

groff

The GNU implementation of `troff`
version 1.24.1
March 2026

Trent A. Fisher
Werner Lemberg
G. Branden Robinson

This manual documents GNU **troff** version 1.24.1.

Copyright © 1994–2018 Free Software Foundation, Inc.

Copyright © 2018–2026 G. Branden Robinson

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled “GNU Free Documentation License”.

Table of Contents

1	Introduction	1
1.1	Background	1
1.2	What Is groff ?	1
1.3	GNU troff Capabilities	2
1.4	Macro Packages	2
1.5	Preprocessors	3
1.6	Output Devices	3
1.7	Installation	3
1.8	Conventions Used in This Manual	4
1.9	Credits	5
2	Invoking groff	7
2.1	Options	7
2.2	Environment	12
2.3	Macro Directories	14
2.4	Font Directories	14
2.5	Paper Format	15
2.6	Invocation Examples	15
3	Tutorial for Macro Package Users	17
3.1	Basics	17
3.2	Common Features	19
3.2.1	Paragraphs	19
3.2.2	Sections and Chapters	20
3.2.3	Headers and Footers	20
3.2.4	Page Layout	20
3.2.5	Displays and Keeps	21
3.2.6	Footnotes and Endnotes	21
3.2.7	Table of Contents	21
3.2.8	Indexing	21
3.2.9	Document Formats	22
3.2.10	Columnation	22
3.2.11	Font and Size Changes	22
3.2.12	Predefined Text	22
3.2.13	Preprocessor Support	22
3.2.14	Configuration and Customization	22
4	Macro Packages	23
4.1	man	23
4.1.1	Optional man extensions	23

Custom headers and footers	23
Ultrix-specific man macros	24
Simple example	25
4.2 <code>mdoc</code>	25
4.3 <code>me</code>	26
4.4 <code>mm</code>	26
4.5 <code>mom</code>	26
4.6 <code>ms</code>	26
4.6.1 Introduction	27
4.6.1.1 Basic information	27
4.6.2 Document Structure	29
4.6.3 Document Control Settings	30
Margin settings	30
Titles (headers, footers)	31
Text settings	31
Paragraph settings	32
Heading settings	33
Footnote settings	33
Display settings	35
Other settings	35
4.6.4 Document Description Macros	35
4.6.5 Body Text	37
4.6.5.1 Text settings	37
4.6.5.2 Typographical symbols	38
4.6.5.3 Paragraphs	38
4.6.5.4 Headings	39
4.6.5.5 Typeface and decoration	42
4.6.5.6 Lists	44
4.6.5.7 Indented regions	46
4.6.5.8 Keeps, boxed keeps, and displays	47
4.6.5.9 Tables, figures, equations, and references	49
4.6.5.10 Footnotes	51
4.6.5.11 Language and localization	52
4.6.6 Page layout	53
4.6.6.1 Headers and footers	53
4.6.6.2 Tab stops	54
4.6.6.3 Margins	54
4.6.6.4 Multiple columns	54
4.6.6.5 Creating a table of contents	55
4.6.7 Differences from AT&T <code>ms</code>	57
4.6.7.1 Unix Version 7 <code>ms</code> macros unimplemented by <code>groff ms</code> ..	59
4.6.8 Legacy Features	59
AT&T accent mark strings	59
Berkeley accent mark and glyph strings	60
4.6.9 Naming Conventions	62

5	GNU troff Reference	63
5.1	Text	63
5.1.1	Filling	63
5.1.2	Sentences	64
5.1.3	Hyphenation	65
5.1.4	Breaking	66
5.1.5	Adjustment	67
5.1.6	Tabs and Leaders	67
5.1.7	Requests and Macros	67
5.1.8	Macro Packages	70
5.1.9	Input Format	70
5.1.10	Input Encodings	71
5.1.11	Input Conventions	72
5.2	Page Geometry	75
5.3	Measurements	76
5.3.1	Motion Quanta	77
5.3.2	Default Units	77
5.4	Numeric Expressions	78
5.5	Identifiers	82
5.6	Formatter Instructions	84
5.6.1	Control Characters	85
5.6.2	Invoking Requests	86
5.6.3	Calling Macros	87
5.6.4	Using Escape Sequences	89
5.6.5	Delimiters	91
5.7	Comments	93
5.8	Registers	94
5.8.1	Setting Registers	95
5.8.2	Interpolating Registers	97
5.8.3	Auto-increment	97
5.8.4	Assigning Register Formats	98
5.8.5	Built-in Registers	100
5.9	Manipulating Filling and Adjustment	101
5.10	Manipulating Hyphenation	108
5.11	Manipulating Spacing	116
5.12	Tabs and Fields	119
5.12.1	Leaders	122
5.12.2	Fields	123
5.13	Character Translations	124
5.14	troff and nroff Modes	125
5.15	Line Layout	126
5.16	Line Continuation	129
5.17	Page Layout	130
5.18	Page Control	131
5.19	Using Fonts	134

5.19.1	Selecting Fonts	135
5.19.2	Font Families	137
5.19.3	Font Positions	139
5.19.4	Characters and Glyphs	140
5.19.5	Character Classes	148
5.19.6	Special Fonts	149
5.19.7	Artificial Fonts	150
5.19.8	Ligatures and Kerning	152
5.19.9	Italic Corrections	154
5.19.10	Dummy Characters	154
5.20	Manipulating Type Size and Vertical Spacing	156
5.20.1	Changing the Type Size	156
5.20.2	Changing the Vertical Spacing	158
5.20.3	Using Fractional Type Sizes	159
5.21	Colors	161
5.22	Strings	163
5.23	Conditionals and Loops	168
5.23.1	Operators in Conditionals	168
5.23.2	if-then	170
5.23.3	if-else	171
5.23.4	Conditional Blocks	171
5.23.5	while	173
5.24	Writing Macros	175
5.24.1	Parameters	178
5.24.2	Copy Mode	180
5.25	Page Motions	184
5.26	Output Line Annotation	189
5.27	Drawing Geometric Objects	192
5.28	Deferring Output	196
5.29	Traps	197
5.29.1	Vertical Position Traps	197
5.29.1.1	Page Location Traps	198
5.29.1.2	The Implicit Page Trap	202
5.29.1.3	Diversion Traps	203
5.29.2	Input Line Traps	203
5.29.3	Blank Line Traps	206
5.29.4	Leading Space Traps	206
5.29.5	End-of-input Traps	206
5.30	Diversions	208
5.31	Punning Names	214
5.32	Environments	216
5.33	Suppressing Output	219
5.34	Host System Service Access	220
5.35	Postprocessor Access	226
5.36	Miscellaneous	228
5.37	GNU troff Internals	228

5.38	Debugging	231
5.38.1	Warnings	236
5.39	Implementation Differences	238
5.39.1	Safer Mode	238
5.39.2	Compatibility Mode	238
5.39.3	Other Differences	242
6	File Formats	247
6.1	Device and Font Description Files	247
6.1.1	DESC File Format	247
6.1.2	Font Description File Format	250
6.2	GNU <code>troff</code> Output	253
6.2.1	Language Concepts	254
6.2.1.1	Syntax	254
6.2.1.2	Argument Units	255
6.2.1.3	Output Structure	255
6.2.2	Command Reference	256
6.2.2.1	Comment Command	256
6.2.2.2	Simple Commands	256
6.2.2.3	Graphics Commands	258
6.2.2.4	Device Control Commands	261
6.2.2.5	Legacy Compressed Encoding	263
6.2.3	GNU <code>troff</code> Output Examples	264
6.2.4	Output Language Compatibility	266
Appendix A	Copying This Manual	267
Appendix B	Request Index	277
Appendix C	Escape Sequence Index	281
Appendix D	Operator Index	283
Appendix E	Register Index	285
Appendix F	Macro Index	289
Appendix G	String Index	291
Appendix H	File Keyword Index	293

Appendix I	Program and File Index.....	295
Appendix J	Concept Index	297

1 Introduction

GNU **roff** (or **groff**) is a programming system for typesetting documents. It is highly flexible and has been used extensively for over thirty years.

1.1 Background

M. Douglas McIlroy, formerly of AT&T Bell Laboratories and present at the creation of the Unix operating system, offers an authoritative historical summary.

The prime reason for Unix was the desire of Ken [Thompson], Dennis [Ritchie], and Joe Ossanna to have a pleasant environment for software development. The fig leaf that got the nod from ... management was that an early use would be to develop a “stand-alone” word-processing system for use in typing pools and secretarial offices. Perhaps they had in mind “dedicated”, as distinct from “stand-alone”; that’s what eventuated in various cases, most notably in the legal/patent department and in the AT&T CEO’s office.

Both those systems were targets of opportunity, not foreseen from the start. When Unix was up and running on the PDP-11, Joe got wind of the legal department having installed a commercial word processor. He went to pitch Unix as an alternative and clinched a trial by promising to make **roff** able to number lines by tomorrow in order to fulfill a patent-office requirement that the commercial system did not support.

Modems were installed so legal-department secretaries could try the Research machine. They liked it and Joe’s superb customer service. Soon the legal department got a system of their own. Joe went on to create **nroff** and **troff**. Document preparation became a widespread use of Unix, but no stand-alone word-processing system was ever undertaken.

A history relating **groff** to its forerunners **roff**, **nroff**, and **troff** is available in *roff*(7).

1.2 What Is groff?

groff (GNU **roff**) is a typesetting system that reads plain text input that includes formatting commands to produce output in PostScript, PDF, HTML, or other formats, or for display to a terminal. Formatting commands can be low-level typesetting primitives, macros from a supplied package, or user-defined macros. All three approaches can be combined.

A reimplementaion and extension of **troff** and other programs from AT&T Unix, **groff** is widely available on POSIX and other systems owing to its long association with Unix manuals, including man pages. It and its

predecessor have produced several best-selling software engineering texts. **groff** can create typographically sophisticated documents while consuming minimal system resources.

Like its predecessor “troff”, the term “groff” affords two popular pronunciations: as one syllable (like the surname), rhyming with “trough”, or as “jee-roff”, in analogy to the Bell Labs pronunciation “tee-roff”. Little risk of confusion exists; use whichever suits you.

The architecture of the GNU **roff** system follows that of other device-independent **roff** implementations, comprising preprocessors, macro packages, output drivers (or “postprocessors”), and a suite of utilities, with the formatter program **troff** at its heart.

The front end programs available in the GNU **roff** system make it easier to use than traditional **roffs** that required the construction of pipelines or use of temporary files to carry a source document from maintainable form to device-ready output.

1.3 GNU troff Capabilities

GNU **troff** is a typesetting document formatting program; it provides a wide range of low-level text and page operations within the framework of a programming language. These operations compose to generate footnotes, tables of contents, mathematical equations, diagrams, multi-column text, and other elements of typeset works. Here is a survey of formatter features; all are under precise user control.

- text filling, breaking, alignment to the left or right margin; centering
- adjustment of inter-word space size to justify text, and of inter-sentence space size to suit local style conventions
- automatic and manual determination of hyphenation break points
- pagination
- selection of any font available to the output device
- adjustment of type size and vertical spacing (or “leading”)
- configuration of line length and indentation amounts; columnation
- drawing of geometric primitives (lines, arcs, polygons, circles, . . .)
- setup of stroke and fill colors (where supported by the output device)
- embedding of hyperlinks, images, document metadata, and other inclusions (where supported by the output device)

1.4 Macro Packages

Elemental typesetting functions can be laborious to use directly with complex documents. A *macro* facility specifies how certain routine operations, such as starting paragraphs, or printing headers and footers, should be performed in terms of those low-level instructions. One then *calls* the

macro to make it perform its task. Macros can be specific to one document or collected together into a *macro package* for use by many. **groff** supplies versions of the widely used macro packages **man**, **mdoc**, **me**, **mm**, **mom**, and **ms**.

1.5 Preprocessors

An alternative approach to complexity management, particularly when constructing tables, setting mathematics, or drawing diagrams, lies in preprocessing. A *preprocessor* employs a domain-specific language to ease the generation of tables, equations, and so forth in terms that are convenient for human entry. Each preprocessor reads a document and translates relevant portions of it into GNU **troff** input. Command-line options to **groff** tell it which preprocessors to use.

groff provides preprocessors for laying out tables (**tbl**), typesetting equations (**eqn**), drawing diagrams (**pic** and **grn**), inserting bibliographic references (**refer**), and drawing chemical structures (**chem**). An associated program that is useful when dealing with preprocessors is **soelim**.

groff also supports **grap**, a preprocessor for drawing graphs. A free implementation of it can be obtained separately.¹

Unique to **groff** is the **preconv** preprocessor that enables GNU **troff** to handle documents in a variety of input encodings, including UTF-8. Unlike most preprocessors, **preconv** operates on its entire input rather than transforming specially marked regions of a document.

Other preprocessors exist, but no free implementations are known. An example is **ideal**, which draws diagrams using a mathematical constraint language.

1.6 Output Devices

GNU **troff**'s output is in a device-independent page description language. An *output driver* translates this language into a file format or byte stream that a piece of (possibly emulated) hardware understands. **groff** features output drivers for PostScript devices, terminal emulators (and other simple typewriter-like machines), X11 (for previewing), TeX DVI, HP LaserJet 4/PCL5 printers, Canon LBP (CaPSL-using printers), HTML, XHTML, and PDF.

1.7 Installation

Locate installation instructions in the files **INSTALL**, **INSTALL.extra**, and **INSTALL.REPO** in the **groff** source distribution. Being a GNU project, **groff** supports the familiar `./configure && make` command sequence.

¹ <https://www.lunabase.org/~faber/Vault/software/grap/>

1.8 Conventions Used in This Manual

We apply the term “groff” to the language documented here, the GNU implementation of the overall system, the project that develops that system, and the command of that name. In the first sense, **groff** is an extended dialect of the **roff** language, for which many similar implementations exist. We say “the formatter” when speaking of behavior that is generally true of **troff** and **nroff** programs.

A tradition has arisen that GNU programs’ names bear a prefix ‘g’ where necessary to distinguish them from other implementations on the host system (see Section 2.2 [Environment], page 12). Thus, for example, ‘**geqn**’ is GNU **eqn**. On operating systems that lack a **troff** of different provenance, this prefix is omitted; GNU **troff** is the only **troff** available. Exceptionally, ‘**groff**’ always retains its leading ‘g’.

We call non-GNU **troff** systems AT&T **troff** because that is the common origin of almost all **troff** implementations² (with more or less compatible changes).

This manual employs Emacs names for non-graphic keycap engravings on the alphabetic section of the keyboard. “RET” is Return or Enter, and “SPC” is the space bar.

The **roff** language features several major syntactical categories within which many items are predefined. Presentations of these items comprise the form in which the item is most commonly used on the left, and, aligned to the right margin, the name of the category in brackets.

\n[example] [Register]

The register ‘example’ is one that **groff** *doesn’t* predefine. You can create it yourself, though; see Section 5.8.1 [Setting Registers], page 95.

To make this document useful as a reference and not merely amiable bedtime reading, we tend to present these syntax items in exhaustive detail when they arise. References to topics discussed later in the text are frequent; skim material you haven’t mastered yet.

We use Texinfo’s “result” ($\Rightarrow$) and error notations to present output written to the standard output and standard error streams, respectively. Diagnostic messages from the GNU **troff** formatter and other programs are examples of the latter, but the formatter can also be directed to write user-specified messages to the standard error stream. The notation then serves to identify the output stream and does not necessarily mean that an error has occurred.³

² Besides **groff**, **neatroff** is an exception.

³ Unix and related operating systems distinguish standard output and standard error streams *because* of **troff**: <https://www.tuhs.org/pipermail/tuhs/2013-December/006113.html>.

```
$ echo "Twelve o'clock and" | groff -T ascii | sed '/^$/d'
⇒ Twelve o'clock and
$ echo '.tm all is well.' | groff > /dev/null
error all is well.
```

Sometimes we use $\Rightarrow$ abstractly to represent formatted text that you will need to use a PostScript or PDF viewer program (or a printer) to observe. While arguably an abuse of notation, we think this preferable to requiring the reader to understand the syntax of these page description languages.

We also present diagnostic messages in an abbreviated form, often omitting the name of the program issuing them, the input file name, and line number or other positional information when such data do not serve to illuminate the topic under discussion.

Most examples are of **roff** language input that would be placed in a text file. Occasionally, we start an example with a '\$' character to indicate a shell prompt, as seen above.

We encourage you to try the examples yourself, and to alter them to better learn **groff**'s behavior. Our examples sometimes need to direct the formatter to set a line length (with '.ll') that fits within the page margins of this manual. We mention this so that you know why it is there before we discuss the ll request formally.⁴

We refer occasionally to *man* pages, in which aspects of the **groff** system or of its operating environment are further documented.⁵ When you see a citation like *groff_man*(7), understand that you can type '**man groff_man**' at the command line to view it. The numbered category distinguishes pages by their purpose. You can try '**man 'groff(1)'**' and '**man 'groff(7)'**' to observe this distinction.⁶ Your system likely offers an *intro*(1) page that will help you make the most of this resource.

1.9 Credits

We adapted portions of this manual from existing documents. James Clark's *man* pages were an invaluable foundation; we have updated them in parallel with the development of this manual. We based the tutorial for macro package users on Eric Allman's introduction to his **me** macro package (which we also provide, little altered from 4.4BSD). Larry Kollar contributed much of the material on the **ms** macro package.

⁴ See Section 5.15 [Line Layout], page 126.

⁵ **roff** is the language of historical Unix manuals, and of *man* pages to this day.

⁶ POSIX has not standardized a mechanism for the **man** command to distinguish pages by numeric category. If '**man 'groff(7)'**' produces an error, attempt '**man 7 groff**' or '**man -s 7 groff**'.

2 Invoking groff

This chapter focuses on how to invoke the **groff** front end, which constructs a pipeline connecting desired preprocessors, the GNU **troff** formatter program, and a postprocessor.

2.1 Options

groff runs the GNU **troff** program and, normally, a postprocessor appropriate to the selected device. The default device is ‘**ps**’, unless changed at **groff**’s build-time configuration. **groff** can preprocess input with any of **pic**, **eqn**, **tbl**, **grn**, **grap**, **chem**, **refer**, **soelim**, or **preconv**.

This section documents only options to the **groff** front end. Since it passes many of its arguments to GNU **troff**, we describe many of the latter’s options here. Arguments to preprocessors and output drivers can be found in the man pages **pic**(1), **eqn**(1), **tbl**(1), **grn**(1), **refer**(1), **chem**(1), **soelim**(1), **preconv**(1), **grotty**(1), **grops**(1), **gropdf**(1), **grohtml**(1), **grodvi**(1), **grolj4**(1), **grolbp**(1), and **gxditview**(1).

A summary of **groff**’s usage follows.

```
groff [-abcCeGgIjklNpRsStUVXzZ] [-d cs] [-d string=text]
      [-D fallback-encoding] [-f font-family]
      [-F font-directory] [-I inclusion-directory]
      [-K input-encoding] [-L spooler-argument]
      [-m macro-package] [-M macro-directory]
      [-n page-number] [-o page-list]
      [-P postprocessor-argument] [-r cnumeric-expression]
      [-r register=numeric-expression] [-T output-device]
      [-w warning-category] [-W warning-category]
      [file ...]
```

troff shares much of this interface; **groff** passes relevant options and operands to it.

```
troff [-abcCEiRSUz] [-f font-family] [-F font-directory]
      [-I inclusion-directory] [-m macro-package]
      [-M macro-directory] [-n page-number] [-o page-list]
      [-r cnumeric-expression]
      [-r register=numeric-expression] [-T output-device]
      [-w warning-category] [-W warning-category]
      [file ...]
```

Options that don’t take arguments can be clustered after a single **-**. A *file* operand of **-** denotes the standard input stream.

All **groff** commands accept a **--help** option, which summarizes usage similarly to the foregoing, and **--version**, which discloses release information. Both exit with a successful status after reporting.

The rest of **groff**’s command-line options are as follows.

- ‘-a’ Generate a plain text approximation of the typeset output. The read-only register `.A` is set to 1. See Section 5.8.5 [Built-in Registers], page 100. This option produces a sort of abstract preview of the formatted output.
- Page breaks are marked by a phrase in angle brackets; for example, ‘<beginning of page>’.
 - Lines are broken where they would be in formatted output.
 - Vertical motion, apart from that implied by a break, is not represented.
 - A horizontal motion of any size is represented as one space. Adjacent horizontal motions are not combined. Supplemental inter-sentence space (configured by the second argument to the `ss` request) is not represented.
 - A special character is rendered as its identifier between angle brackets; for example, a hyphen appears as ‘<hy>’.
- The above description should not be considered a specification; the details of `-a` output are subject to change.
- ‘-b’ Write a backtrace reporting the state of `troff`’s input parser to the standard error stream with each diagnostic message. The line numbers given in the backtrace might not always be correct, because `troff`’s idea of line numbers can be confused by requests that append to macros.
- ‘-c’ Disable multi-color output and `color` request’s ability to enable it.
- ‘-C’ Enable AT&T `troff` compatibility mode; implies `-c`. See Section 5.39 [Implementation Differences], page 238, for the list of incompatibilities between `groff` and AT&T `troff`.
- ‘-d *c*text’
‘-d *string*=*text*’ Define `roff` string *c* or *string* as *text*. *c* must be one character; *string* can be of arbitrary length. Such assignments happen before any macro file is loaded, including the startup file. Due to `getopt_long(3)` limitations, *c* cannot be, and *string* cannot contain, an equals sign, even though that is a valid character in a `roff` identifier. See Section 5.22 [Strings], page 163.
- ‘-D *enc*’ Set fallback input encoding used by `preconv` to *enc*; implies `-k`.
- ‘-e’ Run `eqn` preprocessor.
- ‘-E’ Inhibit `troff` error messages. This option does *not* suppress messages sent to the standard error stream by documents or macro packages using `tm` or related requests.

- ‘**-f fam**’ Use *fam* as the default font family. See Section 5.19.2 [Font Families], page 137.
- ‘**-F dir**’ Search in directory *dir* for the selected output device’s directory of device and font description files. See Section 2.4 [Font Directories], page 14.
- ‘**-g**’ Run **grn** preprocessor.
- ‘**-G**’ Run **grap** preprocessor; implies **-p**.
- ‘**-h**’ Display a usage message and exit.
- ‘**-i**’ Read the standard input stream after all the named input files have been processed.
- ‘**-I dir**’ Search the directory *dir* for files named in several contexts; implies **-g** and **-s**.
- **soelim** replaces lines matching ‘*.so file-name*’ with the contents of *file-name*.
 - **troff** searches for files named as operands in its command line and as arguments to **psbb**, **so**, and **soquiet** requests.
 - Output drivers may search for files; for instance, **grops** looks for files named in ‘**\X'ps: import ...'**’, ‘**\X'ps: file ...'**’, and ‘**\X'pdf: pdfpic ...'**’ device extension escape sequences.
- This option may be specified more than once; the directories are searched in the order specified. If you want to search the current directory before others, add ‘**-I .**’ at the desired place. The current working directory is otherwise searched last. **-I** works similarly to, and is named for, the “include” option of Unix C compilers.
- groff** passes **-I** options and their arguments to **soelim**, **troff**, and output drivers; with the option letter changed to **-M**, it passes the same arguments to **grn**.
- ‘**-j**’ Run **gchem** preprocessor. Implies **-p**.
- ‘**-k**’ Run **preconv** preprocessor. Refer to its man page for its behavior if neither of **groff**’s **-K** or **-D** options is also specified.
- ‘**-K enc**’ Set input encoding used by **preconv** to *enc*; implies **-k**.
- ‘**-l**’ Send the output to a spooler for printing. The **print** directive in the device description file specifies the default command to be used; see Section 6.1 [Device and Font Description Files], page 247. See options **-L** and **-X**.
- ‘**-L arg**’ Pass *arg* to the print spooler. If multiple *args* are required, pass each with a separate **-L** option. **groff** does not prefix an option dash to *arg* before passing it to the spooler.

- '-m *mac*' Search for the macro package *mac.tmac* and read it prior to any input. If not found, *tmac.mac* is attempted. See Section 2.3 [Macro Directories], page 14. **groff** passes -m options and their arguments to **eqn**, **grap**, and **grn**.
- '-M *dir*' Search directory *dir* for macro files. See Section 2.3 [Macro Directories], page 14. **groff** passes -M options and their arguments to **eqn**, **grap**, and **grn**.
- '-n *num*' Begin numbering pages at *num*. The default is '1'.
- '-N' Prohibit newlines between **eqn** delimiters: pass -N to **eqn**.
- '-o *list*' Output only pages in *list*, which is a comma-separated list of page ranges; '*n*' means page *n*, '*m-n*' means every page between *m* and *n*, '*-n*' means every page up to *n*, '*n-*' means every page from *n* on. **troff** stops processing and exits after formatting the last page enumerated in *list*.
- '-p' Run **pic** preprocessor.
- '-P *arg*' Pass *arg* to the postprocessor. If multiple *args* are required, pass each with a separate -P option. **groff** does not prefix an option dash to *arg* before passing it to the postprocessor.
- '-r *numeric-expression*'
- '-r *register=numeric-expression*' Define **roff** register *c* or *register* as *numeric-expression* (see Section 5.4 [Numeric Expressions], page 78). *c* must be one character; *register* can be of arbitrary length. Such assignments happen before any macro file is loaded, including the startup file. Due to *getopt_long*(3) limitations, *c* cannot be, and *register* cannot contain, an equals sign, even though that is a valid character in a **roff** identifier. See Section 5.8 [Registers], page 94.
- '-R' Run **refer** preprocessor. No mechanism is provided for passing arguments to it; most **refer** options have equivalent language elements that can be specified within the document.

troff also accepts a -R option, which is not accessible via **groff**. This option facilitates troubleshooting by preventing the loading of the **troffrc** and **troffrc-end** files.
- '-s' Run **soelim** preprocessor.
- '-S' Operate in "safer" mode; see -U below for its opposite. Safer mode is enabled by default. Explicitly specifying -S causes **troff** to ignore any subsequent -U option.
- '-t' Run **tbl** preprocessor.
- '-T *dev*' Prepare output for device *dev*. **groff** passes the -T option and its argument to **troff**, then (unless the -Z option is used) runs

an output driver to convert `troff`'s output to a form appropriate for `dev`. The following output devices are available.

