selected by name in the command line or by number with a global directive. Local font changes are by number. Note the font names must have an extension since FONT.EP is a portrait font and FONT.EL is a similar landscape font.

In general, EARS can completely change font sets between each page. GEARS, however, only supports font set changes between text files. A user may generate his own font sets by concatinating any sixteen fonts of his choice. This is accomplished with the local switch G (generate) in the command line.

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        First a file FOO.EC should be generated with an editor. The
file is a list of up to sixteen fonts to be concatinated. The font
names appear on separate text lines and are assigned numbers in order
of occurence. Fonts specified in the FOO.EC file must either be in .EP
(EARS portrait) or .EL (EARS landscape) format. Fonts in these formats
are found on the MAXC <FONTS> directory. Alternatively, .EP and .EL
files may be generated from .CU (Carnegie format) fonts using the
program COMPRESS from the <EARS> directory on MAXC. COMPRESS is called
with the font(s) to be compressed in the command line (COMPRESS
FONT1.CU FONT2.CU, etc). Besides creating .EP and .EL files, COMPRESS
creates an .ES (EARS specification) file which may be printed and
contains information about each character.

        After FOO.EC has been created and all of the fonts are on your
disk you run GEARS FOO/G TEXT. This will print your file TEXT in your
font set and generate two other files: FOO.ED (EARS directory) and
FOO.EM (EARS multiple). After the initial generation of a font set run
GEARS FOO/S TEXT.

        Global directives must appear at the beginning of a text file
and only one global directive may appear on a text line. Note that
many global directives require a special password since they are used
for debug only and can produce bizarre results. GEARS makes very few
consistency checks (e.g., if the line height is set less than the font
height, the lines merely overlap a little) -- so be careful!

        Local directives may be arbitrarily sprinkled throughout the
text with interesting results. The coordinate system for page
composition is shown in Figure 1. The basic unit is .002 inches with
the origin in the lower left of a portrait page. Some care should be
used in applying directives. For example, it is avisable, although not
necessary, to change to a landscape font if the ↑L landscape directive
is used.

        A list of the primitive microcode directives that are accessed
by the local directives is given in Appendix 1.
↑L

3.1. Summary of Gears Options

3.1.1. Global Switches

/A	absolute, no formatting except page breaks
/D	process directive preceded by ↑ (Not control)
/F	generate intermediate file FOO.EB where FOO is name of first text file
/L	print in landscape mode
/N	no heading
/P	proportional default font
/R	long lines truncated instead of wrapped around
/S	small default font
/T	test mode--no EFTP
/Z	reads RCG-format files
/n	make n copies for n = 1 to 9

3.1.2. Local Switches

FOO/F	use font FOO (must include extensions listed by FEARS)
FOO/G	generate font set for all following files
FOO/S	use font set FOO for all following files
Text/H	add this text to the default heading on each page - no blanks or slashes allowed
FOO/n	print text file FOO with the TTY Tab set for n spaces rather than the default value of 8

Note: Font set and Default font must come before text file name.
Font set and/or font specification is optional. As many files as you
like may be printed subject to disk restrictions (<500 pages).

GEARS processes four control characters, fourteen global
directives, and sixteen local directives.

3.1.3. Control Characters

carriage return	- end of line
form feed	- end of page
tab	- space to next column
line feed.	- ignored

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3.1.4. Global Directives - [Must be at beginning of file
     but may be embedded in a text string such as a BCPL
     comment.]
               ↑Bn. Bottom Margin
               ↑Cn. Clock Frequency in bits/inch*
               ↑Dn. Default font (0-15)
               ↑Gn. Software Left Margin (Gap)
               ↑Hn. Height from one line to next
               ↑In. Hardware Left Margin* (Indent)
               ↑Ln. Length of line in characters before wrap around.
               ↑Mn. Motor speed in lines/inch*
               ↑Nn. Number of scan lines allowed on page*
               ↑Pn. Password*
               ↑Rn. Raise bottom margin (Hardware)*
               ↑Sn. Change TTY tab stops to n spaces
               ↑Tn. Top Margin.
               ↑Xn. Xerox n copies

                 *These parameters are preset and modified for
                  debug only. The system ignores these directives
                  without the proper password.