<code>ps</code>	For PostScript printers and previewers.
<code>pdf</code>	For PDF viewers or printers.
<code>dvi</code>	For <code>T_EX</code> DVI format.
<code>X75</code>	For a 75 dpi X11 previewer.
<code>X75-12</code>	For a 75 dpi X11 previewer with a 12-point base font in the document.
<code>X100</code>	For a 100 dpi X11 previewer.
<code>X100-12</code>	For a 100 dpi X11 previewer with a 12-point base font in the document.
<code>ascii</code>	For typewriter-like devices using the (7-bit) ISO 646:1991 IRV (US-ASCII) character set.
<code>latin1</code>	For typewriter-like devices that support the ISO Latin-1 (8859-1) character set.
<code>utf8</code>	For typewriter-like devices that use the ISO 10646 (Unicode) character set with UTF-8 encoding.
<code>lj4</code>	For HP LaserJet4-compatible (or other PCL5-compatible) printers.
<code>lbp</code>	For Canon CaPSL printers (LBP-4 and LBP-8 series laser printers).
<code>html</code> <code>xhtml</code>	To produce HTML and XHTML output, respectively. This driver consists of two parts, a preprocessor (<code>pre-grohtml</code>) and a postprocessor (<code>post-grohtml</code>).

The predefined GNU `troff` string `.T` contains the name of the output device; the read-only register `.T` is set to 1 if this option is used (which is always true if `groff` is used to run GNU `troff`). See Section 5.8.5 [Built-in Registers], page 100.

The postprocessor to be used for a device is specified by the `postpro` command in the device description file. (See Section 6.1 [Device and Font Description Files], page 247.) This selection can be overridden with the `-X` option.

‘`-U`’ Operate in *unsafe mode*, enabling the `cf`, `open`, `opena`, `pi`, `pso`, and `sy` requests, which are disabled by default because they allow an untrusted input document to run arbitrary commands, put arbitrary content into `troff` output, or write to arbitrary

file names.¹ This option also adds the current directory to the macro package search path; see the `-m` and `-M` option above. **groff** passes `-U` to **pic** and GNU **troff**.

- `'-v'` Write version information for **groff** and all programs run by it to the standard output stream; that is, the given command line is processed in the usual way, passing `-v` to the formatter and any pre- or postprocessors invoked.
- `'-V'` Output the pipeline that **groff** would run to the standard output stream and exit. If given more than once, **groff** both writes the pipeline to the standard error stream and runs it.
- `'-w cat'`
`'-W cat'` Enable and inhibit, respectively, warnings in category *cat*. See Section 5.38.1 [Warnings], page 236.
- `'-X'` Use **gxditview** instead of the usual postprocessor to (pre)view a document on an X11 display. Combining this option with `-T ps` uses the font metrics of the PostScript device, whereas the `-T X75`, `-T X75-12`, `-T X100`, and `-T X100-12` options use the metrics of X11 fonts.
- `'-z'` Suppress formatted output from **troff**.
- `'-Z'` Disable postprocessing. **troff** output appears on the standard output stream (unless suppressed with `-z`); see Section 6.2 [GNU **troff** Output], page 253, for a description of this format.

2.2 Environment

Environment variables in the host system affect the behavior of programs supplied by **groff** as follows. Normally, the path separator in environment variables ending with `'PATH'` is the colon; this may vary depending on the operating system. For example, Windows uses a semicolon instead.

GROFF_BIN_PATH

Locate **groff** commands in these directories, followed by those in `PATH`. If not set, the installation directory of GNU **roff** executables, documented in *groff*(1), is searched before `PATH`.

GROFF_COMMAND_PREFIX

Apply a prefix to certain GNU **roff** commands. **groff** can be configured at compile time to apply a prefix to the names of programs it provides that had counterparts in AT&T **troff**, so that name collisions are avoided at run time. The default prefix is empty.

¹ GNU **troff** does not, however, accept newlines (line feeds) in file names supplied as arguments to requests.

When used, this prefix is conventionally the letter ‘g’. For example, GNU `troff` would be installed as `troff`. Besides `troff`, the prefix applies to the formatter wrapper `nroff`; the preprocessors `eqn`, `grn`, `pic`, `refer`, `tbl`, and `soelim`; and the utilities `indxbib` and `lookbib`.

GROFF_ENCODING

Specify the assumed character encoding of the input. `groff` passes its value as an argument to the `preconv` preprocessor’s `-e` option. This variable’s existence implies the `groff` option `-k`. If set but empty, `groff` runs `preconv` without an `-e` option. `groff`’s `-K` option overrides `GROFF_ENCODING`. See *preconv*(7).

GROFF_FONT_PATH

Seek the selected output device’s directory of device and font description files in this list of directories. See Section 2.4 [Font Directories], page 14, *troff*(1), and *groff.font*(5).

GROFF_TMAC_PATH

Seek macro packages in this list of directories. See Section 2.3 [Macro Directories], page 14, *troff*(1), and *groff.tmac*(5).

GROFF_TMPDIR

Create temporary files in this directory. If not set, but `TMPDIR` is, the latter is used instead. On Windows systems, if neither of the foregoing are set, the environment variables `TMP` and `TEMP` (in that order) are checked also. Otherwise, temporary files are created in a system-dependent default directory (on Unix and GNU/Linux systems, usually `/tmp`). The `refer`, `grohtml`, and `grops` commands use temporary files.

GROFF_TYPESETTER

Set the default output device. The `-T dev` option overrides it. If empty or unset, a default configured at build time, and documented in *groff*(1), is used.

SOURCE_DATE_EPOCH

Declare a time stamp (expressed as seconds since the Unix epoch) to use as the output creation time stamp in place of the current time. The time is converted to human-readable form using *gmtime*(3) and *asctime*(3) when the formatter starts up and stored in registers usable by documents and macro packages (see Section 5.8.5 [Built-in Registers], page 100).

TZ

Declare the time zone to use when converting the current time to human-readable form; see *tzset*(3). If `SOURCE_DATE_EPOCH` is used, it is always converted to human-readable form using UTC.

2.3 Macro Directories

A macro file must have a name in the form *name.tmac* or *tmac.name* and be placed in a *tmac* directory to be found by the `-m mac` command-line option.² Such naming and placement makes a macro file into a *macro package*; when requested, it is sought in several directories. Together, these locations constitute the *tmac path*. Each directory is searched in the following order until the desired package is found or the list is exhausted.

- Directories specified with the `-M` command-line option.
- Directories listed in the `GROFF_TMAC_PATH` environment variable.
- The current working directory (only if in unsafe mode using the `-U` command-line option).
- The user’s home directory, found in the `HOME` environment variable.
- A site-local platform-dependent directory, a site-local platform-independent directory, and a stock directory. Locations corresponding to your installation are listed in section “Environment” of *troff(1)*. If not otherwise configured, they are as follows.

```
/usr/local/lib/groff/site-tmac
/usr/local/share/groff/site-tmac
/usr/local/share/groff/1.23.0/tmac
```

The foregoing assumes that the version of `groff` is 1.23.0, and that the installation prefix was `/usr/local`. These locations can be customized as part of the build-time configuration process.

2.4 Font Directories

The GNU `troff` formatter and `groff`’s output drivers read *device* and *font description files* that detail the output device and the typefaces available to it, including their glyph repertoires and the *metrics* (dimensions) of each glyph. This information permits the formatter to accurately place glyphs with respect to each other. The device description file is always named `DESC`; fonts are typically described in files with short names like `TR`, `CR`, `HBI`, or `S`.³

Device and font description files are kept in *font directories*, which together constitute the *font path*. The search procedure always appends the directory `devname`, where *name* is the name of the output device. Assuming `TeX` DVI output, and `/foo/bar` as a font directory, the description files for `grodvi` must be in `/foo/bar/devdvi`. Each directory in the font path is searched in the following order until the desired description file is found or the list is exhausted.

² The `mso` request loads a macro file of any name. See Section 5.34 [Host System Service Access], page 220.

³ See Section 6.1 [Device and Font Description Files], page 247.

- Directories specified with the `-f` command-line option. All output drivers (and some preprocessors) support this option as well, because they require information about glyphs to be rendered in the document.
- Directories listed in the `GROFF_FONT_PATH` environment variable.
- A site-local directory and a stock directory. Locations corresponding to your installation are listed in section “Environment” of *troff*(1). If not otherwise configured, they are as follows.

```
/usr/local/share/groff/site-font
/usr/local/share/groff/1.23.0/font
```

The foregoing assumes that the version of `groff` is 1.23.0, and that the installation prefix was `/usr/local`. These locations can be customized as part of the build-time configuration process.

2.5 Paper Format

The formatter reads the device description file `DESC` for the selected output device when it starts; page dimensions declared there are used if present.

`groff`’s build process configures a default page format and writes it to typesetters’ `DESC` files. This installation defaults to ‘`letter`’. If the `DESC` file lacks this information, the formatter and output driver use a page length of ‘11i’ (eleven inches) for compatibility with AT&T `troff`.

In the formatter, the `p1` request changes the page length, but macro packages often do not support alteration of the paper format within a document. One might, for instance, want to switch between portrait and landscape orientations. Macro packages lack a consistent approach to configuration of parameters dependent on the paper format; some, like `ms`, benefit from a preamble in the document prior to the first macro call, while others, like `mm`, instead require the specification of registers on the command line, or otherwise before its macro file is interpreted, to configure page dimensions.

Output drivers for typesetters also recognize command-line options `-p` to override the default page dimensions and `-l` to use landscape orientation. The output driver’s man page, such as *grops*(1), may be helpful.

`groff`’s `-d paper` command-line option is a convenient means of setting the paper format; see *groff_tmac*(5). Combine it with appropriate `-P` options for the output driver, overriding its defaults. The following command formats for PostScript on A4 paper in landscape orientation.

```
$ groff -T ps -d paper=a4l -P -pa4 -P -l -m s my.ms >my.ps
```

2.6 Invocation Examples

`roff` systems are best known for formatting man pages. A `man` librarian program, having located a page, might render it with a `groff` command.

```
$ groff -t -m an -T utf8 /usr/share/man/man1/groff.1
```

The librarian may also pipe the output through a pager, which might not interpret terminal escape sequences **groff** emits for boldface, underlining, italics, or hyperlinking; see the *grotty*(1) man page for a discussion.

To process a **roff** input file using the preprocessors **tbl** and **pic** and the **me** macro package in the way to which AT&T **troff** users were accustomed, one would type (or script) a pipeline.

```
$ pic foo.me | tbl | troff -m e -T utf8 | grotty
```

Shorten this pipeline to an equivalent command using **groff**.

```
$ groff -p -t -m e -T utf8 foo.me
```

An even easier way to do this is to use **grog** to guess the preprocessor and macro options and execute the result by using the command substitution feature of the shell.

```
$ $(grog -T utf8 foo.me)
```

Each command-line option to a postprocessor must be specified with any required leading dashes ‘-’ because **groff** passes the arguments as-is to the postprocessor, permitting transmission of arbitrary arguments. For example, to pass a title to the **gxditview** postprocessor, the shell commands

```
$ groff -X -P -title -P 'trial run' mydoc.t
```

and

```
$ groff -X -Z mydoc.t | gxditview -title 'trial run' -
```

are equivalent.

3 Tutorial for Macro Package Users

Most users of the `roff` language employ a macro package to format their documents. Successful macro packages ease the composition process; their users need not master the full formatting language, nor understand features like diversions, traps, and environments. This chapter aims to familiarize you with basic concepts and mechanisms common to many macro packages (like “displays”). If you prefer a meticulous and comprehensive presentation of the language and its formatter, peruse Chapter 5 [GNU `troff` Reference], page 63, instead.

3.1 Basics

Let us first survey some basic concepts necessary to use a macro package fruitfully.¹ References are made throughout to more detailed information.

GNU `troff` reads input prepared by the user and outputs a formatted document suitable for publication or framing. The input consists of text, or words to be printed, and embedded commands (*requests* and *escape sequences*), which tell GNU `troff` how to format the output. See Section 5.6 [Formatter Instructions], page 84.

The primary function of GNU `troff` is to collect words from its input, *fill* output lines with those words, *break* the line at or near the right-hand margin (possibly by hyphenating a word), *adjust* the line to reach that margin (if necessary) by widening spaces between words, and output the result.

```
In fact, we know full well today that it is futile to
speak of liberty as long as economic slavery exists.
(Kropotkin)
```

```
⇒ In fact, we know full well today that it
⇒ is futile to speak of liberty as long as
⇒ economic slavery exists. (Kropotkin)
```

Sometimes a new output line should start even though the current line is not yet full—for example, at the end of a paragraph. GNU `troff` will do this for us automatically at the end of input, but we often want a break sooner, and more frequently. We wish to *instruct* the formatter.

To that end, not all input lines are *text lines* containing words to be formatted. *Control lines* start with a dot (‘.’) or an apostrophe (‘’’) as the first character, and are followed by a request or macro name that tells a macro package (or GNU `troff` directly) how to format the text.

We can command a break with the `br` request. Some requests cause a break automatically, as do (normally) blank input lines and input lines beginning with a space or tab.

¹ The remainder of this chapter is based on “Writing Papers with NROFF using -me” by Eric P. Allman, which is distributed with `groff` as `meintro.me`.

A *macro* bundles text and/or control lines into a named collection that can be called like a request. A macro can also be called by a *trap* that is set to “go off” automatically at certain places on the page. Thus, while requests perform primitive operations, macros handle complex ones, like arranging the output into columns, collecting and writing out footnotes, or managing page headers and footers.

Many requests and macros accept *arguments* that influence their behavior. A “plain” **sp** request breaks and puts a blank line on the output. But

```
.sp 4
```

spaces four lines instead. Spaces (but *not* tabs) separate arguments from the request or macro name and from each other.

Here are a few hints for preparing text for input to GNU **troff**.

- First, keep the input lines short. Short input lines are easier to edit, and, when filling, GNU **troff** packs words onto longer lines anyhow.
- Second, it is helpful to begin a new line after every sentence, comma, semicolon, or colon, since common revisions are to add, delete, or replace sentences, clauses, phrases, or members of lists.
- If you *don't* start a sentence on a new line, put two spaces after the previous sentence. GNU **troff** then recognizes punctuation that ends a sentence, and inserts inter-sentence space accordingly.

We offer further advice in Section 5.1.11 [Input Conventions], page 72.

Vertical spacing is the distance between lines of text; it is expressed in the same units as the type size—the point. The default is 10-point type on 12-point spacing. To get *double-spaced* text you would set the vertical spacing to 24 points. Some, but not all, macro packages expose a macro or register to configure the vertical spacing.

A number of requests allow you to change the way the output is arranged on the page, sometimes called its *layout*. Most macro packages don't supply macros for performing these (at least not without performing other actions besides), as they are such basic operations. The macro packages for writing man pages, **man** and **mdoc**, discourage explicit use of these requests altogether.

Arguments to requests and macro calls can often be *measurements* rather than simple integers. For instance,

```
.sp 1.5i
My thoughts on the subject
.sp
```

outputs one and a half inches of vertical space, followed by the line “My thoughts on the subject”, followed by a single blank line (more measurement units are available; see Section 5.3 [Measurements], page 76). Excess vertical space is normally discarded at page or column breaks. If the above example appears one inch from the bottom of the page, the half inch of space “left over” does not appear at the top of the next.

If you desire precise spacing control when using a macro package, be advised that it might not honor `sp` requests as you expect; it can use a formatter feature called *no-space mode* to prevent excess space from accumulating. See Section 5.11 [Manipulating Spacing], page 116. Use the facilities the package offers to control spacing between paragraphs, before section headings, and around displays (discussed below).

Text lines can be centered by using the `ce` request. The line after `ce` is centered (horizontally) on the page. To center more than one line, use `‘.ce N’` (where *N* is the number of lines to center), followed by the *N* lines. To center many lines without counting them, try the following technique.

```
.ce 1000
up to one thousand lines of input
.ce 0
```

The `‘.ce 0’` request tells GNU `troff` to center zero more text lines—in other words, to stop centering.

GNU `troff` also offers the `rj` request for right-aligning text. It works analogously to `ce` and is convenient for setting epigraphs.

The `bp` request starts a new page.

All of these requests cause a break, starting a new line. If you invoke them with the apostrophe `‘’`, the *no-break control character*, the (initial) break they normally perform is suppressed. `‘br’` does nothing.

3.2 Common Features

GNU `troff` provides low-level operations for formatting a document. Many routine operations are undertaken in nearly all documents that require a series of such primitive operations to be performed. These common tasks are grouped into *macros*, which are then collected into a *macro package*.

Some macro packages (“major” or “full-service”) assume responsibility for page layout and other critical functions; others (“supplemental” or “auxiliary”) do not.

We present several capabilities of full-service macro packages below. Each package employs its own macro names to exercise them. For details, consult the package’s man page or, for `ms`, see Section 4.6 [ms], page 26.

3.2.1 Paragraphs

Paragraphs can be formatted in various ways. Some indent their first line. Block paragraphs like the following example omit this indentation, and must be separated with vertical space for readability. Separation can be configured for other paragraph types as well.

```
⇒ Some men look at constitutions with sanctimonious rev-
⇒ erence, and deem them like the ark of the covenant,
⇒ too sacred to be touched.
```

We also frequently encounter *tagged* paragraphs, which begin with a label, or *tag*, at the left margin, and indent the remaining text.

```
⇒ one This is a tagged paragraph. Notice how the first
⇒ line of the resulting paragraph lines up with the
⇒ other lines in the paragraph.
```

If the tag is too wide for the indentation amount, the line is broken.

```
⇒ longlabel
⇒ The long tag does not align with subsequent
⇒ lines, but those lines align with each other.
```

A variation of the tagged paragraph is the itemized or enumerated paragraph, which might use punctuation or a digit for a tag, respectively. These are frequently used to construct lists.

```
⇒ * This list item starts with a bullet. If a bullet
⇒ glyph is unavailable, groff produces an asterisk
⇒ instead.
```

Often, use of the same macro without a tag continues such a discussion.

```
⇒ -xyz This option is recognized but ignored.
⇒
⇒ It had a security hole that we don't discuss.
```

3.2.2 Sections and Chapters

A simple kind of section heading is unnumbered, set in a bold or italic style, and occupies a line by itself. Others possess automatically numbered multi-level headings and/or different typeface styles or sizes at different levels. More sophisticated macro packages supply macros for designating chapters and appendices, and permit *run-in headings*, where there is no break between the end of the heading text and the start of the subsequent paragraph.

3.2.3 Headers and Footers

Headers and *footers* occupy the top and bottom of each page, respectively, and contain data like the page number and the article or chapter title. Their appearance is not affected by the running text. Some packages allow for different titles on even- and odd-numbered pages (for printed, bound material).

Headers and footers are together called *titles*, and comprise three parts: left-aligned, centered, and right-aligned. A ‘%’ character appearing anywhere in a title is automatically replaced by the page number. See Section 5.17 [Page Layout], page 130.

3.2.4 Page Layout

Most macro packages let the user specify the size of the page margins. The top and bottom margins are typically handled differently than the left and right margins; the latter are derived from the *page offset*, *indentation*, and *line length*. See Section 5.15 [Line Layout], page 126. Commonly, packages support registers to tune these values.

3.2.5 Displays and Keeps

Displays are sections of text set off from the surrounding material (typically paragraphs), often differing in indentation and/or spacing. Tables, block quotations, and figures are displayed. Equations and code examples, when not much shorter than an output line, often are. Lists may or may not be.

A *keep* is a group of output lines, often a display, that is formatted on a single page if possible; it causes a page break to happen early if necessary to not interrupt the kept material. Packages for setting man pages support example displays but not keeps.

Floating keeps can move, or “float”, relative to the text around them in the input. They are useful for displays that are captioned and referred to by name, as with “See figure 3”. A floating keep might appear at the bottom of the current page if it fits, and at the top of the next otherwise. Alternatively, it might be deferred to the end of a section. Use of a floating keep can prevent a large vertical space from appearing before a tall keep of the ordinary sort when it won’t fit on the page.

3.2.6 Footnotes and Endnotes

Footnotes and *endnotes* are forms of delayed formatting. They are recorded at their points of relevance in the input, but not formatted there. Instead, a *mark* cues the reader to check the “foot”, or bottom, of the current page, or in the case of endnotes, an annotation list later in the document. Macro packages that support these features also supply a means of automatically numbering either type of annotation.

3.2.7 Table of Contents

A package may handle a *table of contents* by directing section heading macros to save the heading’s text and the page number where it occurs for use in a later *entry* for a table of contents. It writes the collected entries at the end of the document, once all are known, upon request. A *leader*, a row of dots, bridges the text on the left with its location on the right. Other collections might work in this manner, providing lists of figures or tables.

A table of contents is often found at the end of a GNU `troff` document because the formatter processes the document in a single pass. The `gropdf` output driver supports a PDF feature that relocates pages at the time the document is rendered; see `gropdf(1)`.

3.2.8 Indexing

An index is similar to a table of contents, in that entry labels and locations must be collected, but poses a greater challenge because it needs to be sorted before it is output. Here, processing the document in multiple passes is inescapable, and tools like the `makeindex(1)` program become necessary.

3.2.9 Document Formats

Some macro packages supply stock configurations of certain types of documents, like business letters and memoranda. These often also have provision for a *cover sheet*, which may be rigid in its format. With these features, it is even more important to use the package's macros in preference to the formatter requests presented earlier, where possible.

3.2.10 Columnation

Macro packages apart from `man` and `mdoc` for man page formatting offer a facility for setting multiple text columns on the page.

3.2.11 Font and Size Changes

The formatter's requests and escape sequences for setting the typeface and size are not always intuitive in their behavior, so all full-service packages provide macros to simplify input of these operations. They can also make mid-word font style changes more convenient, and can handle italic corrections automatically. See Section 5.19.9 [Italic Corrections], page 154.

3.2.12 Predefined Text

Most macro packages supply predefined strings to set computed text like the date, or to perform operations like super- and subscripting.

3.2.13 Preprocessor Support

All macro packages provide support for various preprocessors and may extend their functionality by defining macros to caption their output and/or set it in a display. Examples include `TS` and `TE` for `tbl`, `EQ` and `EN` for `eqn`, and `PS` and `PE` for `pic`. Another preprocessor, `refer`, facilitates the inclusion of bibliographic citations in a consistent format.

3.2.14 Configuration and Customization

Each package provides means of customizing details of its behavior. Often, this is achieved with register and string definitions. Such parameters include the default type size and the appearance of section headings.

4 Macro Packages

This chapter surveys the “major” macro packages that come with **groff**. One, **ms**, is presented in detail.

Major macro packages are also sometimes described as *full-service* due to the breadth of features they provide and because more than one cannot be used by the same document; for example

```
groff -m man foo.man -m ms bar.doc
```

doesn’t work. Option arguments are processed before non-option arguments; the above (failing) sample is thus reordered to

```
groff -m man -m ms foo.man bar.doc
```

Many auxiliary, or supplemental, macro packages are also available. They may in general be used with any full-service macro package and handle a variety of tasks from character encoding selection, to language localization, to inlining of raster images. See *groff.tmac*(5) for a list.

4.1 man

The **man** macro package is the most widely used and probably the most important ever developed for **troff**. It is easy to use, and a vast majority of manual pages (“man pages”) are written in it.

groff’s implementation is documented in *groff.man*(7).

4.1.1 Optional man extensions

Use the file **man.local** to configure its rendering parameters on a persistent basis. With care, its macros can be redefined there (except for **TH**, to which one should, at most, append with the **am** family of requests).

Custom headers and footers

In **groff** versions 1.18.2 and later, you can specify custom headers and footers by redefining the following macros in **man.local**.

.PT [Macro]
Control the content of the headers. Normally, the header prints the command name and section number on either side, and the optional fifth argument to **TH** in the center.

.BT [Macro]
Control the content of the footers. Normally, the footer prints the page number and the third and fourth arguments to **TH**.

Use the **FT** register to specify the footer position. The default is $-0.5i$.

Ultrix-specific man macros

The **groff** source distribution includes a file named `man.ultrix`, containing macros compatible with the Ultrix variant of `man`. Copy this file into `man.local` (or use the `mso` request to load it) to enable the following macros.

- `.CT key` [Macro]
Print ‘<CTRL/*key*>’.
- `.CW` [Macro]
Print subsequent text using a “constant-width” (monospaced) typeface (Courier roman).
- `.Ds` [Macro]
Begin a non-filled display.
- `.De` [Macro]
End a non-filled display started with `Ds`.
- `.EX [indent]` [Macro]
Begin a non-filled display using a monospaced typeface (Courier roman).
Use the optional *indent* argument to indent the display.
- `.EE` [Macro]
End a non-filled display started with `EX`.
- `.G [text]` [Macro]
Set *text* in Helvetica. If no text is present on the line where the macro is called, then the text of the next line appears in Helvetica.
- `.GL [text]` [Macro]
Set *text* in Helvetica oblique. If no text is present on the line where the macro is called, then the text of the next line appears in Helvetica Oblique.
- `.HB [text]` [Macro]
Set *text* in Helvetica bold. If no text is present on the line where the macro is called, then all text up to the next `HB` appears in Helvetica bold.
- `.TB [text]` [Macro]
Identical to `HB`.
- `.MS title sect [punct]` [Macro]
Set a man page reference in Ultrix format. The *title* is in Courier instead of italic. Optional punctuation follows the section number without an intervening space.
- `.NT [C] [title]` [Macro]
Begin a note. Print the optional *title*, or the word “Note”, centered on the page. Text following the macro makes up the body of the note, and is indented on both sides. If the first argument is `C`, the body of the

note is printed centered (the second argument replaces the word “Note” if specified).

- .NE [Macro]
End a note begun with NT.
- .PN *path* [*punct*] [Macro]
Set the path name in a monospaced typeface (Courier roman), followed by optional punctuation.
- .Pn [*punct*] *path* [*punct*] [Macro]
If called with two arguments, identical to PN. If called with three arguments, set the second argument in a monospaced typeface (Courier roman), bracketed by the first and third arguments in the current font.
- .R [Macro]
Switch to roman font and turn off any underlining in effect.
- .RN [Macro]
Print the string ‘<RETURN>’.
- .VS [4] [Macro]
Start printing a change bar in the margin if the number 4 is specified. Otherwise, this macro does nothing.
- .VE [Macro]
End printing the change bar begun by VS.

Simple example

The following example `man.local` file alters the behavior of the SH macro.

```
.\" Make the heading font Helvetica bold.
.ds HF HB
.
.\" Add vertical space prior to headings on typesetters.
.rn SH SH-orig
.de SH
.  if t .sp (u;\n[PD]*2)
.  SH-orig \\$*
..
```

4.2 mdoc

`groff`’s implementation of the BSD `doc` package for man pages is documented in `groff_mdoc(7)`.

Use the file `mdoc.local` to configure its rendering parameters on a persistent basis. With care, its macros can be redefined there (except for `Dd`, to which one should, at most, append with the `am` family of requests).

4.3 me

groff's implementation of the BSD **me** macro package is documented using itself. A tutorial, **meintro.me**, and reference, **mereref.me**, are available in **groff**'s documentation directory. *groff.me*(7) identifies the installation path for these documents.

A French translation of the tutorial is available as **meintro_fr.me** and installed parallel to the English version.

4.4 mm

groff's implementation of the AT&T memorandum macro package is documented in *groff.mm*(7).

A Swedish localization of **mm** is also available; see *groff.mmse*(7).

4.5 mom

The **mom** package's primary documentation is in HTML. Model documents illustrating many features are offered in PDF. See the *groff*(1) man page, section "Installation Directories", for their location.

- **toc.html** Entry point to the full **mom** manual.
- **macrolist.html** Hyperlinked index of macros with brief descriptions, arranged by category.
- **mom-pdf.pdf** PDF features and usage.

The **mom** macros are in active development between **groff** releases. The most recent version, along with up-to-date documentation, is available at <http://www.schaffter.ca/mom/mom-05.html>.

The *groff.mom*(7) man page (type '**man groff_mom**' at the command line) contains a partial list of available macros, however their usage is best understood by consulting the HTML documentation.

4.6 ms

Use the **ms** ("manuscript") package to compose letters, memoranda, reports, and books. These **groff** macros feature cover page and table of contents generation, automatically numbered headings, several paragraph styles, a variety of text styling options, footnotes, and multi-column page layouts. **ms** supports the **tbl**, **eqn**, **pic**, and **refer** preprocessors for inclusion of tables, mathematical equations, diagrams, and consistently formatted bibliographic citations. **groff ms** is mostly compatible with the documented interface and behavior of AT&T Unix Version 7 **ms**. It recreates most extensions from 4.2BSD (Berkeley) and Research Tenth Edition Unix.

4.6.1 Introduction

The `ms` macros are the oldest surviving package for `roff` systems.¹ Whereas `man` suits brief references, `ms` can handle long or complex works intended for printing and possible publication.

Macro, register, and string descriptions frequently mention each other; most references are to macros. Where a register or string is referenced, we annotate its type. `ms`'s identifiers use only capital letters, numerals, and '-'.

4.6.1.1 Basic information

Prepare an `ms` document with your preferred text editor. Call an `ms` macro early in the document to initialize the package. A *macro* is a formatting instruction to `ms`. Put a macro call on a line by itself with a dot before its name. Use `' .PP'` if you want your paragraph's first line indented, or `' .LP'` if you don't. Then type text normally. It is a good practice to start each sentence on a new line, or to put two spaces after sentence-ending punctuation, so that the formatter knows where the sentence boundaries are. You can separate paragraphs with further paragraphing macros, or with blank lines, and you can indent with tabs. When you need one of the features mentioned earlier (see Section 4.6 [ms], page 26), return to this subsection.

Format the document with the `groff` command. `nroff` can be useful for previewing.

```
$ editor radical.ms # vim, emacs, nano, ...
$ nroff -ww -z -ms radical.ms # check for errors
$ nroff -ms radical.ms | less -R
$ groff -T ps -ms radical.ms > radical.ps
$ see radical.ps # or your favorite PDF viewer
```

Our `radical.ms` document might look like this.

```
.LP
Radical novelties are so disturbing that they tend to be
suppressed or ignored, to the extent that even the
possibility of their existence in general is more often
denied than admitted.
```

```
→That's what Dijkstra said, anyway.
```

¹ While manual *pages* are older, early ones used macros supplanted by the `man` package of Seventh Edition Unix (1979). `ms` shipped with Sixth Edition (1975) and was documented by Mike Lesk in a Bell Labs internal memorandum.

ms exposes many aspects of document layout to user control via **groff**'s *registers* and *strings*, which store numbers and text, respectively. Measurements in **groff** are expressed with a suffix called a *scaling unit*.

i	inches
c	centimeters
p	points (1/72 inch)
P	picas (1/6 inch)
v	vees; current vertical spacing
m	ems; width of an “M” in the current font
n	ens; one-half em (same as m on terminals)

Set registers with the **nr** request and strings with the **ds** request. *Requests* are like macro calls; they go on lines by themselves and start with the *control character*, a dot (.). The difference is that they directly instruct the formatter program, rather than the macro package. We'll discuss a few as applicable. It is wise to specify a scaling unit when setting any register that represents a length, size, or distance.

```
.nr PS 10.5p \" Use 10.5-point type.
.ds FAM P    \" Use Palatino font family.
```

In the foregoing, we see that `\"` begins a comment. This is an example of an *escape sequence*, the other kind of formatting instruction. Escape sequences can appear almost anywhere. They begin with the escape character (`\`) and are followed by at least one more character. **ms** documents tend to use only a few of **groff**'s many requests and escape sequences; see Appendix B [Request Index], page 277, and Appendix C [Escape Sequence Index], page 281, or the *groff*(7) man page for complete lists.

<code>\"</code>	Begin comment; ignore remainder of line.
<code>\n[reg]</code>	Interpolate value of register <i>reg</i> .
<code>\nr</code>	abbreviation of <code>\n[r]</code> ; the name <i>r</i> must be only one character
<code>*[str]</code>	Interpolate contents of string <i>str</i> .
<code>*s</code>	abbreviation of <code>*[s]</code> ; the name <i>s</i> must be only one character
<code>\[char]</code>	Interpolate glyph of special character named <i>char</i> .
<code>\&</code>	dummy character
<code>\~</code>	Insert an unbreakable space that is adjustable like a normal space.
<code>\ </code>	Move horizontally by one-sixth em (“thin space”).

Prefix any words that start with a dot ‘.’ or neutral apostrophe ‘’ with `\&` if they are at the beginning of an input line (or might become that

way in editing) to prevent them from being interpreted as macro calls or requests. Suffix ‘.’, ‘?’, and ‘!’ with `\&` when needed to cancel end-of-sentence detection.

```
My exposure was \&.5 to \&.6 Sv of neutrons, said Dr.\&
Wallace after the criticality incident.
```

4.6.2 Document Structure

The `ms` macro package expects a certain amount of structure: a well-formed document contains at least one paragraphing or heading macro call. Organize longer documents as follows.

Document type

Calling the `RP` macro at the beginning of your document puts the document description (see below) on a cover page. Otherwise, `ms` places the information (if any) on the first page, followed immediately by the body text. Some document types found in other `ms` implementations are specific to AT&T or Berkeley, and are not supported by `groff ms`.

Format and layout

By setting registers and strings, you can configure your document’s typeface, margins, spacing, headers and footers, and footnote arrangement. See Section 4.6.3 [`ms Document Control Settings`], page 30.

Document description

A document description consists of any of: a title, one or more authors’ names and affiliated institutions, an abstract, and a date or other identifier. See Section 4.6.4 [`ms Document Description Macros`], page 35.

Body text The main matter of your document follows its description (if any). `ms` supports highly structured text consisting of paragraphs interspersed with multi-level headings (chapters, sections, subsections, and so forth) and augmented by lists, footnotes, tables, diagrams, and similar material. See Section 4.6.5 [`ms Body Text`], page 37.

Tables of contents

Macros enable the collection of entries for a table of contents (or index) as the material they discuss appears in the document. A macro call at the end of the document emits the collected entries. This material necessarily follows the rest of the text since `troff` is a single-pass formatter; it cannot determine the page number of a division of the text until it has been set and output. Since `ms` output was designed for the production of hard copy, the traditional procedure was to manually relocate the pages containing the table of contents between the cover page

and the body text. Today, page resequencing is more often done in the digital domain. An index works similarly, but because it typically needs to be sorted after collection, its preparation requires separate processing.

4.6.3 Document Control Settings

ms exposes many aspects of document layout to user control via **groff** requests. To use them, you must understand how to define registers and strings.

.nr *reg value* [Request]

Set register *reg* to *value*.

.ds *name contents* [Request]

Set string *name* to *contents*.

A list of document control registers and strings follows. For any parameter whose default is unsatisfactory, define its register or string before calling any **ms** macro other than **RP**.

Margin settings

\n[P0] [Register]

Defines the page offset (i.e., the left margin).

Effective: next page.

Default: Varies by output device and paper format; 1 i is used for typesetters using U.S. letter paper, and zero for terminals. See Section 2.5 [Paper Format], page 15.

\n[LL] [Register]

Defines the line length (i.e., the width of the body text).

Effective: next paragraph.

Default: Varies by output device and paper format; 6.5 i is used for typesetters using U.S. letter paper (see Section 2.5 [Paper Format], page 15) and 65 n on terminals.

\n[LT] [Register]

Defines the title line length (i.e., the header and footer width). This is usually the same as **LL**, but need not be.

Effective: next paragraph.

Default: Varies by output device and paper format; 6.5 i is used for typesetters using U.S. letter paper (see Section 2.5 [Paper Format], page 15) and 65 n on terminals.

\n[HM] [Register]

Defines the header margin height at the top of the page.

Effective: next page.

Default: 1 i.

\n[FM] [Register]
Defines the footer margin height at the bottom of the page.
Effective: next page.
Default: 1 i.

Titles (headers, footers)

***[LH]** [String]
Defines the text displayed in the left header position.
Effective: next header.
Default: empty.

***[CH]** [String]
Defines the text displayed in the center header position.
Effective: next header.
Default: ‘-\n[%] -’.

***[RH]** [String]
Defines the text displayed in the right header position.
Effective: next header.
Default: empty.

***[LF]** [String]
Defines the text displayed in the left footer position.
Effective: next footer.
Default: empty.

***[CF]** [String]
Defines the text displayed in the center footer position.
Effective: next footer.
Default: empty.

***[RF]** [String]
Defines the text displayed in the right footer position.
Effective: next footer.
Default: empty.

Text settings

\n[PS] [Register]
Defines the type size of the body text.
Effective: next paragraph.
Default: 10 p.

- \n[VS]** [Register]
 Defines the vertical spacing (type size plus leading).
 Effective: next paragraph.
 Default: 12 p.
- \n[HY]** [Register]
 Defines the automatic hyphenation mode used with the **hy** request. Setting **HY** to 0 disables automatic hyphenation. This is a Research Tenth Edition Unix extension.
 Effective: next paragraph.
 Default: 6.
- *[FAM]** [String]
 Defines the font family used to typeset the document. This is a GNU extension.
 Effective: next paragraph.
 Default: defined by the output device; often ‘T’ (see Section 4.6.5 [ms Body Text], page 37)

Paragraph settings

- \n[PI]** [Register]
 Defines the indentation amount used by the **PP**, **IP** (unless overridden by an optional argument), **XP**, and **RS** macros.
 Effective: next paragraph.
 Default: 5 n.
- \n[PD]** [Register]
 Defines the space between paragraphs.
 Effective: next paragraph.
 Default: 0.3 v (1 v on low-resolution devices).
- \n[QI]** [Register]
 Defines the indentation amount used on both sides of a paragraph set with the **QP** or between the **QS** and **QE** macros.
 Effective: next paragraph.
 Default: 5 n.
- \n[PORPHANS]** [Register]
 Defines the minimum number of initial lines of any paragraph that must be kept together to avoid isolated lines at the bottom of a page. If a new paragraph is started close to the bottom of a page, and there is insufficient space to accommodate **PORPHANS** **groff ms** forces a page break before formatting the paragraph. This is a GNU extension.
 Effective: next paragraph.
 Default: 1.

Heading settings

`\n[PSINCR]` [Register]

Defines an increment in type size to be applied to a heading at a lesser depth than that specified in `GROWPS`. The value of `PSINCR` should be specified in points with the `p` scaling unit and may include a fractional component; for example, `'.nr PSINCR 1.5p'` sets a type size increment of 1.5 p. This is a GNU extension.

Effective: next heading.

Default: 1 p.

`\n[GROWPS]` [Register]

Defines the heading depth above which the type size increment set by `PSINCR` becomes effective. For each heading depth less than the value of `GROWPS`, the type size is increased by `PSINCR`. Setting `GROWPS` to any value less than 2 disables the incremental heading size feature. This is a GNU extension.

Effective: next heading.

Default: 0.

`\n[HORPHANS]` [Register]

Defines the minimum number of lines of an immediately succeeding paragraph that should be kept together with any heading introduced by the `NH` or `SH` macros. If a heading is placed close to the bottom of a page, and there is insufficient space to accommodate both the heading and at least `HORPHANS` lines of the following paragraph, before an automatic page break, then the page break is forced before the heading. This is a GNU extension.

Effective: next paragraph.

Default: 1.

`\*[SN-STYLE]` [String]

Defines the style used to print numbered headings. See Section 4.6.5.4 [Headings in ms], page 39. This is a GNU extension.

Effective: next heading.

Default: alias of `SN-DOT`

Footnote settings

`\n[FI]` [Register]

Defines the footnote indentation. This is a Berkeley extension.

Effective: next footnote.

Default: 2 n.

`\n[FF]` [Register]

Defines the format of automatically numbered footnotes, and those for which the FS request is given a *mark* argument, at the bottom of a column or page. This is a Berkeley extension.

0 Set an automatic number² as a superscript (on typesetters) or surrounded by square brackets (on terminals). The footnote paragraph is indented as with PP if there is an FS argument or an automatic number, and as with LP otherwise. This is the default.

1 As 0, but set *mark* as regular text, and follow an automatic number with a period.

2 As 1, but without indentation (like LP).

3 As 1, but set the footnote paragraph with *mark* hanging (like IP).

Effective: next footnote.

Default: 0.

`\n[FPS]` [Register]

Defines the footnote type size.

Effective: next footnote.

Default: `\n[PS] - 2p`.

`\n[FVS]` [Register]

Defines the footnote vertical spacing.

Effective: next footnote.

Default: `\n[FPS] + 2p`.

`\n[FPD]` [Register]

Defines the footnote paragraph spacing. This is a GNU extension.

Effective: next footnote.

Default: `\n[PD] / 2`.

`\*[FR]` [String]

Defines the ratio of the footnote line length to the current line length. This is a GNU extension.

Effective: next footnote if single-column layout, next page otherwise.

Default: 11/12.

² defined in Section 4.6.5.10 [ms Footnotes], page 51

Display settings

\n[DD] [Register]
 Sets the display distance—the vertical spacing before and after a display, a `tbl` table, an `eqn` equation, or a `pic` image. This is a Berkeley extension.
 Effective: next display boundary.
 Default: 0.5 v (1 v on low-resolution devices).

\n[DI] [Register]
 Sets the default amount by which to indent a display started with `DS` and `ID` without arguments, to ‘`.DS I`’ without an indentation argument, and to equations set with ‘`.EQ I`’. This is a GNU extension.
 Effective: next indented display.
 Default: 0.5 i.

Other settings

\n[MINGW] [Register]
 Defines the default minimum width between columns in a multi-column document. This is a GNU extension.
 Effective: next page.
 Default: 2 n.

\n[TC-MARGIN] [Register]
 Defines the width of the field in which page numbers are set in a table of contents entry; the right margin thus moves inboard by this amount. This is a GNU extension.
 Effective: next `PX` call.
 Default: \w'000'

4.6.4 Document Description Macros

Only the simplest document lacks a title.³ As its level of sophistication (or complexity) increases, it tends to acquire a date of revision, explicitly identified authors, sponsoring institutions for authors, and, at the rarefied heights, an abstract of its content. Define these data by calling the macros below in the order shown; `DA` or `ND` can be called to set the document date (or other identifier) at any time before (a) the abstract, if present, or (b) its information is required in a header or footer. Use of these macros is optional, except that `TL` is mandatory if any of `RP`, `AU`, `AI`, or `AB` is called, and `AE` is mandatory if `AB` is called.

.RP [no-repeat-info] [no-renumber] [Macro]
 Use the “report” (AT&T: “released paper”) format for your document, creating a separate cover page. The default arrangement is to place most

³ Distinguish a document title from “titles”, which are what `roff` systems call headers and footers collectively.

of the document description (title, author names and institutions, and abstract, but not the date) at the top of the first page. If the optional **no-repeat-info** argument is given, **ms** produces a cover page but does not repeat any of its information subsequently (but see the **DA** macro below regarding the date). Normally, **RP** sets the page number following the cover page to 1. Specifying the optional **no-renumber** argument suppresses this alteration. Optional arguments can occur in any order. **ms** recognizes **no** as a synonym of **no-repeat-info** to maintain AT&T compatibility. Options other than **no** are GNU extensions.

.TL [Macro]
Specify the document title. **ms** collects text on input lines following this call into the title until reaching **AU**, **AB**, or a heading or paragraphing macro call.

.AU [Macro]
Specify an author's name. **ms** collects text on input lines following this call into the author's name until reaching **AI**, **AB**, another **AU**, or a heading or paragraphing macro call. Call it repeatedly to specify multiple authors.

.AI [Macro]
Specify the preceding author's institutional affiliation. An **AU** call is usefully followed by at most one **AI** call; if there are more, the last **AI** call controls. **ms** collects text on input lines following this call into the author's institution until reaching **AU**, **AB**, or a heading or paragraphing macro call.

.DA [*x ...*] [Macro]
Typeset the current date, or any arguments *x*, in the center footer, and, if **RP** is also called, left-aligned at the end of the description information on the cover page.

.ND [*x ...*] [Macro]
Typeset the current date, or any arguments *x*, if **RP** is also called, left-aligned at the end of the document description on the cover page. This is **groff ms**'s default.

.AB [*no*] [Macro]
Begin the abstract. **ms** collects text on input lines following this call into the abstract until reaching an **AE** call. By default, **ms** places the word "ABSTRACT" centered and in italics above the text of the abstract. The optional argument **no** suppresses this heading.

.AE [Macro]
End the abstract.

An example document description, using a cover page, follows.

```
.RP
.TL
The Inevitability of Code Bloat
in Commercial and Free Software
.AU
J.\& Random Luser
.AI
University of West Bumblefuzz
.AB
This report examines the long-term growth of the code
bases in two large,
popular software packages;
the free Emacs and the commercial Microsoft Word.
While differences appear in the type or order of
features added,
due to the different methodologies used,
the results are the same in the end.
.PP
The free software approach is shown to be superior in
that while free software can become as bloated as
commercial offerings,
free software tends to have fewer serious bugs and the
added features are more in line with user demand.
.AE
...the rest of the paper...
```

4.6.5 Body Text

A variety of macros, registers, and strings can be used to structure and style the body of your document. They organize your text into paragraphs, headings, footnotes, and inclusions of material such as tables and figures.

4.6.5.1 Text settings

The FAM string, a GNU extension, sets the font family for body text; the default is ‘T’. The PS and VS registers set the type size and vertical spacing (distance between text baselines), respectively. The font family and type size are ignored on terminals. Set these parameters before the first call of a heading, paragraphing, or (non-date) document description macro to apply them to headers, footers, and (for FAM) footnotes.

Which font families are available depends on the output device; as a convention, T selects a serif family (“Times”), H a sans-serif family (“Helvetica”), and C a monospaced family (“Courier”). The man page for the output driver documents its font repertoire. Consult the *groff*(1) man page for lists of available output devices and their drivers.

The hyphenation mode (as used by the `hy` request) is set from the `HY` register. Setting `HY` to ‘0’ is equivalent to using the `nh` request. This is a Research Tenth Edition Unix extension.

4.6.5.2 Typographical symbols

`ms` provides a few strings to obtain typographical symbols not easily entered with the keyboard. These and many others are available as special character escape sequences—see the *groff.char*(7) man page.

`\*[−]` [String]

Interpolate an em dash.

`\*[Q]` [String]

`\*[U]` [String]

Interpolate typographer’s quotation marks where available, and neutral double quotes otherwise. `\*Q` is the left quote and `\*U` the right.

4.6.5.3 Paragraphs

Paragraphing macros *break*, or terminate, any pending output line so that a new paragraph can begin. Several paragraph types are available, differing in how indentation applies to them: to left, right, or both margins; to the first output line of the paragraph, all output lines, or all but the first. These calls insert vertical space in the amount stored in the `PD` register, except at page or column breaks. Alternatively, a blank input line breaks the output line and vertically spaces by one vee.

`.LP` [Macro]

Set a paragraph without any (additional) indentation.

`.PP` [Macro]

Set a paragraph with a first-line left indentation in the amount stored in the `PI` register.

`.IP [mark [width]]` [Macro]

Set a paragraph with a left indentation. The optional *mark* is not indented and is empty by default. It has several applications; see Section 4.6.5.6 [Lists in `ms`], page 44. *width* overrides the indentation amount stored in the `PI` register; its default unit is ‘n’. Once specified, *width* applies to further `IP` calls until specified again or a heading or different paragraphing macro is called.

`.QP` [Macro]

Set a paragraph indented from both left and right margins by the amount stored in the `QI` register.

`.QS` [Macro]
`.QE` [Macro]

Begin (QS) and end (QE) a region where each paragraph is indented from both margins by the amount stored in the QI register. The text between QS and QE can be structured further by use of other paragraphing macros.

`.XP` [Macro]

Set an “exdented” paragraph—one with a left indentation in the amount stored in the PI register on every line *except* the first (also known as a hanging indent). This is a Berkeley extension.

The following example illustrates the use of paragraphing macros.

```
.NH 2
Cases used in the 2001 study
.LP
Two software releases were considered for this report.
.PP
The first is commercial software;
the second is free.
.IP \[bu]
Microsoft Word for Windows,
starting with version 1.0 through the current version
(Word 2000).
.IP \[bu]
GNU Emacs,
from its first appearance as a standalone editor through
the current version (v20).
See [Bloggs 2002] for details.
.QP
Franklin's Law applied to software:
software expands to outgrow both RAM and disk space over
time.
.SH
Bibliography
.XP
Bloggs, Joseph R.,
.I "Everyone's a Critic" ,
Underground Press, March 2002.
A definitive work that answers all questions and
criticisms about the quality and usability of free
software.
```

4.6.5.4 Headings

Use headings to create a sequential or hierarchical structure for your document. The `ms` macros print headings in **bold** using the same font family and, by default, type size as the body text. Headings are available with and

without automatic numbering. Text on input lines following the macro call becomes the heading’s title. Call a paragraphing macro to end the heading text and start the section’s content.

`.NH [depth]` [Macro]
`.NH S heading-depth-index . . .` [Macro]

Set an automatically numbered heading.

`ms` produces a numbered heading the form *a.b.c. . .*, to any depth desired, with the numbering of each depth increasing automatically and being reset to zero when a more significant level is increased. “1” is the most significant or coarsest division of the document. Only non-zero values are output. If *depth* is omitted, `ms` assumes ‘1’.

If you specify *depth* such that an ascending gap occurs relative to the previous `NH` call—that is, you “skip a depth”, as by ‘`.NH 1`’ and then ‘`.NH 3`’—`groff ms` emits a warning on the standard error stream.

Alternatively, you can give `NH` a first argument of `S`, followed by integers to number the heading depths explicitly. Further automatic numbering, if used, resumes using the specified indices as their predecessors. This feature is a Berkeley extension.

An example may be illustrative.

```
.NH 1
Animalia
.NH 2
Arthropoda
.NH 3
Crustacea
.NH 2
Chordata
.NH S 6 6 6
Daimonia
.NH 1
Plantae
```

The above results in numbering as follows; the vertical space that normally precedes each heading is omitted.

```
1.  Animalia
1.1. Arthropoda
1.1.1. Crustacea
1.2. Chordata
6.6.6. Daimonia
7.  Plantae
```

`\*[SN-STYLE]` [String]
`\*[SN-DOT]` [String]

`\*[SN-NO-DOT]` [String]
`\*[SN]` [String]

After NH is called, the assigned number is made available in the strings SN-DOT (as it appears in a printed heading with default formatting, followed by a terminating period) and SN-NO-DOT (with the terminating period omitted). These (and SN-STYLE) are GNU extensions.