3.1.5. Local Directive [imbedded in text strings]

        ↑an.   Alter text line location to n
                bits from bottom page
        ↑bn.   Blank of width n bits
        ↑d.   revert to default font with default spacing
        ↑e   End of page (same as Form feed)
        ↑fn.   Font change to n (0-15)
        ↑hn.   Change height from one line to next.
        ↑jn.   ↑A relative to text base line (Jump)
        ↑l   Landscape string follows
        ↑o   Overlay next character
        ↑rw.h. Solid rectangle of width w and height h.
                Used to generate vertical and horizontal lines in forms.
                This directive only works after an ↑fn. that
                selects font RECTANGLE.EP
        ↑sn.   Space modification for next character
        ↑tn.   Tab to line n
        ↑un.   Unusual line--print only on copy n
        ↑vn.   Vector mode--modify space and width
                 of next character
        ↑wn.   Width modification of next character
        ↑*n.   *escape as in BCPL-n becomes Ascii
                                 8

        Note: Unknown directives are ignored so that ↑↑ will print ↑.
↑L

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4. EARS FILE FORMAT

        This section is included for those who would like to write their own text composers. This file type has an .EB extension on ALTOs and an .EARS extension on MAXC and may be sent to Palo via EFTP on an ALTO or COPY on MAXC. The standard EARS file format is page oriented. Each section of the print file is blocked in 256 word records. The complete file is structured as follows:

Mnemonics	Optional?	Description
DL 1	No	Display list page 1
TL 1	No	Text line array page 1
.		
.		
.		
.		
DL n	Yes	Display list page n
TL n	Yes	Text line array page n
PD	No	Page directory
FD	Yes	Font directory
FM 1	Yes	Font memory set 1
FS 1	Yes	Font specification set 1
.		
.		
.		
.		
.		
.		
.		
FM m	Yes	Font memory set m
FS m	Yes	Font specification set m
DD	No	Document Directory

        The page layout for EARS is shown in Figure 1. The default scan resolution is 500 scan line/inch and 500 bits/inch. These numbers are independently variable for special applications.

4.1. Display List [DL]

        EARS requires a separate display list for each page. A display list contains strings of ascii characters with imbedded directives. Each entry in the display list is an eight bit code. Characters have values between 0 and 177 octal. Directives have a value between 200 and 377. Directives may be either one or two bytes long.   Appendix 1 gives the EARS 8-bits character and directive code. The DL may also contain up to 40 tab stops. If used, the first word of the DL must be -1 followed by 40 tab positions.
↑L

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4.2. Text Line Array [TL]

EARS requires initialization information for each text string on a page. A page may have 512 strings. The TL array has four entries per text string.

Entry

0   distribution index**

1   byte pointer to first character of string in DL

2   initial font *128

3   initial text line location *8 (i.e. YBA *8)

**If this entry is zero, the corresponding text string is printed on all copies. If the entry is n, the string is only printed on copy n. The last distribution index for a page must have its sign bit set.

4.3. Page Directory [PD]

Ears allows up to 256 pages/document. Each page requires four entries in the PD.

Entry

0   starting record of DL for this page
     (referenced from start of file - first entry equals zero)

1   Number of records in DL

2   Number of records in TL

3   Font set number (negative implies default font set)

4.4. Font Directory [FD] [Optional]

Entry

0   Starting record of FM for this font set
     (referenced from beginning of first FM)

1   Number of records in FM

2   Number of records in FS

3   TTY tab for this font set

4.5. Font Memory [FM] [Optional]

EARS allows up to 32k of font memory for each set. This data must be
↑L

in the standard MRLI format for the RCG.   The first word of FM is
special and must always be #20200. No checks are made on this data so
beware!

4.6. Font Specification [FS] [Optional]

This array allows the user to properly identify 128 charactrers in each
of 16 fonts. Each character requires four elements.

Entry

0   character alignment (zero implies
      special character--i.e., undefined
      or blank)

1   space

2   width-1(10MSB) and height-1(6LSB)

3   height-1(MSB) and font address(15LSB)
↑L

4.7. Document Directory [DD]

This is a single 256 word record.

    Entry

0	general password (31415)
	[replaced by first sector in core]
1	total number of records in this file
2	number of pages
3	number of copies
4	font set used on last page (same default
	conventions as used in PD)
5	starting record of last page
6	length of last page DL
7	length of last page TL
10	length of PD
11	length of FD
12	left margin ** -1 implies use of default values
13	bottom margin * All values ignored
14	bits/inch * unless special password is used.
15	lines/inch *
16	maximum number *
	of scan lines **
17	special password (default is zero)
20	**
to	* reserved for PUB
23	**

The following entries are printed on the break
page between files.

200 ID string terminated by EOL (32 words)
  8   8

232 Creator terminated by EOL (20 words)
  8   8

252 Creation date terminated by EOL
  8
   (24 words)
     8

4.8. Disclaimer

It is clear that the preceding file definition is not complete
(e.g., the format of FM is not given and the exact definitions for FS
are not given).   This is intentional since most users do not need to
know the messy details. If you need these details, come talk to me.
↑L

5. EARS FONT FILES

There are five types of font files which are used either directly or indirectly by the EARS system.

5.1. .CU [Carnegie University] Font Files

The font compressor uses .CU files as input and creates .EP, .EL and .ES files.

Record 0 (2 words)

    0   MH (Maximum height of character matrix in bits)
    1   MW (Maximum width of character matrix in 16-bit words)

Record 1 (1 record per character 2 + MH * MW words)

    0   Ascii code for character
    1   Width of this character in bits

The remaining MH*MW words contain a matrix representation of the character scanned left to right and top to bottom.

5.2. .EP [EARS portrait] and .EL [EARS Landscape] Font Files

These files are usually generated by the font compressor and contain redundant information that is easily usable by either a composition program or the EARS character generation hardware.

Record 0 (64 words - only 8 words are used)

    0   Length of record 2 in words
    1   Maximum character width in bits
    2   Maximum character height in bits
    3   Default TTY Tab in bits (usually one space)
    4   **
    5   *   Reserved for PSPOOL on MAXC
    6   *
    7   **

Record 1   (1024 words - 8 entries/character)

0	font address in words
1	storage length in words
2	character space in bits
3	character width in bits
4	character height in bits
5	character baseline in bits

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```
        6     code  <0;   MRLI coding

                    =0; special character
                        (blank or undefined)

                    >0; matrix coding
                        height in bytes

        7     character alignment in bits - i.e. the same as
              baseline in .EP but equals the distance from
              top of matrix to bottom of ink in .EL


     Record 2  (font storage)

       FM    data in MRLI format


     Record 3  (512 words - Font Specification Table
                    - 4 entries/character)

        0     Alignment (13 MSB) and Code (3LSB)
                    Alignment  two's complement
                    Matrix bit 13
                    End of page bit 14
                    Not end of line bit 15
        1     Space in bits
        2     Width -1 in bits (10 MSB) and
              height-1 in bytes (6 LSB)
        3     LSB of height-1 (MSB) and
              font address in words (15 LSB)
```

5.3. .ES [EARS specification]

    This is a text file output by the font compresser   which gives
detailed information about each character in the font.

5.4. .EM [EARS Multiple] font file

    This file contains up to sixteen fonts. It is constructed from
.EP and .EL files and is equivalent to the FM and FS entries in an .EB
or .EARS file. An .ED (EAnRS directory) file is created simultaneously
with an .EM file. The .ED file is discussed in the next section and is
a small directory into the .EM file.

        Record 0 (up to 32k words long - padded to
                be a multiple of 256 words)
                Word 0 of this record is always #20200. The
                rest of the record is MRLI data copies from the
                second record of selected .EP and .EL files.
↑L

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Record 1

This record is a directory or specification for the font data in record 0 of this file. Each character is specified by four numbers as follows:

    0   Alignment (13 MSB) and Code (3 LSB)
    1   Space in bits
    2   Width-1 in bits (10MSB) and
         height-1 in bytes (6 LSB)
    3   LSB of height-1 (MSB) and font address
         in words (15 LSB)

Note that this data may be copied directly from record 3 of an appropriate .EP or .EL file with the exception that each font address entry must be relocated to point to the proper data in record 0. The first 128 characters of this record represent characters 0-127 in font 0. The next 128 characters represent characters 0-127 in font 1. Up to 16 fonts may be included provided record 0 does not exceed 32k words.

5.5. .ED [EARS Directory] file

This is a small file that is a directory for a .EM file and is used by GEARS.   It is always 260 words long of which the first four words are a header and the remaining are allocated 16 words per font. Unused space should be zero'd.

    Header
         0   Number of fonts in font set
         1   Number of 256 word records in FM
         2   Number of 256 word records in FS
         3   Default TTY Tab in bits

    Font Data
         0   Number of characters in font name
         1   Maximum width in bits
         2   Maximum height in bits
         3   TTY tab in bits
         4-17 BCPL string containing font name
              (unused bytes should contain nulls)
↑L