You can control the style used to print numbered headings by defining an appropriate alias for the string SN-STYLE. By default, SN-STYLE is aliased to SN-DOT. If you prefer to omit the terminating period from numbers appearing in numbered headings, you may define the alias as follows.

```
.als SN-STYLE SN-NO-DOT
```

Any such change in numbering style becomes effective from the next use of NH following redefinition of the alias for SN-STYLE. The formatted number of the current heading is available in the SN string (a feature first documented by Berkeley), which facilitates its inclusion in, for example, table captions, equation labels, and XS/XA/XE table of contents entries.

`.SH [depth]` [Macro]

Set an unnumbered heading.

The optional *depth* argument is a GNU extension indicating the heading depth corresponding to the *depth* argument of NH. It matches the type size at which the heading is set to that of a numbered heading at the same depth when the GROWPS and PSINCR heading size adjustment mechanism is in effect.

If the GROWPS register is set to a value greater than the *level* argument to NH or SH, the type size of a heading produced by these macros increases by PSINCR units over the size specified by PS multiplied by the difference of GROWPS and *level*. The value stored in PSINCR is interpreted in **groff** basic units; the **p** scaling unit should be employed when assigning a value specified in points.

The input

```
.nr PS 10
.nr GROWPS 3
.nr PSINCR 1.5p
.NH 1
Carnivora
.NH 2
Felinae
.NH 3
Felis catus
.SH 2
Machairodontinae
```

causes “1. Carnivora” to be printed in 13-point type, followed by “1.1. Felinae” in 11.5-point type, while “1.1.1. Felis catus” and all more deeply

nested heading levels remains in the 10-point type specified by the PS register. “Machairodontinae” is printed at 11.5 points, since it corresponds to heading level 2.

In **groff ms**, the **NH** and **SH** macros consult the **HORPHANS** register to prevent the output of isolated headings at the bottom of a page; it specifies the minimum number of lines of an immediately subsequent paragraph that must be kept on the same page as the heading. If insufficient space remains on the current page to accommodate the heading and this number of lines of paragraph text, **groff ms** forces a page break before setting the heading. Any display macro call or **tbl**, **pic**, or **eqn** region between the heading and the subsequent paragraph suppresses this grouping. See Section 4.6.5.8 [**ms** keeps and displays], page 47, and Section 4.6.5.9 [**ms** Insertions], page 49.

4.6.5.5 Typeface and decoration

The **ms** macros provide a variety of ways to style text. Attend closely to the ordering of arguments labeled *pre* and *post*, which is not intuitive. Support for *pre* arguments is a GNU extension.⁴

.B [*text* [*post* [*pre*]]] [Macro]

Style *text* in **bold**, followed by *post* in the previous font style without intervening space, and preceded by *pre* similarly. Without arguments, **ms** styles subsequent text in bold until the next paragraphing, heading, or no-argument typeface macro call.

.R [*text* [*post* [*pre*]]] [Macro]

As **B**, but use the roman style (upright text of normal weight) instead of bold. Argument recognition is a GNU extension.

.I [*text* [*post* [*pre*]]] [Macro]

As **B**, but use an *italic* or oblique style instead of bold.

.BI [*text* [*post* [*pre*]]] [Macro]

As **B**, but use a bold italic or bold oblique style instead of upright bold. This is a Research Tenth Edition Unix extension.

.CW [*text* [*post* [*pre*]]] [Macro]

As **B**, but use a **constant-width** (monospaced) roman typeface instead of bold. This is a Research Tenth Edition Unix extension.

.BX [*text*] [Macro]

Typeset *text* and draw a box around it. On terminals, reverse video or another means of highlighting is used instead. If you want *text* to contain space, use unbreakable space or horizontal motion escape sequences (**\~**, **\SPC**, **\^**, **\|**, **\0** or **\h**).

⁴ This idiosyncrasy arose through feature accretion; for example, the **B** macro in Sixth Edition Unix **ms** (1975) accepted only one argument, the text to be set in boldface. By Version 7 (1979) it recognized a second argument; in 1990, **groff ms** added a “pre” argument, placing it third to avoid breaking support for older documents.

.UL [*text* [*post*]] [Macro]
 Typeset *text* with an underline. On terminals, *text* is bracketed with underscores ‘_’. *post*, if present, is set after *text* with no intervening space.

.LG [Macro]
 Set subsequent text in larger type (two points larger than the current size) until the next type size, paragraphing, or heading macro call. Call the macro multiple times to enlarge the type size further.

.SM [Macro]
 Set subsequent text in smaller type (two points smaller than the current size) until the next type size, paragraphing, or heading macro call. Call the macro multiple times to reduce the type size further.

.NL [Macro]
 Set subsequent text at the normal type size (the amount in register PS).

pre and *post* arguments are typically used to simplify the attachment of punctuation to styled words. When *pre* is used, a hyphenation control escape sequence `\%` that would ordinarily start *text* must start *pre* instead to have the desired effect.

```
The CS course's students found one C language keyword
.CW static ) \%(
most troublesome.
```

The foregoing example produces output as follows.

The CS course's students found one C language keyword (**static**)
 most troublesome.

You can use the output line continuation escape sequence `\c` to achieve the same result (see Section 5.16 [Line Continuation], page 129). It is also portable to older *ms* implementations.

```
The CS course's students found one C language keyword
\%( \c
.CW \%static )
most troublesome.
```

groff ms also offers strings to begin and end super- and subscripting. These are GNU extensions.

```
\* [{] [String]
\* []] [String]
Begin and end superscripting, respectively.
```

```
\* [<] [String]
\* [>] [String]
Begin and end subscripting, respectively.
```

Rather than calling the `CW` macro, in `groff ms` you might prefer to change the font family to Courier by setting the `FAM` string to ‘C’. You can then use all four style macros above, returning to the default family (Times) with ‘`.ds FAM T`’. Because changes to `FAM` take effect only at the next paragraph, `CW` remains useful to “inline” a change to the font family, similarly to the practice of this document in noting syntactical elements of `ms` and `groff`.

4.6.5.6 Lists

The `mark` argument to the `IP` macro can be employed to present a variety of lists; for instance, you can use a bullet glyph (`\[bu]`) for unordered lists, a number (or auto-incrementing register) for numbered lists, or a word or phrase for glossary-style or definition lists. If you set the paragraph indentation register `PI` before calling `IP`, you can later reorder the items in the list without having to ensure that a *width* argument remains affixed to the first call.

The following is an example of a bulleted list.

```
.nr PI 2n
A bulleted list:
.IP \[bu]
lawyers
.IP \[bu]
guns
.IP \[bu]
money
```

A bulleted list:

- lawyers
- guns
- money

The following is an example of a numbered list.

```
.nr step 0 1
.nr PI 3n
A numbered list:
.IP \n+[step]
lawyers
.IP \n+[step]
guns
.IP \n+[step]
money
```

A numbered list:

1. lawyers
2. guns
3. money

Here we have employed the `nr` request to create a register of our own, ‘`step`’. We initialized it to zero and assigned it an auto-increment of 1. Each time we use the escape sequence ‘`\n+[step]`’ (note the plus sign), the formatter applies the increment just before interpolating the register’s value. Preparing the `PI` register as well enables us to rearrange the list without the tedium of updating macro calls.

The next example illustrates a glossary-style list.

```
A glossary-style list:
.IP lawyers 0.4i
Two or more attorneys.
.IP guns
Firearms,
preferably large-caliber.
.IP money
Gotta pay for those
lawyers and guns!
```

A glossary-style list:

```
lawyers
    Two or more attorneys.

guns  Firearms, preferably large-caliber.

money
    Gotta pay for those lawyers and guns!
```

In the previous example, observe how the `IP` macro places the definition on the same line as the term if it has enough space. If this is not what you want, there are a few workarounds we illustrate by modifying the example. First, you can use a `br` request to force a break after printing the term or label.

```
.IP guns
.br
Firearms,
```

Second, you could apply the `\p` escape sequence to force a break. The space following the escape sequence is important; if you omit it, **groff** prints the first word of the paragraph text on the same line as the term or label (if it fits) *then* breaks the line.

```
.IP guns
  \p Firearms,
```

Finally, you may append a horizontal motion to the mark with the `\h` escape sequence; using the same amount as the indentation ensures that the mark is too wide for **groff** to treat it as “fitting” on the same line as the paragraph text.

```
.IP guns\h'0.4i'
  Firearms,
```

In each case, the result is the same.

```
A glossary-style list:

lawyers
    Two or more attorneys.

guns
    Firearms, preferably large-caliber.

money
    Gotta pay for those lawyers and guns!
```

4.6.5.7 Indented regions

You can indent a region of text while otherwise formatting it normally. Such indented regions can be nested; change `\n[PI]` before each call to vary the amount of inset.

```
.RS [Macro]
Begin a region where headings, paragraphs, and displays are indented
(further) by the amount stored in the PI register.
```

```
.RE [Macro]
End the (next) most recent indented region.
```

This feature enables you to easily line up text under hanging and indented paragraphs. For example, you may wish to structure lists hierarchically.

```
.IP \[bu] 2
Lawyers:
.RS
.IP \[bu]
Dewey,
.IP \[bu]
Cheatham,
and
.IP \[bu]
Howe.
.RE
.IP \[bu]
Guns
```

- Lawyers:
 - Dewey,
 - Cheatham, and
 - Howe.
- Guns

4.6.5.8 Keeps, boxed keeps, and displays

On occasion, you may want to *keep* several lines of text, or a region of a document, together on a single page, preventing an automatic page break within certain boundaries. This can cause a page break to occur earlier than it normally would. For example, you may want to keep two paragraphs together, or a paragraph that refers to a table, list, or figure adjacent to the item it discusses. `ms` provides the `KS` and `KE` macros for this purpose.

You can alternatively specify a *floating keep*: if a keep cannot fit on the current page, `ms` holds it, allowing material following the keep (in the source document) to fill the remainder of the current page. When the page breaks by reaching its bottom or by `bp` request, `ms` puts the floating keep at the beginning of the next page. Use floating keeps to house large graphics or tables that do not need to appear exactly where they occur in the source document.

.KS	[Macro]
.KF	[Macro]
.KE	[Macro]

KS begins a keep, KF a floating keep, and KE ends a keep of either kind.

As an alternative to the keep mechanism, the **ne** request forces a page break if there is not at least the amount of vertical space specified in its argument remaining on the page (see Section 5.18 [Page Control], page 131). One application of **ne** is to reserve space on the page for a figure or illustration to be included later.

A *boxed keep* has a frame drawn around it.

```
.B1 [Macro]
.B2 [Macro]
B1 begins a keep with a box drawn around it. B2 ends a boxed keep.
```

Boxed keep macros cause breaks; to box words within a line, recall **BX** in Section 4.6.5.5 [Typeface and decoration], page 42. **ms** draws box lines close to the text they enclose so that they are usable within paragraphs. When boxing entire paragraphs thus, you may improve their appearance by calling **B1** after the first paragraphing macro, and invoking the **sp** request before calling **B2**.

```
.LP
.B1
.I Warning:
Happy Fun Ball may suddenly accelerate to dangerous
speeds.
.sp \n[PD]/2 \" space by half the inter-paragraph distance
.B2
```

If you want a boxed keep to float, enclose the **B1** and **B2** calls within a pair of **KF** and **KE** calls.

Displays turn off filling; lines of verse or program code are shown with their lines broken as in the source document without requiring **br** requests between lines. Displays can be kept on a single page or allowed to break across pages. The **DS** macro begins a kept display of the layout specified in its first argument; non-kept displays are begun with dedicated macros corresponding to their layout.

```
.DS L [Macro]
.LD [Macro]
Begin (DS: kept) left-aligned display.
```

```
.DS [I [indent]] [Macro]
.ID [indent] [Macro]
Begin (DS: kept) display indented by indent if specified, and by the
amount of the DI register otherwise.
```

```
.DS B [Macro]
.BD [Macro]
Begin a (DS: kept) a block display: the entire display is left-aligned, but
indented such that the longest line in the display is centered on the page.
```

`.DS C` [Macro]
`.CD` [Macro]
 Begin a (DS: kept) centered display: each line in the display is centered.

`.DS R` [Macro]
`.RD` [Macro]
 Begin a (DS: kept) right-aligned display. This is a GNU extension.

`.DE` [Macro]
 End any display.

`groff ms` inserts the distance stored in the DD register before and after each pair of display macros; this is a Berkeley extension. This distance replaces any adjacent inter-paragraph distance or subsequent spacing prior to a section heading. The DI register is a GNU extension; its value is an indentation applied to displays created with ‘`.DS`’ and ‘`.ID`’ without arguments, to ‘`.DS I`’ without an indentation argument, and to indented equations set with ‘`.EQ`’. Changes to either register take effect at the next display boundary.

The display distance applies even in footnotes (discussed below), which may cause a footnote with a display at its end to “emptily” spill to the next page. Consider the following tactic to compensate.

```
.FS
Recall the ideal gas law.
.nr DD-saved \n[DD] \" stash display distance
.nr DD 0          \" eliminate automatic space around display
.sp \n[DD-saved]u  \" manually put space before it
.EQ
P V = n R T
.EN
.FE
.nr DD \n[DD-saved] \" restore previous setting
```

4.6.5.9 Tables, figures, equations, and references

`ms` often sees use with the `tbl`, `pic`, `eqn`, and `refer` preprocessors. Mark text meant for preprocessors by enclosing it in pairs of tokens as follows, with nothing between the dot and the macro name. Preprocessors match these tokens only at the start of an input line. The formatter interprets them as macro calls.

`.TS [H]` [Macro]
`.TE` [Macro]

Demarcate a table to be processed by the `tbl` preprocessor. The optional argument `H` to `TS` instructs `ms` to repeat table rows (often column headings) at the top of each new page the table spans, if applicable; calling the `TH` macro marks the end of such rows. The GNU `tbl(1)` man page provides a comprehensive reference to the preprocessor and offers examples of its use.

`.PS h v` [Macro]
`.PE` [Macro]
`.PF` [Macro]

`PS` begins a picture to be processed by the `pic` preprocessor; either of `PE` or `PF` ends it, the latter with “flyback” to the vertical position at its top. Create `pic` input manually or with a program such as `xfig`. *h* and *v* are the horizontal and vertical dimensions of the picture; `pic` supplies them automatically.

`.EQ [align [label]]` [Macro]
`.EN` [Macro]

Demarcate an equation to be processed by the `eqn` preprocessor. The equation is centered by default; *align* can be ‘C’, ‘L’, or ‘I’ to (explicitly) center, left-align, or indent it by the amount stored in the DI register, respectively. If specified, *label* is set right-aligned.

`.[` [Macro]
`.]` [Macro]

Demarcate a bibliographic citation to be processed by the `refer` preprocessor. `refer(1)` provides a comprehensive reference to the preprocessor and the format of its bibliographic database.

When `refer` emits collected references (as might be done on a “Works Cited” page), it interpolates the `REFERENCES` string as an unnumbered heading (SH).

The following is an example of how to set up a table that may print across two or more pages.

```
.TS H
allbox;
Cb | Cb .
Part→Description
-
.TH
.T&
GH-1978→Fribulating gonkulator
...the rest of the table follows...
.TE
```

Attempting to place a multi-page table inside a keep can lead to unpleasant results, particularly if the `tbl allbox` option is used.

Mathematics can be typeset using the language of the `eqn` preprocessor.

```
.EQ C (\*[SN-NO-DOT]a)
p ~ = ~ q sqrt { ( 1 + ~ ( x / q sup 2 ) ) }
.EN
```

This input formats a labelled equation. We used the `SN-NO-DOT` string to base the equation label on the current heading number, giving us more flexibility to reorganize the document.

Create diagrams with `pic`.

```
.PS
circle "input";
arrow;
box width 1.5i "\f[CR]groff -Rept -ms\f[ ]";
arrow;
circle "output";
.PE
```

`groff` options run preprocessors on the input: `-e` for `eqn`, `-p` for `pic`, `-R` for `refer`, and `-t` for `tbl`.

4.6.5.10 Footnotes

A footnote is typically anchored to a place in the text with a *mark*, which is a small integer, a symbol such as a dagger, or arbitrary user-specified text.

`\*[*]` [String]

Place an *automatic number*, an automatically generated numeric footnote mark, in the text. Each time this string is interpolated, the number it produces increments by one. Automatic numbers start at 1. This is a Berkeley extension.

Enclose the footnote text in `FS` and `FE` macro calls to set it at the nearest available “foot”, or bottom, of a text column or page.

`.FS [mark]` [Macro]
`.FE` [Macro]

Begin (`FS`) and end (`FE`) a footnote. `FS` calls `FS-MARK` with any supplied *mark* argument, which is then also placed at the beginning of the footnote text. If *mark* is omitted, the next pending automatic number enqueued by interpolation of the `*` string is used, and if none exists, nothing is prefixed.

You may not desire automatically numbered footnotes in spite of their convenience. You can indicate a footnote with a symbol or other text by specifying its mark at the appropriate place (for example, by using `\[dg]` for the dagger glyph) *and* as an argument to the `FS` macro. Such manual marks should be repeated as arguments to `FS` or as part of the footnote text to disambiguate their correspondence. You may wish to use `\*{` and `\*}` to superscript the mark at the anchor point, in the footnote text, or both.

`groff ms` provides a hook macro, `FS-MARK`, for user-determined operations to be performed when the `FS` macro is called. It is passed the same arguments as `FS` itself. An application of `FS-MARK` is anchor placement for a hyperlink reference, so that a footnote can link back to its referential context. By default, this macro has an empty definition. `FS-MARK` is a GNU extension.

Footnotes can be safely used within keeps and displays, but you should avoid using automatically numbered footnotes within floating keeps. You can

place a second `\**` interpolation between a `\**` and its corresponding `FS` call as long as each `FS` call occurs *after* the corresponding `\**` and occurrences of `FS` are in the same order as corresponding occurrences of `\**`.

Footnote text is formatted as paragraphs are, using analogous parameters. The registers `FI`, `FPD`, `FPS`, and `FVS` correspond to `PI`, `PD`, `PS`, and `CS`, respectively; `FPD`, `FPS`, and `FVS` are GNU extensions.

The `FF` register controls the formatting of automatically numbered footnote paragraphs, and those for which `FS` is given a *mark* argument, See Section 4.6.3 [ms Document Control Settings], page 30.

The default footnote line length is 11/12ths of the normal line length for compatibility with the expectations of historical `ms` documents; you may wish to set the `FR` string to ‘1’ to align with contemporary typesetting practices. In the past,⁵ an `FL` register was used for the line length in footnotes; however, setting this register at document initialization time had no effect on the footnote line length in multi-column arrangements.⁶

Prefer the `FR` string over the `FL` register in contemporary documents. The footnote line length is effectively computed as ‘*column-width* * `\*[FR]`’. If you require an absolute footnote line length, recall that `roff` formatters evaluate numeric expressions strictly from left to right, without operator precedence (parentheses are honored).

```
.ds FR 0+3i \" Set footnote line length to 3 inches.
```

4.6.5.11 Language and localization

`groff ms` provides several strings that you can customize for your own purposes, or redefine to adapt the macro package to languages other than English. It is already localized for Czech, German, Spanish, French, Italian, Polish, Russian, and Swedish. Load the desired localization macro package after `ms`; see `groff_tmac`(5).

```
$ groff -ms -mfr bienvenue.ms
```

The following strings are available.

- `\*[REFERENCES]` [String]
Contains the string printed at the beginning of a references (bibliography) page produced with GNU `refer`(1). The default is ‘References’.
- `\*[ABSTRACT]` [String]
Contains the string printed at the beginning of the abstract. The default is ‘`\f[I]ABSTRACT\f[]`’; it includes font selection escape sequences to set the word in italics.
- `\*[TOC]` [String]
Contains the string printed at the beginning of the table of contents. The default is ‘Table of Contents’.

⁵ Unix Version 7 `ms`, its descendants, and GNU `ms` prior to `groff` version 1.23.0

⁶ You could reset it after each call to `1C`, `2C`, or `MC`.

<code>* [MONTH1]</code>	<code>[String]</code>
<code>* [MONTH2]</code>	<code>[String]</code>
<code>* [MONTH3]</code>	<code>[String]</code>
<code>* [MONTH4]</code>	<code>[String]</code>
<code>* [MONTH5]</code>	<code>[String]</code>
<code>* [MONTH6]</code>	<code>[String]</code>
<code>* [MONTH7]</code>	<code>[String]</code>
<code>* [MONTH8]</code>	<code>[String]</code>
<code>* [MONTH9]</code>	<code>[String]</code>
<code>* [MONTH10]</code>	<code>[String]</code>
<code>* [MONTH11]</code>	<code>[String]</code>
<code>* [MONTH12]</code>	<code>[String]</code>

Contain the full names of the calendar months. The defaults are in English: ‘January’, ‘February’, and so on.

4.6.6 Page layout

`ms`’s default page layout arranges text in a single column with the page number between hyphens centered in a header on each page except the first, and produces no footers. You can customize this arrangement.

4.6.6.1 Headers and footers

There are multiple ways to produce headers and footers. One is to define the strings `LH`, `CH`, and `RH` to set the left, center, and right headers, respectively; and `LF`, `CF`, and `RF` to set the left, center, and right footers. This approach suffices for documents that do not distinguish odd- and even-numbered pages.

Another method is to call macros that set headers or footers for odd- or even-numbered pages. Each such macro takes a delimited argument separating the left, center, and right header or footer texts from each other. You can replace the neutral apostrophes (‘) shown below with any character not appearing in the header or footer text. These macros are Berkeley extensions.

<code>.OH 'left'center'right'</code>	<code>[Macro]</code>
<code>.EH 'left'center'right'</code>	<code>[Macro]</code>
<code>.OF 'left'center'right'</code>	<code>[Macro]</code>
<code>.EF 'left'center'right'</code>	<code>[Macro]</code>

The `OH` and `EH` macros define headers for odd- (recto) and even-numbered (verso) pages, respectively; the `OF` and `EF` macros define footers for them.

With either method, a percent sign `%` in header or footer text is replaced by the current page number. By default, `ms` places no header on a page numbered “1” (regardless of its number format).

<code>.P1</code>	<code>[Macro]</code>
------------------	----------------------

Typeset the header even on page 1. To be effective, this macro must be called before the header trap is sprung on any page numbered “1”;

in practice, unless your page numbering is unusual, this means that you should call it early, before TL or any heading or paragraphing macro. This is a Berkeley extension.

For even greater flexibility, **ms** is designed to permit the redefinition of the macros that are called when formatter traps that ordinarily cause the headers and footers to be output are sprung. **PT** (“page trap”) is called by **ms** when the header is to be written, and **BT** (“bottom trap”) when the footer is to be. The **groff** page location trap that **ms** sets up to format the header also calls the (normally undefined) **HD** macro after **PT**; you can define **HD** if you need additional processing after setting the header (for example, to draw a line below it). The **HD** hook is a Berkeley extension. Any such macros you (re)define must implement any desired specialization for odd-, even-, or first numbered pages.

4.6.6.2 Tab stops

Use the **ta** request to define tab stops as needed. See Section 5.12 [Tabs and Fields], page 119.

.TA [Macro]
Reset the tab stops to the **ms** default (every 5 ens). Redefine this macro to create a different set of default tab stops.

4.6.6.3 Margins

Control margins using the registers summarized in “Margin settings” in Section 4.6.3 [**ms** Document Control Settings], page 30, above. There is no setting for the right margin; the combination of page offset **\n[P0]** and line length **\n[LL]** determines it.

4.6.6.4 Multiple columns

ms can set text in as many columns as reasonably fit on the page. The following macros force a page break if a multi-column layout is active when they are called. The **MINGW** register stores the default minimum gutter width; it is a GNU extension. When multiple columns are in use, **keeps** and the **HORPHANS** and **PORPHANS** registers work with respect to column breaks instead of page breaks.

.1C [Macro]
Arrange page text in a single column (the default).

.2C [Macro]
Arrange page text in two columns.

.MC [*column-width* [*gutter-width*]] [Macro]
Arrange page text in multiple columns. If you specify no arguments, it is equivalent to the **2C** macro. Otherwise, *column-width* is the width of each column and *gutter-width* is the minimum distance between columns.

4.6.6.5 Creating a table of contents

Because `roff` formatters process their input in a single pass, material on page 50, for example, cannot influence what appears on page 1—this poses a challenge for a table of contents at its traditional location in front matter, if you wish to avoid manually maintaining it. `ms` enables the collection of material to be presented in the table of contents as it appears, saving its page number along with it, and then emitting the collected contents on demand toward the end of the document. The table of contents can then be resequenced to its desired location by physically rearranging the pages of a printed document, or as part of post-processing—with a `sed(1)` script to reorder the pages in `troff`’s output, with `pdfjam(1)`, or with `gropdf(1)`’s `pdfswitchtopage` macro, for example.

Define an entry to appear in the table of contents by bracketing its text between calls to the `XS` and `XE` macros. A typical application is to call them immediately after `NH` or `SH` and repeat the heading text within them. The `XA` macro, used within ‘`.XS`’/‘`.XE`’ pairs, supplements an entry—for instance, when it requires multiple output lines, whether because a heading is too long to fit or because style dictates that page numbers not be repeated. You may wish to indent the text thus wrapped to correspond to its heading depth; this can be done in the entry text by prefixing it with tabs or horizontal motion escape sequences, or by providing a second argument to the `XA` macro. `XS` and `XA` automatically associate the page number where they are called with the text following them, but they accept arguments to override this behavior. At the end of the document, call `TC` or `PX` to emit the table of contents; `TC` resets the page number to ‘`i`’ (Roman numeral one), and then calls `PX`. All of these macros are Berkeley extensions.

<code>.XS</code>	<code>[page-number]</code>	[Macro]
<code>.XA</code>	<code>[page-number [indentation]]</code>	[Macro]
<code>.XE</code>		[Macro]

Begin, supplement, and end a table of contents entry. Each entry is associated with *page-number* (otherwise the current page number); a *page-number* of ‘`no`’ prevents a leader and page number from being emitted for that entry. Use of `XA` within `XS/XE` is optional; it can be repeated. If *indentation* is present, a supplemental entry is indented by that amount; ens are assumed if no unit is indicated. Text on input lines between `XS` and `XE` is stored for later recall by `PX`.

<code>.PX</code>	<code>[no]</code>	[Macro]
------------------	-------------------	---------

Switch to single-column layout. Unless `no` is specified, center and interpolate the TOC string in bold and two points larger than the body text. Emit the table of contents entries.

<code>.TC</code>	<code>[no]</code>	[Macro]
------------------	-------------------	---------

Set the page number to 1, the page number format to lowercase Roman numerals, and call `PX` (with a `no` argument, if present).

Here's an example of typical **ms** table of contents preparation. We employ horizontal escape sequences `\h` to indent the entries by sectioning depth.

```
.NH 1
Introduction
.XS
Introduction
.XE
...
.NH 2
Methodology
.XS
\h'2n'Methodology
.XA
\h'4n'Fassbinder's Approach
\h'4n'Kahiu's Approach
.XE
...
.NH 1
Findings
.XS
Findings
.XE
...
.TC
```

The remaining features in this subsection are GNU extensions. **groff ms** obviates the need to repeat heading text after **XS** calls. Call **XN** and **XH** after **NH** and **SH**, respectively.

```
.XN heading-text [Macro]
.XH depth heading-text [Macro]
```

Format *heading-text* and create a corresponding table of contents entry. **XN** computes the indentation from the depth of the preceding **NH** call; **XH** requires a *depth* argument to do so.

groff ms encourages customization of table of contents entry production.

```
.XN-REPLACEMENT heading-text [Macro]
.XH-REPLACEMENT depth heading-text [Macro]
```

These hook macros implement **XN** and **XH**, respectively. They call **XN-INIT** and pass their *heading-text* arguments to **XH-UPDATE-TOC**.

```
.XN-INIT [Macro]
.XH-UPDATE-TOC depth heading-text [Macro]
```

The **XN-INIT** hook macro does nothing by default. **XH-UPDATE-TOC** brackets *heading-text* with **XS** and **XE** calls, indenting it by 2 ens per level of *depth* beyond the first.

We could therefore produce a table of contents similar to that in the previous example with fewer macro calls. (The difference is that this input follows the “Approach” entries with leaders and page numbers.)

```
.NH 1
.XN Introduction
...
.NH 2
.XN Methodology
.XH 3 "Fassbinder's Approach"
.XH 3 "Kahiu's Approach"
...
.NH 1
.XN Findings
...
```

To get the section number of the numbered headings into the table of contents entries, we might define `XN-REPLACEMENT` as follows. (We obtain the heading depth from `groff ms`’s internal register `nh*hl`.)

```
.de XN-REPLACEMENT
.XN-INIT
.XH-UPDATE-TOC \n[nh*hl] \\\$@
\&\\*[SN] \\\$*
..
```

You can change the style of the leader that bridges each table of contents entry with its page number; define the `TC-LEADER` special character by using the `char` request. A typical leader combines the dot glyph ‘.’ with a horizontal motion escape sequence to spread the dots. The width of the page number field is stored in the `TC-MARGIN` register.

4.6.7 Differences from AT&T `ms`

The `groff ms` macros are an independent reimplementaion, using no AT&T code. Since they take advantage of the extended features of GNU `troff`, they cannot be used with AT&T `troff`. `groff ms` supports features described above as Berkeley and Research Tenth Edition Unix extensions, and adds several of its own.

- The internals of `groff ms` differ from those of AT&T `ms`. Documents that depend upon implementation details of AT&T `ms` may not format properly with `groff ms`. Such details include macros whose function was not documented in the AT&T `ms` manual.⁷
- The error-handling policy of `groff ms` is to detect and report errors, rather than to ignore them silently.
- Research Tenth Edition Unix supported `P1/P2` macros to bracket code examples; `groff ms` does not.

⁷ “Typing Documents on the UNIX System: Using the -ms Macros with Troff and Nroff”, M. E. Lesk, Bell Laboratories, 1978

- **groff ms** does not work in GNU **troff**'s AT&T compatibility mode. If loaded when that mode is enabled, it aborts processing with a diagnostic message.
- Multiple line spacing is not supported. Use a larger vertical spacing instead.
- **groff ms** uses the same header and footer defaults in both **nroff** and **troff** modes as AT&T **ms** does in **troff** mode; AT&T's default in **nroff** mode is to put the date, in U.S. traditional format (e.g., "January 1, 2021"), in the center footer (the **CF** string).
- Many **groff ms** macros, including those for paragraphs, headings, and displays, cause a reset of paragraph rendering parameters, and may change the indentation; they do so not by incrementing or decrementing it, but by setting it absolutely. This can cause problems for documents that define additional macros of their own that manipulate indentation. Use the **ms RS** and **RE** macros instead of the **in** request.
- AT&T **ms** interpreted the values of the registers **PS** and **VS** in points, and did not support the use of scaling units with them. **groff ms** interprets values of the registers **PS**, **VS**, **FPS**, and **FVS** equal to or larger than 1,000 (one thousand) as decimal fractions multiplied by 1,000.⁸ This threshold makes use of a scaling unit with these parameters practical for high-resolution devices while preserving backward compatibility. It also permits expression of non-integral type sizes. For example, '**groff -rPS=10.5p**' at the shell prompt is equivalent to placing '**.nr PS 10.5p**' at the beginning of the document.
- AT&T **ms**'s **AU** macro supported arguments whose values were used with some non-RP document types; that of **groff ms** does not.
- Right-aligned displays are available. The AT&T **ms** manual observes that "it is tempting to assume that '**.DS R**' will right adjust lines, but it doesn't work". In **groff ms**, it does.
- To make **groff ms** use the default page offset (which also specifies the left margin), the **P0** register must stay undefined until the first **ms** macro is called.

This implies that '**\n[P0]**' should not be used early in the document, unless it is changed also: accessing an undefined register automatically defines it.

- **groff ms** supports the **PN** register, but it is not necessary; you can access the page number via the usual **%** register and invoke the **af** request to assign a different format to it if desired.⁹

⁸ Register values are converted to and stored as basic units. See Section 5.3 [Measurements], page 76.

⁹ If you redefine the **ms PT** macro and desire special treatment of certain page numbers (like '1'), you may need to handle a non-Arabic page number format, as **groff ms**'s **PT** does; see the macro package source. In **groff ms**, the **PN** and **%** registers are aliases.

- The AT&T **ms** manual documents registers **CW** and **GW** as setting the default column width and “intercolumn gap”, respectively, and which applied when **MC** was called with fewer than two arguments. **groff ms** instead treats **MC** without arguments as synonymous with **2C**; there is thus no occasion for a default column width register. Further, the **MINGW** register and the second argument to **MC** specify a *minimum* space between columns, not the fixed gutter width of AT&T **ms**.
- The AT&T **ms** manual did not document the **QI** register; Berkeley and **groff ms** do.

`\n[GS]` [Register]
groff ms sets the register **GS** to 1; AT&T **ms** does not use it. A document can test its value to determine whether it is being formatted with **groff ms** or another implementation.

4.6.7.1 Unix Version 7 **ms** macros unimplemented by **groff ms**

Several macros described in the Unix Version 7 **ms** documentation are unimplemented by **groff ms** because they are specific to the requirements of documents produced internally by Bell Laboratories, some of which also require a glyph for the Bell System logo that **groff** does not support. These macros implemented several document type formats (**EG**, **IM**, **MF**, **MR**, **TM**, **TR**), were meaningful only in conjunction with the use of certain document types (**AT**, **CS**, **CT**, **OK**, **SG**), stored the postal addresses of Bell Labs sites (**HQ**, **IH**, **MH**, **PY**, **WH**), or lacked a stable definition over time (**UX**). To compatibly render historical **ms** documents using these macros, we advise your documents to invoke the **rm** request to remove any such macros it uses and then define replacements with an authentically typeset original at hand.¹⁰ For informal purposes, a simple definition of **UX** should maintain the readability of the document’s substance.

```
.rm UX
.ds UX Unix\
```

4.6.8 Legacy Features

groff ms retains some legacy features solely to support formatting of historical documents; contemporary ones should not use them because they can render poorly. See the *groff_char(7)* man page.

AT&T accent mark strings

AT&T **ms** defined accent mark strings as follows.

`\*[']` [String]
 Apply acute accent to subsequent glyph.

¹⁰ Removal beforehand is necessary because **groff ms** aliases these macros with a diagnostic one; you want to reorient the aliased name before (re-)populating the macro.

<code>*[`]</code>	[String]
Apply grave accent to subsequent glyph.	
<code>*[:]</code>	[String]
Apply dieresis (umlaut) to subsequent glyph.	
<code>*[^]</code>	[String]
Apply circumflex accent to subsequent glyph.	
<code>*[~]</code>	[String]
Apply tilde accent to subsequent glyph.	
<code>*[C]</code>	[String]
Apply caron to subsequent glyph.	
<code>*[.,]</code>	[String]
Apply cedilla to subsequent glyph.	

Berkeley accent mark and glyph strings

Berkeley `ms` offered an `AM` macro; calling it redefined the AT&T accent mark strings (except for `\*C'`), applied them to the *preceding* glyph, and defined additional strings, some for spacing glyphs.

<code>.AM</code>	[Macro]
Enable alternative accent mark and glyph-producing strings.	
<code>*[']</code>	[String]
Apply acute accent to preceding glyph.	
<code>*[`]</code>	[String]
Apply grave accent to preceding glyph.	
<code>*[:]</code>	[String]
Apply dieresis (umlaut) to preceding glyph.	
<code>*[^]</code>	[String]
Apply circumflex accent to preceding glyph.	
<code>*[~]</code>	[String]
Apply tilde accent to preceding glyph.	
<code>*[.,]</code>	[String]
Apply cedilla to preceding glyph.	
<code>*[/]</code>	[String]
Apply stroke (slash) to preceding glyph.	
<code>*[v]</code>	[String]
Apply caron to preceding glyph.	

<code>*[_]</code>	[String]
Apply macron to preceding glyph.	
<code>*[.]</code>	[String]
Apply underdot to preceding glyph.	
<code>*[o]</code>	[String]
Apply ring accent to preceding glyph.	
<code>*[?]</code>	[String]
Interpolate inverted question mark.	
<code>*[!]</code>	[String]
Interpolate inverted exclamation mark.	
<code>*[8]</code>	[String]
Interpolate small letter sharp s.	
<code>*[q]</code>	[String]
Interpolate small letter o with hook accent (ogonek).	
<code>*[3]</code>	[String]
Interpolate small letter yogh.	
<code>*[d-]</code>	[String]
Interpolate small letter eth.	
<code>*[D-]</code>	[String]
Interpolate capital letter eth.	
<code>*[th]</code>	[String]
Interpolate small letter thorn.	
<code>*[Th]</code>	[String]
Interpolate capital letter thorn.	
<code>*[ae]</code>	[String]
Interpolate small æ ligature.	
<code>*[Ae]</code>	[String]
Interpolate capital Æ ligature.	
<code>*[oe]</code>	[String]
Interpolate small oe ligature.	
<code>*[OE]</code>	[String]
Interpolate capital OE ligature.	

4.6.9 Naming Conventions

groff ms uses the following conventions for names of macros, strings, and registers. External names available to documents that use the macros contain only uppercase letters and digits. The package reserves the following identifiers for internal use.

- those containing the characters `*`, `@`, and `::`; and
- those containing only uppercase letters and digits.

When selecting a name for your document's own macros, registers, macros, and strings, avoid those reserved by **groff ms** and those defined by GNU **troff**. See Appendix E [Register Index], page 285, Appendix F [Macro Index], page 289, and Appendix G [String Index], page 291, or *groff*(7) for complete lists thereof.

groff ms organizes most of its internal names into modules. The naming convention is as follows.

- Names used only within one module are of the form *module*name*.
- Names used outside the module in which they are defined are of the form *module@name*.
- Names associated with a particular environment are of the form *environment:name*; these are used only within the **par** module.
- *name* does not have a module prefix.
- Names constructed to implement arrays are of the form *array!index*.

5 GNU troff Reference

This chapter covers *all* of the facilities of the GNU **troff** formatting program. Users of macro packages may skip it if not interested in details.

5.1 Text

AT&T **troff** was designed to take input as it would be composed on a typewriter, including the teletypewriters used as early computer terminals, and relieve the user drafting a document of concern with details like line length maintenance, hyphenation breaking, and consistent paragraph indentation. Early in its development, the program gained the ability to prepare output for a phototypesetter; a document could then be prepared for output to a teletypewriter, a phototypesetter, or both. GNU **troff** continues this tradition of permitting an author to compose a single master version of a document which can then be rendered upon a variety of output formats or devices, including PDF, HTML, laser printers, and terminal displays.

roff input contains text interspersed with instructions to control the formatter. Even in the absence of such instructions, GNU **troff** still processes its input in several ways, by filling, hyphenating, breaking, and adjusting it, and supplementing it with inter-sentence space.

5.1.1 Filling

When GNU **troff** starts up, it obtains information about the device for which it is preparing output.¹ An essential property is the length of the output line, such as “6.5 inches”.

GNU **troff** interprets plain text files employing the Unix line-ending convention. It reads input a character at a time, collecting words as it goes, and fits as many words together on an output line as it can—this is known as *filling*. To GNU **troff**, a *word* is any sequence of one or more characters that aren’t spaces or newlines. The exceptions separate words.² To disable filling, see Section 5.9 [Manipulating Filling and Adjustment], page 101.

```
It is a truth universally acknowledged
that a single man in possession of a
good fortune must be in want of a wife.
```

```
⇒ It is a truth universally acknowledged that a
⇒ single man in possession of a good fortune must
⇒ be in want of a wife.
```

¹ See Section 6.1 [Device and Font Description Files], page 247.

² *Tabs* and *leaders* also separate words. *Escape sequences* can function as word characters, word separators, or neither—the last simply have no effect on GNU **troff**’s idea of whether an input character is within a word. We’ll discuss all of these in due course.

5.1.2 Sentences

A passionate debate has raged for decades among writers of the English language over whether more space should appear between adjacent sentences than between words within a sentence, and if so, how much, and what other circumstances should influence this spacing.³ GNU **troff** follows the example of AT&T **troff**; it attempts to detect the boundaries between sentences, and supplements them with inter-sentence space.

```
Hello, world!
Welcome to groff.
⇒ Hello, world!  Welcome to groff.
```

GNU **troff** flags certain characters (normally ‘!’, ‘?’, and ‘.’) as potentially ending a sentence. When GNU **troff** encounters one of these *end-of-sentence characters* at the end of an input line, or one of them is followed by two (unescaped) spaces on the same input line, it appends an inter-word space followed by an inter-sentence space in the output.

```
R. Harper subscribes to a maxim of P. T. Barnum.
⇒ R. Harper subscribes to a maxim of P. T. Barnum.
```

In the above example, inter-sentence space is not added after ‘P.’ or ‘T.’ because the periods do not occur at the end of an input line, nor are they followed by two or more spaces. Let’s imagine that we’ve heard something about defamation from Mr. Harper’s attorney, recast the sentence, and reflowed it in our text editor.

```
I submit that R. Harper subscribes to a maxim of P. T.
Barnum.
⇒ I submit that R. Harper subscribes to a maxim of
⇒ P. T.  Barnum.
```

“Barnum” doesn’t begin a sentence! What to do? Let us meet our first *escape sequence*, a series of input characters that give instructions to GNU **troff** instead of being used to construct output device glyphs.⁴ An escape sequence begins with the backslash character `\` by default, an uncommon character in natural language text, and is *always* followed by at least one other character, hence the term “sequence”.

The dummy character escape sequence `\&` can be used after an end-of-sentence character to defeat end-of-sentence detection on a per-instance basis. We can therefore rewrite our input more defensively.

³ A well-researched jeremiad appreciated by **groff** contributors on both sides of the sentence-spacing debate can be found at <https://web.archive.org/web/20171217060354/http://www.heracliteanriver.com/?p=324>.

⁴ This statement oversimplifies; there are escape sequences whose purpose is precisely to produce glyphs on the output device, and input characters that *aren’t* part of escape sequences can undergo a great deal of processing before getting to the output.

```
I submit that R.\& Harper subscribes to a maxim of P.\&
T.\& Barnum.
⇒ I submit that R. Harper subscribes to a maxim of
⇒ P. T. Barnum.
```

Adding text caused our input to wrap; now, we don’t need `\&` after ‘T.’ but we do after ‘P.’. Consistent use of the escape sequence ensures that potential sentence boundaries are robust to editing activities. Further advice along these lines follows in Section 5.1.11 [Input Conventions], page 72.

Normally, the occurrence of a visible non-end-of-sentence character (as opposed to a space or tab) immediately after an end-of-sentence character cancels detection of the end of a sentence. For example, it would be incorrect for the formatter to infer the end of a sentence after the dot in ‘3.14159’. However, it treats several characters *transparently* after the occurrence of an end-of-sentence character—it does not cancel end-of-sentence status upon encountering them. Such characters are often used as footnote marks or to close quotations and parentheticals. The default set is ‘”’, ‘’’, ‘)’, ‘]’, ‘*’, `\[dg]`, `\[dd]`, `\[rq]`, and `\[cq]`. The last four are examples of *special characters*, escape sequences whose purpose is to obtain glyphs that are not easily typed at the keyboard, or which have special meaning to the formatter (like `\` itself).⁵

```
\[lq]The idea that the poor should have leisure has always
been shocking to the rich.\[rq]
(Bertrand Russell, 1935)
```

```
⇒ “The idea that the poor should have
⇒ leisure has always been shocking to
⇒ the rich.” (Bertrand Russell, 1935)
```

Configure the sets of characters that potentially end sentences or are transparent to sentence endings with the `cflags` request (see Section 5.19.4 [Characters and Glyphs], page 140). Use the `ss` request to change—or eliminate—supplemental inter-sentence space (see Section 5.9 [Manipulating Filling and Adjustment], page 101).

5.1.3 Hyphenation

When an output line is nearly full, it is uncommon for the next word collected from the input to exactly fill it—often, there is room left over for only part of the next word. *Hyphenation* is the process of splitting a word so that it appears partially on one line, followed by a hyphen to indicate to the reader that the word has been broken, and that its remainder lies on the next. Hyphenation break points can be manually specified; GNU `troff` also uses a hyphenation algorithm and language-specific pattern files (based on `TeX`’s) to decide which words can be hyphenated and where.

⁵ The mnemonics for the special characters shown here are “dagger”, “double dagger”, “right (double) quote”, and “closing (single) quote”. See `groff_char(7)`.

Hyphenation does not always occur even when the hyphenation rules for a word allow it; it can be disabled, and when not disabled there are several parameters that can prevent it in certain circumstances. See Section 5.10 [Manipulating Hyphenation], page 108.

5.1.4 Breaking

Once an output line is full, the formatter places the next word (or remainder of a hyphenated one) on a different output line; this is called a *break*. In this manual and in **roff** discussions generally, a “break” if not further qualified always refers to the termination of an output line. When the formatter is filling text, it introduces breaks automatically to keep output lines from exceeding the configured line length. After an automatic break, the formatter adjusts the line if applicable (see below), and then resumes collecting and filling text on the next output line.

Sometimes, a line cannot be broken automatically. This usually does not happen with natural language text unless the output line length has been manipulated to be extremely short, but it can with specialized text like program source code. We can use **perl** at the shell prompt to contrive an example of failure to break the line. We also employ the **-z** option to suppress normal output.

```
$ perl -e 'print "#" x 80, "\n";' | nroff -z
error cannot adjust line; overset by 15n
```

The remedy for these cases is to tell GNU **troff** where the line may be broken without hyphens. This is done with the non-printing break point escape sequence `\:`; see Section 5.10 [Manipulating Hyphenation], page 108.

What if the document author wants to stop filling lines temporarily, for instance to start a new paragraph? There are several solutions. A blank input line not only causes a break, but by default it also outputs a one-line vertical space (effectively a blank output line). This behavior can be modified; see Section 5.29.3 [Blank Line Traps], page 206. Macro packages may discourage or disable the blank line method of paragraphing in favor of their own macros.

A line that begins with one or more spaces causes a break. The spaces are output at the beginning of the next line without being *adjusted* (see below); however, this behavior can be modified (see Section 5.29.4 [Leading Space Traps], page 206). Again, macro packages may provide other methods of producing indented paragraphs. Trailing spaces on text lines are discarded.⁶

What if the file ends before enough words have been collected to fill an output line? Or the output line is exactly full but not yet broken, and there is no more input? The formatter breaks the pending output line without adjustment upon encountering the end of input. Certain requests also cause breaks, implicitly or explicitly. This is discussed in Section 5.9 [Manipulating Filling and Adjustment], page 101.

⁶ See [text lines], page 68. AT&T **troff** also cancels end-of-sentence detection.

5.1.5 Adjustment

After performing an automatic break, the formatter may then *adjust* the line, widening inter-word spaces until the text reaches the right margin. Extra spaces between words are preserved. Leading and trailing spaces are handled as noted above. You can align text to the left or right margin only, or center it; see Section 5.9 [Manipulating Filling and Adjustment], page 101.

5.1.6 Tabs and Leaders

The formatter translates input horizontal tab characters (“tabs”) and **Control+A** characters (“leaders”) into movements to the next tab stop. Tabs simply move to the next tab stop; leaders place enough periods to fill the space. Tab stops are by default located every half inch measured from the drawing position corresponding to the beginning of the input line; see Section 5.2 [Page Geometry], page 75. Tabs and leaders do not cause breaks and therefore do not interrupt filling. Below, we use arrows $\rightarrow$ and bullets $\bullet$ to indicate input tabs and leaders, respectively.

```
A→B→C•D→•E
.br
1
→2→3•4
→•5
⇒ A      B      C.....D      .....E
⇒ 1      2      3.....4      .....5
```

Tabs and leaders lend themselves to table construction.⁷ The tab and leader fill characters can be configured, and further facilities for sophisticated table composition are available; see Section 5.12 [Tabs and Fields], page 119. There are many details to track when using such low-level features, so most users turn to the `tbl(1)` preprocessor to lay out tables.

5.1.7 Requests and Macros

We have now encountered almost all of the syntax there is in the **roff** language, with an exception already noted in passing.⁸ A *request* is an instruction to the formatter that occurs after a *control character*, which is recognized at the beginning of an input line. The regular control character is a dot (`.`). Its counterpart, the *no-break control character*, a neutral apostrophe (`'`), suppresses the break that is implied by some requests. These characters were chosen because it is uncommon for lines of text in natural languages to begin with them. If you require a formatted period or apostrophe (closing single quotation mark) where the formatter expects a control character, prefix the dot or neutral apostrophe with the dummy character escape sequence, `'\&'`.

⁷ “Tab” abbreviates “tabulation”, suggesting a table arrangement mechanism.

⁸ The backspace character is also meaningful; see Section 5.25 [Page Motions], page 184.

An input line beginning with a control character is called a *control line*. Every line of input that is not a control line is a *text line*.⁹

Requests often take *arguments*, words (separated from the request name and each other by spaces) that specify details of the action you expect the formatter to perform. If a request is meaningless without arguments, it is typically ignored.

Requests and escape sequences comprise the control language of the formatter. Of key importance are the requests that define macros. Macros are invoked like requests, enabling the request repertoire to be extended or overridden.¹⁰

A *macro* can be thought of as an abbreviation you can define for a collection of control and text lines. When a document *calls* a macro by placing its name after a control character, the formatter replaces the control line with the macro's definition. The process of textual replacement is known as *interpolation*.¹¹ Interpolations are handled as soon as they are recognized, and once performed, the formatter scans the replacement for further requests, macro calls, and escape sequences.

In **roff** systems, the **de** request defines a macro.¹²

```
.de DATE
2020-11-14
..
```

The foregoing input produces no output by itself; all we have done is store information in a macro named 'DATE'. Observe the pair of dots that ends the macro definition. This is a default; you can specify your own terminator for the macro definition as the second argument to the **de** request.

```
.de NAME ENDNAME
Heywood Jabuzzoff
.ENDNAME
```

In fact, the ending mark is itself the name of a macro to be called, or a request to be invoked, if it is defined at the time its control line is read.

```
.de END
Big Rip
..
.de START END
Big Bang
.END
.START
⇒ Big Rip Big Bang
```

⁹ The **\RET** escape sequence can alter how an input line is classified; see Section 5.16 [Line Continuation], page 129.

¹⁰ Argument handling in macros is more flexible but also more complex. See Section 5.6.3 [Calling Macros], page 87.

¹¹ Some escape sequences undergo interpolation as well.

¹² GNU **troff** offers additional ones. See Section 5.24 [Writing Macros], page 175.

In the foregoing example, “Big Rip” printed before “Big Bang” because its macro was *called* first. Consider what would happen if we dropped `END` from the `‘.de START’` line and added `..` after `.END`. Would the order change?

Let us consider a more elaborate example.

```
.de DATE
2020-10-05
..
.
.de BOSS
D.\& Kruger,
J.\& Peterman
..
.
.de NOTICE
Approved:
.DATE
by
.BOSS
..
.
Insert tedious regulatory compliance paragraph here.

.NOTICE

Insert tedious liability disclaimer paragraph here.

.NOTICE
⇒ Insert tedious regulatory compliance paragraph here.
⇒
⇒ Approved: 2020-10-05 by D. Kruger, J. Peterman
⇒
⇒ Insert tedious liability disclaimer paragraph here.
⇒
⇒ Approved: 2020-10-05 by D. Kruger, J. Peterman
```

The above document started with a series of control lines. Three macros were defined, with a `de` request declaring each macro’s name, and the “body” of the macro starting on the next line and continuing until a line with two dots `‘..’` marked its end. The text proper began only after the macros were defined; this is a common pattern. Only the `NOTICE` macro was called “directly” by the document; `DATE` and `BOSS` were called only by `NOTICE` itself. Escape sequences were used in `BOSS`, two levels of macro interpolation deep.

The advantage in typing and maintenance economy may not be obvious from such a short example, but imagine a much longer document with dozens of such paragraphs, each requiring a notice of managerial approval. Consider what must happen if you are in charge of generating a new version of such

a document with a different date, for a different boss. With well-chosen macros, you only have to change each datum in one place.

In practice, we would probably use strings (see Section 5.22 [Strings], page 163) instead of macros for such simple interpolations; what is important here is to glimpse the potential of macros and the power of recursive interpolation.

We could have defined our `DATE` and `BOSS` macros in the opposite order; perhaps less obviously, we could also have defined them *after* `NOTICE`. Such “forward references” are well-defined because the body of a macro definition is, for the most part, stored rather than interpreted (see Section 5.24.2 [Copy Mode], page 180). While a macro is being defined (or appended to), requests are not interpreted and macros not interpolated; some commonly used escape sequences *are* however interpreted. `roff` systems also support recursive macro calls, as long as you have a way to break the recursion (see Section 5.23 [Conditionals and Loops], page 168). Maintainable `roff` documents tend to arrange macro definitions to minimize forward references.

5.1.8 Macro Packages

Macro definitions can be collected into *macro files*, `roff` input files designed to produce no output themselves but instead ease the preparation of other `roff` documents. There is no syntactical difference between a macro file and any other `roff` document; only its purpose distinguishes it. When a macro file is installed at a standard location and suitable for use by a general audience, it is often termed a *macro package*.¹³ Macro packages can be loaded by supplying the `-m` option to GNU `troff` or a `groff` front end. Alternatively, a document requiring a macro package can load it with the `mso` (“macro source”) request.

5.1.9 Input Format

Organize input to GNU `troff` into lines separated by the Unix newline character (`U+000A`), using the character encoding it recognizes: ISO Latin-1 (8859-1). A document encoded in ISO 646:1991 IRV (US-ASCII), or, equivalently, uses only code points from the “C0 Controls” and “Basic Latin” parts of the Unicode character set is also a valid ISO Latin-1 document; the standards are interchangeable in their first 128 code points.¹⁴

Some control characters (from the sets “C0 Controls” and “C1 Controls” as Unicode describes them) are invalid as input characters. GNU `troff` discards them upon reading.¹⁵ It processes a character sequence “foo”, followed by an invalid character and then “bar”, as “foobar”.

¹³ Macro files and packages frequently define registers and strings as well.

¹⁴ The *semantics* of certain punctuation code points have gotten stricter with the successive standards, a cause of some frustration among man page writers; see `groff_char(7)`.

¹⁵ It also emits a warning in category ‘`input`’. See Section 5.38.1 [Warnings], page 236.

Invalid input characters comprise 0x00, 0x0B, 0x0D–0x1F, and 0x80–0x9F.¹⁶ GNU **troff** uses some of these code points for internal purposes, making non-trivial the extension of the program to accept UTF-8 or other encodings that use characters from these ranges.

5.1.10 Input Encodings

Recall from Section 2.1 [Groff Options], page 7, that the **groff** command's **-k** option runs the **preconv** preprocessor to perform input character encoding conversions to satisfy GNU **troff**'s requirement of a single-byte encoding compatible with ISO 646:1991 IRV (US-ASCII).

Localization influences automatic hyphenation in two distinct but related respects. A macro file specific to a character coding identifies which character codes correspond to letters expected in the language's hyphenation pattern files and sets up case equivalences for those letters. A language's macro file determines which of these letters are equivalent to other letters for hyphenation purposes.

For example, in English, the letter 'ñ' occurs in loan words. The **latin1.tmac** and **latin9.tmac** macro files define a hyphenation code for 'ñ' and make 'Ñ' equivalent to it. The English localization file **en.tmac** furthermore makes 'ñ' equivalent to 'n'. In Spanish (**es.tmac**), however, 'ñ' and 'n' are *not* equivalent. The language localization file (see Section 5.10 [Manipulating Hyphenation], page 108) loads an appropriate encoding localization file; a document need not do so directly.

- | | |
|---------------|---|
| koi8-r | To use KOI8-R, an encoding for the Russian language, either place <code>‘.mso koi8-r.tmac’</code> at the very beginning of your document or supply <code>‘-m koi8-r’</code> as a command-line argument to groff . The ru.tmac localization file loads koi8-r.tmac automatically. ¹⁷ |
| latin1 | ISO Latin-1 is an encoding for Western European languages. The de.tmac , en.tmac , it.tmac , and sv.tmac localization files load latin1.tmac automatically. |

¹⁶ Historically, control characters like ASCII STX, ETX, and BEL (**Control+B**, **Control+C**, and **Control+G**, respectively) have been observed in **roff** documents, particularly in macro packages employing them as delimiters with the output comparison operator to try to avoid collisions with the content of arbitrary user-supplied parameters (see Section 5.23.1 [Operators in Conditionals], page 168). We discourage this expedient; in GNU **troff** it is unnecessary (outside of compatibility mode) because the program parses delimited arguments at a different input level than their surrounding context. See Section 5.39 [Implementation Differences], page 238.

¹⁷ KOI8-R code points in the range 0x80–0x9F are not valid input to GNU **troff**; recall Section 5.1.9 [Input Format], page 70. This restriction should be no impediment to practical documents, as these KOI8-R code points do not encode letters, but box-drawing symbols and characters that are better obtained via special character escape sequences; see **groff_char(7)**.

- latin2** To use ISO Latin-2, an encoding for Central and Eastern European languages, invoke `‘.mso latin2.tmac’` at the beginning of your document or supply `‘-m latin2’` as a command-line argument to **groff**. The `cs.tmac` and `pl.tmac` localization files load `latin2.tmac` automatically.
- latin5** To use ISO Latin-5, an encoding for the Turkish language, invoke `‘.mso latin5.tmac’` at the beginning of your document or supply `‘-m latin5’` as a command-line argument to **groff**.
- latin9** ISO Latin-9 succeeds Latin-1; it includes a Euro sign and better coverage for French. To use this encoding, invoke `‘.mso latin9.tmac’` at the beginning of your document or supply `‘-m latin9’` as a command-line argument to **groff**. The `es.tmac` and `fr.tmac` localization files load `latin9.tmac` automatically.

Some characters from an input encoding may not be available with a particular output driver, or their glyphs may not have representation in the font used. For terminal devices, fallbacks are defined, like `‘EUR’` for the Euro sign and `‘(C)’` for the copyright sign. For typesetter devices, you may need to “mount” fonts that support glyphs required by the document. See Section 5.19.3 [Font Positions], page 139.

Because a Euro glyph was not historically defined in PostScript fonts, **groff** comes with a font called `freeeuro.pfa` that provides the Euro in several styles. Standard PostScript fonts contain the glyphs from Latin-5 and Latin-9 that Latin-1 lacks, so these encodings are supported for the **ps** and **pdf** output devices as **groff** ships, while Latin-2 is not.

Unicode supports characters from all other input encodings; the **utf8** output driver for terminals therefore does as well. The DVI output driver supports the Latin-2 and Latin-9 encodings if the command-line option `‘-m ec’` is used as well.¹⁸

5.1.11 Input Conventions

Since a **roff** formatter fills text automatically, its experienced users tend to avoid visual composition of text in input files: the esthetic appeal of the formatted output is what matters. Therefore, **roff** input should be arranged such that it is easy for authors and maintainers to compose and develop the document, understand the syntax of **roff** requests, macro calls, and preprocessor languages used, and predict the behavior of the formatter. Several traditions have accrued in service of these goals.

- Follow sentence endings in the input with newlines to ease their recognition (see Section 5.1.2 [Sentences], page 64). It is frequently convenient to end text lines after colons and semicolons as well, as these typically

¹⁸ The DVI output device defaults to using the Computer Modern (CM) fonts; `ec.tmac` loads the EC fonts instead, which provide Euro `‘\[Eu]’` and per mille `‘\[%0]’` glyphs.

precede independent clauses. Consider doing so after commas; they often occur in lists that become easy to scan when itemized by line, or constitute supplements to the sentence that are added, deleted, or updated to clarify it. Parenthetical and quoted phrases are also good candidates for placement on text lines by themselves.

- Set your text editor’s line length to 72 characters or fewer.¹⁹ This limit, combined with the previous item of advice, makes it less common that an input line will wrap in your text editor, and thus will help you perceive excessively long constructions in your text. Recall that natural languages originate in speech, not writing, and that punctuation is correlated with pauses for breathing and changes in prosody.
- Use `\&` after ‘!’, ‘?’, and ‘.’ if they are followed by space or newline characters and don’t end a sentence.
- In filled text lines, use `\&` before ‘.’ and ‘!’ if they are preceded by space, so that revisions to the input don’t turn them into control lines.
- Do not use spaces to perform indentation or align columns of a table. Leading spaces are reliable when text is not being filled. (Exception: when laying out a table with GNU `tbl`, specifying the `nospaces` region option causes the program to ignore spaces at the boundaries of table cells.)
- Comment your document. It is never too soon to apply comments to record information of use to future document maintainers (including your future self). We thus introduce another escape sequence, `\`, which causes the formatter to ignore the remainder of the input line.
- Use the empty request—a control character followed immediately by a newline—to visually manage separation of material in input files. Many of the `groff` project’s own documents use an empty request between sentences, after macro definitions, and where a break is expected, and two empty requests between paragraphs or other requests or macro calls that will introduce vertical space into the document.

You can combine the empty request with the comment escape sequence to include whole-line comments in your document, and even “comment out” sections of it.

We conclude this section with an example sufficiently long to illustrate most of the above suggestions in practice. For the purpose of fitting the example between the margins of this manual with the font used for its typeset version, we have shortened the input line length to 56 columns. As before, an arrow `→` indicates a tab character.

¹⁹ Emacs: `fill-column: 72`; Vim: `textwidth=72`

```

.\"  nroff this_file.roff | less
.\"  groff -T ps this_file.roff > this_file.ps
→The theory of relativity is intimately connected with
the theory of space and time.
.
I shall therefore begin with a brief investigation of
the origin of our ideas of space and time,
although in doing so I know that I introduce a
controversial subject.  \" remainder of paragraph elided
.
.

→The experiences of an individual appear to us arranged
in a series of events;
in this series the single events which we remember
appear to be ordered according to the criterion of
\[lq]earlier\[rq] and \[lq]later\[rq], \" punct swapped
which cannot be analysed further.
.
There exists,
therefore,
for the individual,
an I-time,
or subjective time.
.
This itself is not measurable.
.
I can,
indeed,
associate numbers with the events,
in such a way that the greater number is associated with
the later event than with an earlier one;
but the nature of this association may be quite
arbitrary.
.
This association I can define by means of a clock by
comparing the order of events furnished by the clock
with the order of a given series of events.
.
We understand by a clock something which provides a
series of events which can be counted,
and which has other properties of which we shall speak
later.
.\" Albert Einstein, _The Meaning of Relativity_, 1922

```

5.2 Page Geometry

`roff` systems format text under certain assumptions about the size of the output medium, or page. For the formatter to correctly break a line it is filling, it must know the line length, which it derives from the page width (see Section 5.15 [Line Layout], page 126). For it to decide whether to write an output line to the current page or wait until the next one, it must know the page length (see Section 5.17 [Page Layout], page 130).

A device's *resolution* converts practical units like inches or centimeters to *basic units*, a convenient length measure for the output device or file format. The formatter and output driver use basic units to reckon page measurements. The device description file defines its resolution and page dimensions (see Section 6.1.1 [DESC File Format], page 247).

A *page* is a two-dimensional structure upon which a `roff` system imposes a rectangular coordinate system with its origin near the upper left corner. Coordinate values are in basic units and increase down and to the right. Useful ones are typically positive and within numeric ranges corresponding to the page boundaries.

Text is arranged on a one-dimensional lattice of text baselines from the top to the bottom of the page. A *text baseline* is a (usually invisible) line upon which the glyphs of a typeface are aligned. *Vertical spacing* is the distance between adjacent text baselines. Typographic tradition sets this quantity to 120% of the type size. Typographers term this unit a *vee*.

While the formatter (and, later, output driver) is processing a page, it keeps track of its *drawing position*, which is the location at which the next glyph will be written, from which the next motion will be measured, or where a geometric object will commence rendering. Notionally, glyphs are drawn from the text baseline upward and to the right.²⁰ A glyph therefore “starts” at its bottom-left corner. The formatter's origin is one vee below the page top to prevent a glyph from lying partially or wholly off the page.

Further, it is conventional not to write or draw at the extreme edges of the page. Typesetters configure a *page offset*, a rightward shift from the left edge that defines the zero point from which the formatter reckons the line indentation and length.²¹

Combining the foregoing facts results in an origin that lies at the page offset in the horizontal dimension and at the text baseline (using the default vertical spacing) in the vertical dimension. A document can change these prior to its first written or drawn output; see Section 5.15 [Line Layout], page 126, and Section 5.20 [Manipulating Type Size and Vertical Spacing], page 156.

Vertical spacing has an impact on page-breaking decisions. Generally, when a break occurs, the formatter automatically moves the drawing position

²⁰ `groff` does not yet support right-to-left scripts.

²¹ `groff`'s terminal output devices have page offsets of zero.

to the next text baseline. If the formatter were already writing to the last line that fits on the page, advancing by one vee would place the next text baseline off the page. To avoid that, **roff** formatters instruct the output driver to eject the page, start a new one, and again place the drawing position at the page offset one vee below the page top; this is a *page break*.

When the last line of input text corresponds to the last output line that fits on the page, the break caused by the end of input also breaks the page, producing a useless blank one. Macro packages keep users from having to confront this difficulty by setting “traps” (see Section 5.29 [Traps], page 197); moreover, all but the simplest page layouts tend to have headers and footers, or at least bear vertical margins of at least one vee.

5.3 Measurements

A **roff** document sometimes requires the input of numeric parameters to specify measurements. Express them as integers or decimal fractions with an optional scaling unit suffixed. A *scaling unit* is a letter that immediately follows the magnitude of a measurement. Digits after the decimal point are optional. Examples of measurements include ‘10.5p’, ‘11i’, ‘.5f’, and ‘3.c’.

The formatter scales measurements by the specified scaling unit, storing them internally (with any fractional part discarded) in basic units. The device resolution can therefore be obtained by storing a value of ‘1i’ to a register, then reading the register.

u	Basic unit; it is at least as small as any other unit.
i	Inch; defined as 2.54 centimeters.
c	Centimeter; a centimeter is about 0.3937 inches.
p	Point; a typesetter’s unit used for measuring type size. There are 72 points to an inch.
P	Pica; another typesetter’s unit. There are 6 picas to an inch and 12 points to a pica.
s	Scaled point; see Section 5.20.3 [Using Fractional Type Sizes], page 159.
z	Typographical point; like p, but used only with type sizes, to overcome a limitation of AT&T troff ; see Section 5.20.3 [Using Fractional Type Sizes], page 159.
f	GNU troff defines this unit to scale decimal fractions in the interval [0, 1] to 16-bit unsigned integers. It multiplies a quantity by 65,536. See Section 5.21 [Colors], page 161, for usage.

The magnitudes of other scaling units depend on the text formatting parameters in effect. These are useful when specifying measurements that need to scale with the typeface or vertical spacing.

m	Em; an em is equal to the current type size in points. It is named thus because it is approximately the width of the letter ‘M’.
n	En; on typesetters, an en is one-half em, but on terminals an en equals an em, because they align all text to a grid of character cells.
v	Vee; recall Section 5.2 [Page Geometry], page 75.
M	Hundredth of an em.

5.3.1 Motion Quanta

The basic unit **u** is not necessarily an output device’s smallest addressable length; **u** can be smaller to avoid integer rounding errors. The minimum distances that a device can work with in the horizontal and vertical directions are termed its *motion quanta*. The formatter rounds measurements to applicable motion quanta. Half-quantum fractions round toward zero.

<code>\n[.H]</code>	[Register]
<code>\n[.V]</code>	[Register]

These read-only registers interpolate the horizontal and vertical motion quantum, respectively, of the output device in basic units.

For example, we might draw short baseline rules on a terminal device as follows. See Section 5.27 [Drawing Geometric Objects], page 192.

```
.tm \n[.H]
    error 24
.nf
\l'36u' 36u
\l'37u' 37u
    => _ 36u
    => __ 37u
```

5.3.2 Default Units

A general-purpose register (one created or updated with the **nr** request²²) is implicitly dimensionless, or reckoned in basic units if interpreted in a measurement context. But it is convenient for many requests and escape sequences to infer a scaling unit for an argument if none is specified. An explicit scaling unit (not after a closing parenthesis) can override an undesirable default. Effectively, the default unit is suffixed to the expression if a scaling unit is not already present. GNU **troff**’s use of integer arithmetic should also be kept in mind.²³

²² See Section 5.8 [Registers], page 94.

²³ See Section 5.4 [Numeric Expressions], page 78.

The `ll` request interprets its argument in ems by default. Consider several attempts to set a line length of 3.5 inches when the type size is 10 points on a terminal device with a resolution of 240 basic units and horizontal motion quantum of 24. Some expressions become zero; the request clamps them to that quantum.

```
.ll 3.5i      \" 3.5i (= 840u)
.ll 7/2       \" 7u/2u -> 3u -> 3m -> 0, clamped to 24u
.ll (7 / 2)u  \" 7u/2u -> as above
.ll 7/2i      \" 7u/2i -> 7u/480u -> 0 -> as above
.ll 7i/2      \" 7i/2u -> 1680u/2m -> 1680u/24u -> 35u
.ll 7i/2u     \" 3.5i (= 840u)
```

The safest way to specify measurements is to attach a scaling unit. To multiply or divide by a dimensionless quantity, use ‘u’ as its scaling unit.

5.4 Numeric Expressions

When evaluated, a *numeric expression* interpolates an integer: it can be as simple as a literal ‘0’ or it can be a complex sequence of register and string interpolations interleaved with measurements and operators.

GNU `troff` provides a set of mathematical and logical operators familiar to programmers—as well as some unusual ones—but supports only integer arithmetic.²⁴ The internal data type used for computing results depends on the host machine but is at least a 32-bit signed integer, which suffices to represent magnitudes within a range of ± 2 billion.²⁵ Arithmetic saturates.²⁶

Arithmetic infix operators perform a function on the numeric expressions to their left and right; they are `+` (addition), `-` (subtraction), `*` (multiplication), `/` (truncating division), and `%` (modulus). *Truncating division* rounds to the integer nearer to zero, no matter how large the fractional portion. Division and modulus by zero are errors and abort evaluation of a numeric expression.

Arithmetic unary operators operate on the numeric expression to their right; they are `-` (negation) and `+` (assertion—for completeness; it does nothing). The unary minus must often be used with parentheses to avoid confusion with the decrementation operator, discussed below.

²⁴ Provision is made for interpreting and reporting decimal fractions in certain cases.

²⁵ If that’s not enough, see the *groff_tmac*(5) man page for the `62bit.tmac` macro package.

²⁶ If overflow would occur, GNU `troff` emits a warning in category ‘range’. See Section 5.38.1 [Warnings], page 236.

Observe the rounding behavior and effect of negative operands on the modulus and truncating division operators.

```
.nr T 199/100
.nr U 5/2
.nr V (-5)/2
.nr W 5/-2
.nr X 5%2
.nr Y (-5)%2
.nr Z 5%-2
T=\n[T] U=\n[U] V=\n[V] W=\n[W] X=\n[X] Y=\n[Y] Z=\n[Z]
⇒ T=1 U=2 V=-2 W=-2 X=1 Y=-1 Z=1
```

The sign of the modulus of operands of mixed signs is determined by the sign of the first. Division and modulus operators satisfy the following property: given a dividend a and a divisor b , a quotient q formed by ‘ (a / b) ’ and a remainder r by ‘ $(a \% b)$ ’, then $qb + r = a$.

GNU **troff**’s scaling operator, used with parentheses as $(c; e)$, evaluates a numeric expression e using c as the default scaling unit. If c is omitted, scaling units are ignored in the evaluation of e . This operator can save typing by avoiding the attachment of scaling units to every operand out of caution. Your macros can select a sensible default unit in case the user neglects to supply one.

```
.\" Indent by amount given in first argument; assume ens.
.de Indent
.  in (n;\\$1)
..
```

Without the scaling operator, the foregoing macro would, if called with a unitless argument, cause indentation by the **in** request’s default scaling unit (ems). The result would be twice as much indentation as expected.

GNU **troff** also provides a pair of operators to compute the extrema of two operands: $>?$ (maximum) and $<?$ (minimum).

```
.nr slots 5
.nr candidates 3
.nr salaries (\n[slots] <? \n[candidates])
Looks like we'll end up paying \n[salaries] salaries.
⇒ Looks like we'll end up paying 3 salaries.
```

Comparison operators comprise $<$ (less than), $>$ (greater than), $<=$ (less than or equal), $>=$ (greater than or equal), and $=$ (equal, with synonym $==$). When evaluating a comparison, the formatter replaces it with ‘0’ if it is false and ‘1’ if true. In the **roff** language, positive values are true, others false.

We can operate on truth values with the logical operators **&** (logical conjunction or “and”) and **:** (logical disjunction or “or”). They evaluate as comparison operators do.

A logical complementation (“not”) operator, **!**, works only within **if**, **ie**, and **while** requests. Furthermore, the formatter recognizes **!** only at

the beginning of a numeric expression not contained by another numeric expression. In other words, `!` must be the “outermost” operator. Its presence elsewhere causes the expression to evaluate false.²⁷ This unfortunate limitation maintains compatibility with AT&T `troff`. Test a numeric expression for falsity within a complex expression by comparing it to a false value.²⁸

```
.nr X 1
.nr Y 0
.\" This does not work as expected.
.if (\n[X])&(!\n[Y]) .nop A: X is true, Y is false
.
.\" Use this construct instead.
.if (\n[X])&(\n[Y]<=0) .nop B: X is true, Y is false
    [error] warning: expected numeric expression, got '!'
    ⇒ B: X is true, Y is false
```

The `roff` language has no operator precedence: expressions are evaluated strictly from left to right, in contrast to schoolhouse arithmetic. Use parentheses `( )` to impose a desired precedence upon subexpressions.

```
.nr X 3+5*4
.nr Y (3+5)*4
.nr Z 3+(5*4)
X=\n[X] Y=\n[Y] Z=\n[Z]
⇒ X=32 Y=32 Z=23
```

For many requests and escape sequences that cause motion on the page, the unary operators `+` and `-` work differently when leading a numeric expression. They then indicate a motion relative to the drawing position: positive is down in vertical contexts, right in horizontal ones.

`+` and `-` are also treated differently by the following requests and escape sequences: `bp`, `in`, `ll`, `lt`, `nm`, `nr`, `pl`, `pn`, `po`, `ps`, `pvs`, `rt`, `ti`, `\H`, `\R`, and `\s`. Here, leading plus and minus signs serve as incrementation and decrementation operators, respectively. To negate an expression in these contexts, subtract it from zero or include the unary minus in parentheses with its argument. See Section 5.8.1 [Setting Registers], page 95, for examples.

A leading `|` operator indicates a measurement relative not to the drawing position but to a boundary. For horizontal motions, the boundary is the drawing position corresponding to the beginning of the *input* line. By default, tab stops reckon movements in this way. Most escape sequences do not; `|` tells them to do so.

²⁷ GNU `troff` emits a warning in category ‘`number`’. See Section 5.38.1 [Warnings], page 236.

²⁸ See Section 5.23 [Conditionals and Loops], page 168.

```

Mind the \h'1.2i'gap.
.br
Mind the \h'|1.2i'gap.
.br
Mind the
\h'|1.2i'gap.
    ⇒ Mind the           gap.
    ⇒ Mind the      gap.
    ⇒ Mind the           gap.

```

One use of this feature is to define macros whose scope is limited to the output they format.

```

.\" underline word $1 with trailing punctuation $2
.de Underline
.  nop \\$1\\l'|0\\[ul]'\\$2
..
Typographical emphasis is best used
.Underline sparingly .

```

In the above example, ‘|0’ specifies a negative motion from the current position (at the end of the argument just emitted, \(\$1) to the beginning of the input line. Thus, the \l escape sequence in this case draws a line from right to left. A macro call occurs at the beginning of an input line;²⁹ if the | operator were omitted, then the underline would be drawn at zero distance from the current position, producing device-dependent, and likely undesirable, results. On the ‘ps’ output device, it underlines the period.

For vertical motions, the | operator specifies a distance from the first text baseline on the page or in the current diversion.³⁰

```

A
.br
B \Z'C'\v'|0'D
    ⇒ A D
    ⇒ B C

```

In the foregoing example, we’ve used the \Z escape sequence (see Section 5.25 [Page Motions], page 184) to restore the drawing position after formatting ‘C’, then moved vertically to the first text baseline on the page.

\B'input' [Escape sequence]
 Interpolate 1 if *input* is a valid numeric expression, and 0 otherwise. The delimiter need not be a neutral apostrophe; see Section 5.6.5 [Delimiters], page 91.

²⁹ Control structure syntax creates an exception to this rule, but is designed to remain useful: recalling our example, ‘.if 1 .Underline this’ would underline only “this”, precisely. See Section 5.23 [Conditionals and Loops], page 168.

³⁰ See Section 5.30 [Diversion], page 208.

You might use `\B` along with the `if` request to filter out invalid macro or string arguments. See Section 5.23 [Conditionals and Loops], page 168.

```
.\" Indent by amount given in first argument; assume ens.
.de Indent
.  if \B'\\$1' .in (n;\\$1)
.  el          .tm \\$0: invalid number '\\$1'
..
```

A register interpolated as an operand in a numeric expression must have an Arabic format; luckily, this is the default. See Section 5.8.4 [Assigning Register Formats], page 98.

Because spaces separate arguments to requests, spaces are not allowed in numeric expressions unless parentheses surround the (sub)expression containing them. See Section 5.6.2 [Invoking Requests], page 86, and Section 5.23 [Conditionals and Loops], page 168.

```
.nf
.nr a 1+2 + 2+1
\na
    error   expected numeric expression, got a space
⇒ 3
.nr a 1+(2 + 2)+1
\na
⇒ 6
```

The `nr` request (see Section 5.8.1 [Setting Registers], page 95) expects its second and optional third arguments to be numeric expressions; a bare `+` does not qualify, so our first attempt elicited an error diagnostic.

5.5 Identifiers

An *identifier* labels a GNU `troff` datum such as a register, name (macro, string, or diversion), typeface (font, family, or style), color, special character or character class, hyphenation language code, environment, or stream. Valid identifiers consist of one or more ordinary characters.³¹ An *ordinary character* is any Unicode Basic Latin character that is not a space and not the escape character; recall Section 5.1.9 [Input Format], page 70. Thus, the identifiers `'br'`, `'PP'`, `'end-list'`, `'ref*normal-print'`, `'|'`, `'@_'`, and `'!\"#$%'()*+,-./'` are all valid. Discretion should be exercised to prevent confusion. Identifiers starting with `'(` or `'[` require care.

³¹ Use of escape sequences in identifiers is not portable. For example, DWB 3.3 `troff` accepts `\_`. Plan 9 `troff` does too, along with `\'`, `\``, and `\-`. Solaris `troff` rejects all of these except `\_`, but accepts `\&`, `\{`, `\}`, `\SPC`, `\%`, and `\c`. Heirloom Doctools `troff` rejects all of these, including `\_`, but accepts `\!`, which the others reject. GNU `troff` rejects all of the foregoing.

```
.nr x 9
.nr y 1
.nr (x 2
.nr [y 3
.nr sum1 (\n(x + \n[y])
error a space character is not allowed in an escape
error sequence parameter
A:2+3=\n[sum1]
.nr sum2 (\n((x + \n[[y])
B:2+3=\n[sum2]
.nr sum3 (\n[(x] + \n([y)
C:2+3=\n[sum3]
⇒ A:2+3=1 B:2+3=5 C:2+3=5
```

An identifier with a closing bracket (']') in its name can't be accessed with bracket-form escape sequences that expect an identifier as a parameter. For example, '\[foo]]' accesses the glyph 'foo', followed by ']' in whatever the surrounding context is, whereas '\C'foo]'' formats a glyph named 'foo]'. Similarly, the identifier '(' can't be interpolated *except* with bracket forms.

Beginning a macro, string, or diversion name with the character '[' or '['' forecloses use of the **refer** preprocessor, which recognizes input lines starting with '.', '[', and '['' as bibliographic reference delimiters.

\A'input' [Escape sequence]

Interpolate 1 if *input* is a valid identifier, and 0 otherwise. The delimiter need not be a neutral apostrophe; see Section 5.6.5 [Delimiters], page 91. Because GNU troff ignores any input character with an invalid code when reading it, invalid identifiers are empty or contain spaces, tabs, newlines, or escape sequences that interpolate something other than a sequence of ordinary characters.

You can employ \A to validate a macro argument before using it to construct another escape sequence or identifier.

```
.\" usage: .init-coordinate-pair name val1 val2
.\" Create a coordinate pair where name!x=val1 and
.\" name!y=val2.
.de init-coordinate-pair
.  if \A'\\$1' \{\
.    if \B'\\$2' .nr \\$1!x \\$2
.    if \B'\\$3' .nr \\$1!y \\$3
.  \}
..
.init-coordinate-pair center 5 10
.init-coordinate-pair "poi→nt" trash garbage \" ignored
.init-coordinate-pair point waste rubbish \" ignored
The center is at (\n[center!x], \n[center!y]).
⇒ The center is at (5, 10).
```

In this example, we also validated the numeric arguments; the registers ‘point!x’ and ‘point!y’ remain undefined. See Section 5.4 [Numeric Expressions], page 78, for the \B escape sequence.

The formatter’s handling of undefined identifiers is context-dependent. There is no way to invoke an undefined request; such syntax is interpreted as a macro call instead. If the identifier is interpreted as a string, macro, or diversion name, the formatter defines it as empty and interpolates nothing.³² Similarly, if the identifier is interpreted as a register name, the formatter initializes it to zero and interpolates that value.³³ Attempting to use an undefined typeface, special character or character class, color, environment, hyphenation language code, or stream generally provokes an error diagnostic.

Identifiers for requests, macros, strings, and diversions share one name space; special characters and character classes another. No other object types do.

```
.de xxx
.  nop foo
..
.di xxx
bar
.br
.di
.
.xxx
⇒ bar
```

The foregoing example shows that GNU **troff** reuses the identifier ‘xxx’, changing it from a macro to a diversion. No warning is emitted, and the previous contents of ‘xxx’ are lost.

5.6 Formatter Instructions

To support documents that require more than filling, automatic line breaking and hyphenation, adjustment, and supplemental inter-sentence space, the **roff** language offers two means of embedding instructions to the formatter.

One is a *request*, which begins with a control character and takes up the remainder of the input line. Requests often perform relatively large-scale operations such as setting the page length, breaking the line, or starting a new page. They also conduct internal operations like defining macros.

The other is an *escape sequence*, which begins with the escape character and can be embedded anywhere in the input, even in arguments to requests and other escape sequences. Escape sequences interpolate special characters, strings, or registers, and handle comparatively minor formatting tasks like sub- and superscripting.

³² GNU **troff** emits a warning in category ‘**mac**’. See Section 5.38.1 [Warnings], page 236.

³³ GNU **troff** emits a warning in category ‘**reg**’. See Section 5.38.1 [Warnings], page 236.

Some operations, such as font selection and type size alteration, are available via both requests and escape sequences.

5.6.1 Control Characters

The mechanism of using `roff`'s control characters to invoke requests and call macros was introduced in Section 5.1.7 [Requests and Macros], page 67. The formatter recognizes a control character only at the beginning of an input line, or at the beginning of a branch of a control structure request; see Section 5.23 [Conditionals and Loops], page 168.

A few requests cause a break implicitly; invoke them with the no-break control character to prevent the break. Break suppression is its sole behavioral distinction. Employing the no-break control character to invoke requests that don't cause breaks is harmless but poor style. See Section 5.9 [Manipulating Filling and Adjustment], page 101.

The control `'.'` and no-break control `''` characters can each be changed to any ordinary character³⁴ with the `cc` and `c2` requests, respectively.

`.cc` [*o*] [Request]

Recognize the ordinary character *o* as the control character. If *o* is absent or invalid, the default control character `'.'` is selected. If *o* (or `'.'` if *o* is invalid) is already the escape or no-break control character, an error is diagnosed and the request ignored. The identity of the control character is associated with the environment (see Section 5.32 [Environments], page 216).

`.c2` [*o*] [Request]

Recognize the ordinary character *o* as the no-break control character. If *o* is absent or invalid, the default no-break control character `''` is selected. If *o* (or `''` if *o* is invalid) is already the escape or control character, an error is diagnosed and the request ignored. The identity of the no-break control character is associated with the environment (see Section 5.32 [Environments], page 216).

When writing a macro, you might wish to know which control character was used to call it.

`\n[.br]` [Register]

This read-only register interpolates 1 if the currently executing macro was called using the normal control character and 0 otherwise. If a macro is interpolated as a string, the `.br` register's value is inherited from the context of the string interpolation. See Section 5.22 [Strings], page 163.

Use this register to reliably intercept requests that imply breaks.

³⁴ Recall Section 5.5 [Identifiers], page 82.

```
.als bp*orig bp
.de bp
.  ie \\n[.br] .bp*orig
.  el          'bp*orig
..
```

Testing the `.br` register outside of a macro definition makes no sense.

5.6.2 Invoking Requests

A control character is optionally followed by tabs and/or spaces and then an identifier naming a request or macro. The invocation of an unrecognized request is interpreted as a macro call. Defining a macro with the same name as a request replaces the request. Deleting a request name with the `rm` request makes it unavailable. The `als` request can alias requests, permitting them to be wrapped or non-destructively replaced. See Section 5.22 [Strings], page 163.

There is no inherent limit on argument length or quantity. Most requests take one or more arguments, and ignore any they do not expect. A request may be separated from its arguments by tabs or spaces, but only spaces can separate an argument from its successor. Only one between arguments is necessary; any excess is ignored.³⁵ GNU `troff` does not interpret tabs as argument separators.³⁶

Generally, a space *within* a request argument is not relevant, not meaningful, or is supported by bespoke provisions, as with the `t1` request's delimiters (see Section 5.17 [Page Layout], page 130). Some requests, like `ds`, interpret the remainder of the control line as a single argument. See Section 5.22 [Strings], page 163.

Spaces and tabs immediately after a control character are ignored. Commonly, authors use them to indent the source of documents or macro files.

```
.de center
.  if \\n[.br] \
.    br
.  ce \\$1
..
.
.
.de right-align
.→if \\n[.br] \
.→→br
.→rj \\$1
..
```

³⁵ In compatibility mode, a space is not necessary after a request or macro name of two characters' length.

³⁶ Plan 9 `troff` does.

If you assign an empty blank line trap, you can separate macro definitions (or any input lines) with blank lines.

```
.de do-nothing
..
.blm do-nothing  \" activate blank line trap

.de center
.  if \\n[.br] \
.    br
.  ce \\$1
..

.de right-align
.→if \\n[.br] \
.→→br
.→rj \\$1
..

.blm          \" deactivate blank line trap
```

See Section 5.29.3 [Blank Line Traps], page 206.

5.6.3 Calling Macros

If a macro of the desired name does not exist when called, the formatter creates it and assigns it an empty definition.³⁷ Calling an undefined macro *does* end a macro definition naming it as its end macro (see Section 5.24 [Writing Macros], page 175).

To embed spaces *within* a macro argument, enclose the argument in neutral double quotes ". Horizontal motion escape sequences are sometimes a better choice for arguments to be formatted as text.

Consider calls to a hypothetical section heading macro ‘uh’.

```
.uh The Mouse Problem
.uh "The Mouse Problem"
.uh The~Mouse~Problem
.uh The\ Mouse\ Problem
```

The first line calls `uh` with three arguments: ‘The’, ‘Mouse’, and ‘Problem’. The remainder call the `uh` macro with one argument, ‘The Mouse Problem’. The last solution, using escaped spaces, can be found in documents prepared for AT&T `troff`. It can cause surprise when text is adjusted, because `\SPC` inserts a *fixed-width*, non-breaking space. GNU `troff`’s `\~` escape sequence inserts an adjustable, non-breaking space.³⁸

³⁷ GNU `troff` emits a warning in category ‘`mac`’. See Section 5.38.1 [Warnings], page 236.

³⁸ `\~` is fairly portable; see Section 5.39.3 [Other Differences], page 242.

The foregoing raises the question of how to embed neutral double quotes or backslashes in macro arguments when *those* characters are desired as literals. In GNU **troff**, the special character escape sequence `\[rs]` produces a backslash and `\[dq]` a neutral double quote.

In GNU **troff**'s AT&T compatibility mode, these characters remain available as `\(rs` and `\(dq`, respectively. AT&T **troff** did not consistently define these special characters, but its descendants can be made to support them. See Section 6.1 [Device and Font Description Files], page 247.

If even that is not feasible, options remain. To obtain a literal escape character in a macro argument, you can simply type it if you change or disable the escape character first. See Section 5.6.4 [Using Escape Sequences], page 89. Otherwise, you must escape the escape character repeatedly to a context-dependent extent. See Section 5.24.2 [Copy Mode], page 180.

For the (neutral) double quote, you have recourse to an obscure syntactical feature of AT&T **troff**. Because a double quote can begin a macro argument, the formatter keeps track of whether the current argument was started thus, and doesn't require a space after the double quote that ends it.³⁹ In the argument list to a macro, a double quote that *isn't* preceded by a space *doesn't* start a macro argument. If not preceded by a double quote that began an argument, this double quote becomes part of the argument. Furthermore, within a quoted argument, a pair of adjacent double quotes becomes a literal double quote.

```
.de eq
.  tm arg1:\\$1 arg2:\\$2 arg3:\\$3
.  tm arg4:\\$4 arg5:\\$5 arg6:\\$6
.. \" 4 backslashes on the next line
.eq a" "b c" "de"f\\\\"g" h""i "j""k"
    error arg1:a" arg2:b c arg3:de
    error arg4:f\\g" arg5:h""i arg6:j"k
```

Apart from the complexity of the rules, this traditional solution has the disadvantage that double quotes don't survive repeated argument expansion in AT&T **troff** or GNU **troff**'s compatibility mode. This can frustrate efforts to pass such arguments intact through multiple macro calls.

³⁹ Strictly, you can neglect to close the last quoted macro argument, relying on the end of the control line to do so. We consider this lethargic practice poor style.

```

.cp 1
.de eq
.  tm arg1:\\$1 arg2:\\$2 arg3:\\$3
.  tm arg4:\\$4 arg5:\\$5 arg6:\\$6
..
.de xe
.  eq \\$1 \\$2 \\$3 \\$4 \\$5 \\$6
.. \" 8 backslashes on the next line
.xe a" "b c" "de"f\\\\\\\\\\\\g" h""i "j""k"
    error arg1:a" arg2:b arg3:c
    error arg4:de arg5:f\\g" arg6:h""i

```

Outside of compatibility mode, GNU `troff` doesn’t exhibit this problem because it tracks the nesting depth of interpolations. See Section 5.39 [Implementation Differences], page 238.

5.6.4 Using Escape Sequences

Whereas requests must occur on control lines, escape sequences can occur intermixed with text and may appear in arguments to requests, macros, and other escape sequences. An escape sequence is introduced by the escape character, a backslash `\` (but see the `ec` request below). The next character selects the escape’s function.

Escape sequences vary in length. Some take an argument, and of those, some have different syntactical forms for a one-character, two-character, or arbitrary-length argument. Others accept *only* an arbitrary-length argument. In the former scheme, a one-character argument follows the function character immediately, an opening parenthesis ‘`(`’ introduces a two-character argument (no closing parenthesis is used), and an argument of arbitrary length is enclosed in brackets ‘`[]`’. In the latter scheme, the user selects a delimiter character. A few escape sequences are idiosyncratic, and support both of the foregoing conventions (`\s`), designate their own termination sequence (`\?`), consume input until the next newline (`\!`, `\"`, `\#`), or support an additional modifier character (`\s` again, and `\n`). In no case can an escape sequence parameter contain an unescaped newline. As with requests, use of some escape sequences in source documents may interact poorly with a macro package you use; consult its documentation to learn of “safe” sequences or alternative facilities it provides to achieve the desired result.

If the character that follows the escape character does not identify a valid operation, the formatter ignores the escape character.⁴⁰

⁴⁰ GNU `troff` emits a warning in category ‘`escape`’. See Section 5.38.1 [Warnings], page 236.

```
$ groff -T ps -ww
.nr N 12
.ds co white
.ds animal elephant
I have \fI\nN \*(co \*[animal]s,\f[]
said \P.\&\~Pseudo Pachyderm.
[error] warning: ignoring escape character before 'P'
⇒ I have 12 white elephants, said P. Pseudo Pachyderm.
```

Escape sequence interpolation is of higher precedence than escape sequence argument interpretation. This rule affords flexibility in using escape sequences to construct parameters to other escape sequences.

```
.ds family C\" Courier
.ds style I\" oblique
Choose a typeface \f(\*[family]\*[style]wisely.
⇒ Choose a typeface wisely.
```

In the above, the syntax form ‘\f(’ accepts only two characters for an argument; the example works because the subsequent escape sequences are interpolated before the selection escape sequence argument is processed, and strings *family* and *style* interpolate one character each.⁴¹

The escape character is nearly always interpreted when encountered; it is therefore desirable to have a way to interpolate it, disable it, or change it.

\e [Escape sequence]
Interpolate the escape character. **\e** is interpreted even in copy mode (see Section 5.24.2 [Copy Mode], page 180).

The **\[rs]** special character escape sequence formats a backslash glyph. In macro and string definitions, the input sequences **** and **\E** defer interpretation of escape sequences. See Section 5.24.2 [Copy Mode], page 180.

.eo [Request]
Disable the escape mechanism except in copy mode. Once this request is invoked, no input character is recognized as starting an escape sequence in interpretation mode.

.ec [*o*] [Request]
Recognize the ordinary character *o* as the escape character. If *o* is absent or invalid, the default escape character ‘\’ is selected. If *o* (or ‘\’ if *o* is invalid) is already the control or no-break control character, an error is diagnosed and the request ignored.

Switching escape sequence interpretation off to define a macro and back on afterward can obviate the need to double the escape character within the definition. See Section 5.24 [Writing Macros], page 175. This technique

⁴¹ The omission of spaces before the comment escape sequences is necessary; see Section 5.22 [Strings], page 163.

is not available if your macro needs to interpolate values at the time it is *defined*—but many do not.

```
.\" simplified `BR` macro from the man(7) macro package
.eo
.de BR
.  ds result \&
.  while (\n[.] >= 2) {\
.    as result \fB\${1}\fR\${2}\
.    shift 2
.  }
.  if \n[.] .as result \fB\${1}\
\[result]
.  rm result
.  ft R
..
.ec
```

```
.ecs [Request]
.ecr [Request]
```

The `ecs` request stores the escape character for recall with `ecr`. `ecr` sets the escape character to ‘\’ if none has been saved.

Use these requests together to temporarily change the escape character.

Using a different escape character, or disabling it, when calling macros not under your control will likely cause errors, since GNU `troff` has no mechanism to “intern” macros—that is, to convert a macro definition into a form independent of its representation.⁴² When a macro is called, its contents are interpreted literally.

5.6.5 Delimiters

Some escape sequences that require parameters delimit them. The neutral apostrophe ‘`'`’ is a popular delimiter choice and shown in this document. The neutral double quote ‘`"`’ is also commonly seen. Punctuation characters are the best choice (and most portable to other `troffs`), except for those meaningful in numeric expressions; see below.

```
\l'1.5i\[\bu]' \" draw 1.5 inches of bullet glyphs
```

The following escape sequences are not themselves delimited, and thus are allowed as delimiters: `\SPC`, `\%`, `\|`, `\^`, `\{`, `\}`, `\'`, `\``, `\-`, `\_`, `\!`, `\?`, `\)`, `\/`, `\,`, `\&`, `\:`, `\~`, `\0`, `\a`, `\c`, `\d`, `\e`, `\E`, `\p`, `\r`, `\t`, and `\u`. However, we discourage using them this way; they can make the input confusing to read.⁴³ An invalid escape sequence is valid as a delimiter if the character after the escape character would be valid.

⁴² `TEX` does have such a mechanism.

⁴³ The GNU `eqn(1)` and `tbl(1)` preprocessors use parameterized but non-delimited special character escape sequences `\(` and `\[` to bracket portions of their output.

The escape sequences `\D`, `\h`, `\H`, `\l`, `\L`, `\N`, `\R`, `\s`, `\S`, `\v`, and `\x` prohibit delimiters that are meaningful in numeric expressions, because they accept numeric expressions as (or within) their arguments. For consistency, GNU **troff** prohibits the same delimiters in the argument to the `t1` request.⁴⁴ The `if`, `ie`, and `while` requests each interpret their first argument as a conditional expression;⁴⁵ only characters that are not meaningful as operators in that context can be used as output comparison delimiters. The following inputs are therefore invalid as delimiters in GNU **troff**.

- the numerals 0-9 and the decimal point `.`
- the (single-character) operators `'+-/*%<>=&:()|'`
- the space and tab characters
- any escape sequences other than `\%`, `\:`, `\{`, `\}`, `\'`, `\``, `\-`, `\_`, `\!`, `\/`, `\c`, `\e`, and `\p`

Delimiter syntax is flexible (and laborious to describe) primarily for historical reasons; the foregoing restrictions need be kept in mind mainly when using GNU **troff** in AT&T compatibility mode. Normally, GNU **troff** keeps track of the nesting depth of escape sequence interpolations, so the only characters you need to avoid using as delimiters are those that appear in the arguments you input, not those that result from interpolation. Typically, `'` works fine.⁴⁶

```
$ groff -T ps
.de Mw
. nr wd \w'\$1'
. tm "\$1" is \n(wd units wide.
..
.Mw Wet'suwet'en
.Mw Wet+200i
.cp 1 \" turn on compatibility mode
.Mw Wet'suwet'en
.Mw Wet'
.Mw Wet+200i
[error] "Wet'suwet'en" is 54740 units wide.
[error] "Wet'+200i" is 42610 units wide.
[error] "Wet'suwet'en" is 15860 units wide.
[error] "Wet'" is 15860 units wide.
[error] "Wet'+200i" is 14415860 units wide.
```

We see here that in compatibility mode, the part of the argument after the `'` delimiter escapes, if you will, from its context and, if nefariously crafted, influences the computation of the `wd` register's value in a surprising way.

⁴⁴ See Section 5.17 [Page Layout], page 130.

⁴⁵ See Section 5.23.1 [Operators in Conditionals], page 168.

⁴⁶ See Section 5.39 [Implementation Differences], page 238.

5.7 Comments

One of the most common forms of escape sequence is the comment.⁴⁷

\" [Escape sequence]
Start a comment; read everything up to the next newline in copy mode (see Section 5.24.2 [Copy Mode], page 180) and discard it. **\"** is interpreted even in copy mode.

It can be tricky to keep the comments from interfering with the appearance of the output. If the escape sequence is to the right of some text or a request, that portion of the line is ignored, but GNU **troff** processes spaces preceding it normally. This affects requests that read the remainder of the control line as a single argument, including **ds**, **as**, **tm**, and **char**; their variants; as well as **ab**, **device**, **length**, **output**, **pi**, **ps**, **rd**, **sy**, **write**, and **writec**.

One possibly irritating idiosyncrasy is that tabs should not be used to vertically align comments in the source document. Tab characters are not treated as separators between a request name and its first argument, nor between arguments.

The formatter handles a **\"** comment on a line by itself as a blank line, because after eliminating the comment, that is all that remains.

```
apples bananas
\" cantaloupes
durians
⇒ apples bananas
⇒
⇒ durians
```

To compensate, it is common to combine the empty request with the comment escape sequence as **‘.\'**, causing the input line to be ignored.

Another commenting scheme sometimes seen is three consecutive neutral apostrophes (**'''**) at the beginning of an input line. This works,⁴⁸ but GNU **troff** emits a warning diagnostic (if enabled) about an undefined macro (namely **'''**).

\# [Escape sequence]
Start a whole-line comment; read everything up to and including the next newline in copy mode⁴⁹ and discard it. GNU **troff** introduced this extension to avoid the problems described above. (**\"** is still widely seen, and remains useful for partial-line comments on control lines.) **\#** is interpreted even in copy mode.

⁴⁷ This claim may be more aspirational than descriptive.

⁴⁸ except in copy mode on Plan 9 **troff**

⁴⁹ See Section 5.24.2 [Copy Mode], page 180.

```
.nr in-indonesia 1
apples bananas \" common favorites
\# cantaloupes
.ie \n[in-indonesia] durians \" Borneo, Sumatra
.el
    elderberries \" England, France
⇒ apples bananas durians
```

If we change the comment escape sequence from \" to \# on the line with the `ie` request, we get the following undesired output.

```
⇒ apples bananas durians .el elderberries
```

`.ig [end]` [Request]
 Ignore input until, in the current conditional block (if any),⁵⁰ the macro `end` is called at the start of a control line, or the control line `..` is encountered if `end` is not specified. `ig` is parsed as if it were a macro definition, but its contents are discarded, not stored.⁵¹

```
.ll 45n
hand\c
.de TX
fasting
..
.ig TX
This is part of a large block of input that has been
temporarily(?) commented out.
.TX
shake
⇒ handfasting shake
```

Observe the result if we remove the `ig` request and the call of its `end` macro.

```
⇒ handThis is part of a large block of input
⇒ that has been temporarily(?) commented out.
⇒ shake
```

5.8 Registers

In the `roff` language, numbers and measurements can be stored in *registers*. Many built-in registers exist, supplying anything from components of the date to details of formatting parameters; some of these are read-only. You can also define your own. Recall Section 5.5 [Identifiers], page 82, regarding the construction of valid names for registers.

Each register (except read-only ones) can be assigned a *format*, causing its value to interpolate with leading zeroes, in Roman numerals, or alpha-

⁵⁰ See Section 5.23.4 [Conditional Blocks], page 171.

⁵¹ Exception: auto-incrementing registers defined outside the ignored region *will* be modified if interpolated with `\n±` inside it. See Section 5.8.3 [Auto-increment], page 97.

betically. Some read-only registers are string-valued, meaning that they interpolate text and lack a format.

5.8.1 Setting Registers

Define registers and update their values with the **nr** request or the **\R** escape sequence.

.nr *ident* *value* [Request]
\R'*ident* *value*' [Escape sequence]

Set register *ident* to *value*. If *ident* doesn't exist, the formatter creates it. In the **\R** escape sequence, the delimiter need not be a neutral apostrophe; see Section 5.6.5 [Delimiters], page 91.

```
.nr a (((17 + (3 * 4))) % 4)
\n[a]
.\R'a (((17 + (3 * 4))) % 4)'
\n[a]
⇒ 1 1
```

(Later, we will discuss additional forms of **nr** and **\R** that can change a register's value after it is dereferenced but before it is interpolated. See Section 5.8.3 [Auto-increment], page 97.)

GNU **troff** does not tokenize **\R** when reading it; the escape sequence updates only the formatter's register dictionary and does not contribute (directly) to output. See Section 5.37 [GNU **troff** Internals], page 228.

Further surprise can occur if you use registers like **.k**,⁵² whose values are not determined until they are interpolated.

```
.ll 1.6i
.
aaa bbb ccc ddd eee fff ggg hhh\R':k \n[.k]'
.tm :k == \n[:k]
⇒ :k == 126950
.
.br
.
aaa bbb ccc ddd eee fff ggg hhh\h'O'\R':k \n[.k]'
.tm :k == \n[:k]
⇒ :k == 15000
```

If you process this with the PostScript device (**-T ps**), there will be a line break eventually after **ggg** in both input lines. However, after processing the space after **ggg**, the partially collected line is not overfull yet, so GNU **troff** continues to collect input until it sees the space (or in this case, the newline) after **hhh**. At this point, the line is longer than the line length, and the line gets broken.

⁵² See Section 5.25 [Page Motions], page 184.

In the first input line, since the `\R` escape sequence leaves no traces, the check for the overfull line hasn't been done yet at the point where `\R` gets handled, and you get a value for the `.k` register that is even greater than the current line length.

In the second input line, the insertion of `\h'0'` to cause a zero-width motion forces GNU `troff` to check the line length, which in turn causes the start of a new output line. Now `.k` returns the expected value.

`.nr` and `\R` each have two additional special forms to increment or decrement a register.

<code>.nr ident +value</code>	[Request]
<code>.nr ident -value</code>	[Request]
<code>\R'ident +value'</code>	[Escape sequence]
<code>\R'ident -value'</code>	[Escape sequence]

Increment (decrement) register *ident* by *value*. In the `\R` escape sequence, the delimiter need not be a neutral apostrophe; see Section 5.6.5 [Delimiters], page 91.

```
.nr a 1
.nr a +1
\na
⇒ 2
```

A `roff` formatter always interprets a leading minus sign in *value* as a decrementation operator, not an algebraic sign. To assign a register a negative value or the negated value of another register, you must force the formatter to interpret ‘-’ as a negation or minus, rather than decrementation, operator: enclose the ‘-’ with its operand in parentheses or subtract the expression of interest from zero.

```
.nr a 7
.nr b 3
.nr a -\nb
\na
⇒ 4
.nr a (-\nb)
\na
⇒ -3
.nr a 0-\nb
\na
⇒ -3
```

If a register's prior value does not exist—the register was undefined—an increment or decrement is applied as if to 0.

<code>.rr reg . . .</code>	[Request]
----------------------------	-----------

Remove each register *reg*. If *reg* doesn't exist, the request is ignored. Technically, only the name is removed; the register's contents are still accessible under aliases created with `aln`, if any.

This request is incorrectly documented in the AT&T **troff** manual as accepting only one argument.

.rnn *ident1 ident2* [Request]

Rename register *ident1* to *ident2*. If *ident1* doesn't exist, the request is ignored. Renaming a built-in register does not otherwise alter its properties.

.aln *new-register old-register* [Request]

Create alias (additional name) *new-register* of *existing-register*, causing the names to refer to the same stored object. If *existing-register* is undefined, the formatter ignores the request.⁵³

To remove a register alias, invoke **rr** on its name. A register's contents do not become inaccessible until it has no more names.

5.8.2 Interpolating Registers

The **\n** escape sequence interpolates register contents.

\ni [Escape sequence]

\n(id [Escape sequence]

\n[ident] [Escape sequence]

Interpolate register with name *ident* (one-character name *i*, two-character name *id*). If the register is undefined, the formatter creates it and assigns it a value of '0', and interpolates that value.⁵⁴ **\n** is interpreted even in copy mode (see Section 5.24.2 [Copy Mode], page 180).

```
.nr a 5
.nr as \na+\na
\n(as
    ⇒ 10

.nr a1 5
.nr ab 6
.ds str b
.ds num 1
\n[a\n[num]]
    ⇒ 5
\n[a\*[str]]
    ⇒ 6
```

5.8.3 Auto-increment

User-defined registers can also be incremented or decremented by a configured amount at the time they are interpolated. The value of the increment is specified with a third argument to the **nr** request, and a special interpo-

⁵³ GNU **troff** emits a warning in category '**reg**'. See Section 5.38.1 [Warnings], page 236.

⁵⁴ GNU **troff** emits a warning in category '**reg**'. See Section 5.38.1 [Warnings], page 236.

lation syntax alters and then retrieves the register’s value. Together, these features are called *auto-increment*.⁵⁵

.nr *ident* *value* *incr* [Request]
 Set register *ident* to *value* and its auto-incrementation amount to *incr*.
 The `\R` escape sequence doesn’t support an *incr* argument.

Auto-incrementation is not *completely* automatic; the `\n` escape sequence in its basic form never alters the value of a register. To apply auto-incrementation to a register, interpolate it with ‘`\n±`’.

<code>\n+i</code>	[Escape sequence]
<code>\n-i</code>	[Escape sequence]
<code>\n+(<i>id</i></code>	[Escape sequence]
<code>\n-(<i>id</i></code>	[Escape sequence]
<code>\n+[<i>ident</i>]</code>	[Escape sequence]
<code>\n-[<i>ident</i>]</code>	[Escape sequence]

Increment or decrement *ident* (one-character name *i*, two-character name *id*) by the register’s auto-incrementation value and then interpolate the new register value. If *ident* has no auto-incrementation value, GNU **troff** interpolates its value without alteration.

```
.nr a 0 1
.nr xx 0 5
.nr foo 0 -2
\n+a, \n+a, \n+a, \n+a, \n+a
.br
\n-(xx, \n-(xx, \n-(xx, \n-(xx, \n-(xx
.br
\n+[foo], \n+[foo], \n+[foo], \n+[foo], \n+[foo]
⇒ 1, 2, 3, 4, 5
⇒ -5, -10, -15, -20, -25
⇒ -2, -4, -6, -8, -10
```

To change the increment value without changing the value of a register, assign the register’s value to itself by interpolating it, and specify the desired increment normally. Apply an increment of ‘0’ to disable auto-incrementation of the register.

5.8.4 Assigning Register Formats

A writable register’s value can be interpolated in several number formats. By default, conventional Arabic numerals are used. Other formats see use in sectioning and outlining schemes and alternative page numbering arrangements.

⁵⁵ A negative auto-increment can be considered an “auto-decrement”.

.af *reg* *fmt* [Request]
 Use number format *fmt* when interpolating register *reg*. Valid number formats are as follows.

- 0. . . Arabic numerals 0, 1, 2, and so on. Any decimal digit is equivalent to ‘0’; the formatter merely counts the digits specified. Multiple Arabic numerals in *fmt* cause interpolations to be zero-padded on the left if necessary to at least as many digits as specified (interpolations never truncate a register value). A register with format ‘00’ interpolates values 1, 2, 3 as ‘01’, ‘02’, ‘03’. The default format for all writable registers is ‘0’.
- I Uppercase Roman numerals: 0, I, II, III, IV, . . .
- i Lowercase Roman numerals: 0, i, ii, iii, iv, . . .
- A Uppercase letters: 0, A, B, C, . . . , Z, AA, AB, . . .
- a Lowercase letters: 0, a, b, c, . . . , z, aa, ab, . . .

Omitting *fmt* causes a warning in category ‘missing’. See Section 5.38.1 [Warnings], page 236, regarding the enablement and suppression of warnings. Specifying an unrecognized format is an error.

Zero values are interpolated as ‘0’ in non-Arabic formats. Negative quantities are prefixed with ‘-’ irrespective of format. In Arabic formats, the sign supplements the field width. If *reg* doesn’t exist, it is created with a zero value.

```
.nr a 10
.af a 0          \" the default format
\na,
.af a I
\na,
.af a 321
.nr a (-\na)
\na,
.af a a
\na
⇒ 10, X, -010, -j
```

The representable extrema in the ‘i’ and ‘I’ formats correspond to Arabic $\pm 39,999$. GNU **troff** uses ‘w’ and ‘z’ to represent 5,000 and 10,000 in Roman numerals, respectively, following the convention of AT&T **troff**—currently, the correct glyphs for Roman numerals five thousand (U+2181) and ten thousand (U+2182) are not used.

Assigning the format of a read-only register is an error. Instead, copy the read-only register’s value to, and assign the format of, a writable register.

\gr	[Escape sequence]
\g(rg	[Escape sequence]

`\g[reg]` [Escape sequence]
 Interpolate the format of the register *reg* (one-character name *r*, two-character name *rg*). Zeroes represent Arabic formats. If *reg* is not defined, *reg* is not created and nothing is interpolated. `\g` is interpreted even in copy mode (see Section 5.24.2 [Copy Mode], page 180).

GNU **troff** interprets only Arabic numerals. The Roman numeral or alphabetic formats cannot be used as operands to arithmetic operators in expressions (see Section 5.4 [Numeric Expressions], page 78). For instance, it may be desirable to test the page number independently of its format.

```
.af % i \" front matter
.de header-trap
.  \" To test the page number, we need it in Arabic.
.  ds saved-page-number-format \"g%\"
.  af % 0
.  nr page-number-in-decimal \"n%
.  af % \"*[saved-page-number-format]
.  ie \"n[page-number-in-decimal]=1 .do-first-page-stuff
.  el {\
.    ie o .do-odd-numbered-page-stuff
.    el .do-even-numbered-page-stuff
.  \}
.  rm saved-page-number-format
..
.wh 0 header-trap
```

5.8.5 Built-in Registers

Predefined registers whose identifiers start with a dot are read-only. Many are Boolean-valued, interpolating a true or false value testable with the **if**, **ie**, or **while** requests.

Caution: Built-in registers are subject to removal like others; once removed, they can be recreated only as normal writable registers and will not otherwise reflect the configuration of the formatter.

A register name is often associated with a request of the same name (without the dot). A complete listing of all built-in registers can be found in Appendix E [Register Index], page 285.

We present here a few built-in registers that are not described elsewhere in this manual; they have to do with invariant properties of GNU **troff**, or obtain information about its command-line options or processing progress.

`\n[.A]` Approximate output is being formatted (Boolean-valued); see **groff**'s **-a** option (Section 2.1 [Groff Options], page 7).

`\n[.c]`

`\n[c.]` Input line number. `'c.'` is a writable synonym, affecting subsequent interpolations of both `'c'` and `'c.'`.

<code>\n[.F]</code>	Name of input file (string-valued).
<code>\n[.g]</code>	Always true in GNU troff (Boolean-valued). Documents can use this to ask the formatter if it claims groff compatibility.
<code>\n[.P]</code>	Output page selection status (Boolean-valued); see groff 's <code>-o</code> option (Section 2.1 [Groff Options], page 7).
<code>\n[.R]</code>	Count of available unused registers; in GNU troff this register always interpolates the maximum representable integer. ⁵⁶ Favor its use over numeric literals with many zeroes or nines to indicate an arbitrary large quantity.
<code>\n[.T]</code>	Indicator of output device selection (Boolean-valued); see groff 's <code>-T</code> option (Section 2.1 [Groff Options], page 7).
<code>\n[.U]</code>	Unsafe mode enablement status (Boolean-valued); see groff 's <code>-U</code> option (Section 2.1 [Groff Options], page 7).
<code>\n[.x]</code>	Major version number of the running GNU troff formatter. For example, if the version number is 1.23.0, then <code>.x</code> contains '1'.
<code>\n[.y]</code>	Minor version number of the running GNU troff formatter. For example, if the version number is 1.23.0, then <code>.y</code> contains '23'.
<code>\n[.Y]</code>	Revision number of the running GNU troff formatter. For example, if the version number is 1.23.0, then <code>.Y</code> contains '0'.

5.9 Manipulating Filling and Adjustment

When an output line is pending (see below), a break moves the drawing position to the beginning of the next text baseline, interrupting filling. Recall Section 5.1.4 [Breaking], page 66. The `br` request likewise causes a break. Several other requests imply breaks: `bp`, `brp`, `ce`, `cf`, `fi`, `fl`, `in`, `nf`, `rj`, `sp`, `ti`, and `trf`. If the no-break control character is used with any of these requests, GNU **troff** suppresses the break; instead the requested operation takes effect at the next break. `"br` and `"brp` do nothing.

```
.ll 55n
This line is normally filled and adjusted.
.br
A line's alignment is decided
'ce \" Center the next input line (with no initial break).
when it is output.
This line returns to normal filling and adjustment.
⇒ This line is normally filled and adjusted.
⇒ A line's alignment is decided when it is output.
⇒ This line returns to normal filling and adjustment.
```

Output line properties like page offset, indentation, adjustment, and even the location of its text baseline, are not determined until the line has been

⁵⁶ GNU **troff** dynamically allocates memory for as many registers as required.

broken. An output line is said to be *pending* if some input has been collected but an output line corresponding to it has not yet been written; such an output line is also termed *partially collected*. If no output line is pending, it is as if a break has already happened; additional breaks, whether explicit or implicit, have no effect. If the vertical drawing position is negative—as it is when the formatter starts up—a break starts a new page (even if no output line is pending) unless an end-of-input macro is being interpreted. See Section 5.29.5 [End-of-input Traps], page 206.

.br [Request]

Break the line: emit any pending output line without adjustment.

```
foo bar
.br
baz
'br
qux
⇒ foo bar
⇒ baz qux
```

You can prevent a break between words, as with a quantity and its units.

\~ [Escape sequence]

Insert an adjustable, unbreakable space. As with ordinary spaces, the formatter discards any sequence of these at the end of an output line if a break occurs.

```
Set the output speed to\~1.
There are 1,024\~bytes in 1\~KiB.
J.\~F.\~Ossanna wrote the original CSTR\~#54.
```

By default, the formatter fills text and adjusts it to reach the output line length. The **nf** request disables filling; the **fi** request reënables it.

.fi [Request]

\n[.u] [Register]

Enable filling of output lines; a pending output line is broken. The read-only register **.u** is set to 1. The filling enablement status, sometimes called *fill mode*, is associated with the environment (see Section 5.32 [Environments], page 216). See Section 5.16 [Line Continuation], page 129, for interaction with the **\c** escape sequence.

.nf [Request]

Disable filling of output lines: the output line length (see Section 5.15 [Line Layout], page 126) is ignored and output lines are broken where the input lines are. A pending output line is broken and adjustment is suppressed. The read-only register **.u** is set to 0. The filling enablement status is associated with the environment (see Section 5.32 [Environments], page 216). See Section 5.16 [Line Continuation], page 129, for interaction with the **\c** escape sequence.

.ad [<i>mode</i>]	[Request]
\n[.j]	[Register]

Enable output line adjustment in *mode*, taking effect when the pending (or next) output line is broken. Adjustment is suppressed when filling is. *mode* can have one of the following values.

- b**
- n** Adjust “normally”: if the output line does not consume the distance between the indentation and the configured output line length, GNU **troff** stretches adjustable spaces within the line until that length is reached. When the indentation is zero, this mode spreads the line to both the left and right margins. This is the GNU **troff** default.
- c** Center filled text. Contrast with the **ce** request, which centers text *without* filling it.
- l** Align text to the left without adjusting it.
- r** Align text to the right without adjusting it.

mode can also be a value previously stored in the **.j** register. Using **ad** without an argument is the same as **.ad \n[.j]**; unless filling is disabled, GNU **troff** resumes adjusting lines in the same way it did before adjustment was disabled by invocation of the **na** request.

The adjustment mode and enablement status are encoded in the read-only register **.j**. These parameters are associated with the environment (see Section 5.32 [Environments], page 216).

The value of **.j** for any adjustment mode is an implementation detail and should not be relied upon as a programmer’s interface. Do not write logic to interpret or perform arithmetic on it.

```

.ll 48n
.de AD
. br
. ad \\$1
..
.de NA
. br
. na
..
left
.AD r
.nr ad \n(.j
right
.AD c
center
.NA
left
.AD
center
.AD \n(ad
right
    ⇒ left
    ⇒
    ⇒ center
    ⇒ left
    ⇒ center
    ⇒ right

```

.na [Request]
 Disable output line adjustment, produciing the same output as left-alignment, but altering the value of the adjustment mode register `.j` differently. The adjustment mode and enablement status are associated with the environment.⁵⁷

Normally, an explicit break implies non-adjustment of the pending output line, as at the end of a paragraph.

.brp [Request]
`\p` [Escape sequence]
 The **brp** request commands a break as **br** does, but also forces adjustment of the output line per the current adjustment mode. Like **br**, it does nothing if invoked with the no-break control character.
`\p` schedules a break with adjustment at the next word boundary. The escape sequence is itself neither a break nor a space of any kind; it can

⁵⁷ See Section 5.32 [Environments], page 216.

thus be placed in the middle of a word to cause a break at the end of that word.

`\p` is typically used for fine-tuning of typeset output late in the document revision process. One of its applications is prevention of a break after an explicit hyphen when this occurs in an undesired place, such as at the end of a recto page, or before a displayed figure. The hyphenation mode can be configured to prevent breaks after *automatically* placed hyphens, but not explicit ones.⁵⁸ What one can do in this scenario is place `\p` at the end of the word *before* the one that breaks undesirably.

```
.ll 1.375i
The next data were out-of-band. \" breaks after "out-"
.br
The next data were\\p out-of-band. \" breaks after "were"
```

Breaking with immediate adjustment can produce ugly results since GNU troff doesn't have a sophisticated paragraph-building algorithm, as T_EX has, for example. Instead, GNU troff fills and adjusts a paragraph line by line.

```
.ll 4.5i
This is an uninteresting sentence.
This is an uninteresting sentence.\\p
This is an uninteresting sentence.
```

is formatted as follows.

```
This is an uninteresting sentence. This is
an uninteresting sentence.
This is an uninteresting sentence.
```

To clearly present the next couple of requests, we must introduce the concept of “productive” input lines. A *productive input line* is one that directly produces formatted output. Text lines produce output,⁵⁹ as do control lines containing requests like `‘.tl //Page %//’` or escape sequences like `‘\l'1i'’`. Macro calls are not themselves productive, but their interpolations can be. Empty requests, and requests and escape sequences that define registers or strings or alter the formatting environment (as with changes to the size, face, height, slant, or color of the type) are not productive.⁶⁰ We will also preview the output line continuation escape sequence, `\c`, which “connects” two input lines that would otherwise be counted separately.⁶¹

⁵⁸ See Section 5.10 [Manipulating Hyphenation], page 108.

⁵⁹ though not necessarily to the output device; see Section 5.30 [Diversions], page 208

⁶⁰ If you're not sure whether an input line has been productive, you can use the `pline` request before and after it to see whether it produced any output nodes. See Section 5.38 [Debugging], page 231.

⁶¹ See Section 5.16 [Line Continuation], page 129.

```
.de hello
Hello, world!
..
.ce \" center output of next productive input line
.
.nr junk-reg 1
.ft I
Chorus: \c
.ft
.hello
Went the day well?
⇒                               Chorus: Hello, world!
⇒ Went the day well?
```

`.ce [n]` [Request]
`\n[.ce]` [Register]

Break (unless the no-break control character is used), center the output of the next *n* productive input lines with respect to the line length and indentation without filling, then break again regardless of the invoking control character. If the argument is not positive, centering is disabled. Omitting the argument implies an *n* of ‘1’. The count of input lines remaining to be centered is stored in the read-only register `.ce` and is associated with the environment (see Section 5.32 [Environments], page 216).

While the ‘`.ad c`’ request also centers text, it fills the text as well.

```
.de FR
This is a small text fragment that shows the differences
between the ‘.ce’ and the ‘.ad c’ requests.
..
.ll 4i
.ce \n(.R
.FR
.ce 0

.ad c
.FR
⇒ This is a small text fragment that shows
⇒ the differences
⇒ between the ‘.ce’ and the ‘.ad c’ requests.
⇒
⇒ This is a small text fragment that shows
⇒ the differences between the ‘.ce’ and
⇒ the ‘.ad c’ requests.
```

The previous example illustrates a common idiom of turning centering on for a quantity of lines far in excess of what is required,⁶² and off again after the text to be centered. This technique relieves humans of counting lines for requests that take a count of input lines as an argument.

.rj [*n*] [Request]
\n[.rj] [Register]

Break (unless the no-break control character is used), align the output of the next *n* productive input lines to the right margin without filling, then break again regardless of the control character. If the argument is not positive, right-alignment is disabled. Omitting the argument implies an *n* of ‘1’. The count of input lines remaining to be right-aligned is stored in the read-only registerinput **r .rj** and is associated with the environment (see Section 5.32 [Environments], page 216).

```
.ll 49n
```

```
.rj 3
```

```
At first I hoped that such a technically unsound
project would collapse but I soon realized it was
doomed to success. \[em] C. A. R. Hoare
```

```
⇒ At first I hoped that such a technically unsound
⇒ project would collapse but I soon realized it was
⇒ doomed to success. -- C. A. R. Hoare
```

.ss *word-space-size* [*additional-sentence-space-size*] [Request]
\n[.ss] [Register]
\n[.sss] [Register]

Set the sizes of spaces between words and sentences⁶³ in twelfths of the space width of the currently selected font.⁶⁴ (A *word space* is typically one-fourth to one-third em for Western scripts.) The default for both parameters is 12. Negative values are erroneous. The first argument is a minimum; if an output line undergoes adjustment, such spaces may increase in width. The optional second argument sets the amount of additional space separating sentences on the same output line. If omitted, this amount is set to *word-space-size*. The request is ignored if there are no parameters.

Additional inter-sentence space is used only if the output line is not full when the end of a sentence occurs in the input. If a sentence ends at the end of an input line, then both an inter-word space and an inter-sentence space are added to the output; if two spaces follow the end of a

⁶² The **.R** register interpolates the largest value that GNU **troff** can work with. Recall Section 5.8.5 [Built-in Registers], page 100.

⁶³ Recall Section 5.1.1 [Filling], page 63, and Section 5.1.2 [Sentences], page 64, for the definitions of word and sentence boundaries, respectively.

⁶⁴ See Section 6.1.2 [Font Description File Format], page 250. This request is incorrectly documented in the AT&T **troff** manual as using units of 1/36 em.

sentence in the middle of an input line, then the second space becomes an inter-sentence space in the output. Additional inter-sentence space is not adjusted, but the inter-word space that always precedes it may be. Further input spaces after the second, if present, are adjusted as normal. The read-only registers `.ss` and `.sss` hold the minimum inter-word space and supplemental inter-sentence space amounts, respectively. These parameters are part of the environment (see Section 5.32 [Environments], page 216).

The `ss` request can insert discardable horizontal space; that is, space that is discarded at a break. For example, some footnote styles collect the notes into a single paragraph with large gaps between each note.

```
.ll 48n
1.\~J. Fict. Ch. Soc. 6 (2020), 3\en14.
.ss 12 48 \" applies to next sentence ending
Reprints no longer available through FCS.
.ss 12 \" go back to normal
2.\~Better known for other work.
    ⇒ 1. J. Fict. Ch. Soc. 6 (2020), 3-14. Reprints
    ⇒ no longer available through FCS.      2. Better
    ⇒ known for other work.
```

If *undiscardable* space is required, use the `\h` escape sequence to put horizontal motion on the output.

5.10 Manipulating Hyphenation

When filling, GNU `troff` hyphenates words as needed at user-specified and automatically determined hyphenation points. The machine-driven determination of hyphenation points in words requires algorithms and data, and is susceptible to conventions and preferences. Before tackling such *automatic hyphenation*, let us consider how hyphenation points can be set explicitly.

Explicitly hyphenated words such as “mother-in-law” are eligible for breaking after each of their hyphens. Relatively few words in a language offer such obvious break points, however, and automatic detection of syllabic (or phonetic) boundaries for hyphenation is not perfect,⁶⁵ particularly for unusual words found in technical literature. We can instruct GNU `troff` how to hyphenate specific words if the need arises.

```
.hw word ... [Request]
Define each argument word (comprising ordinary, special, or indexed
characters) as a hyphenation exception word such that each occurrence of
a hyphen-minus ‘-’ in word indicates a hyphenation point. For example,
the request

    .hw in-sa-lub-rious alpha
```

⁶⁵ Whether a perfect algorithm for this application is even possible is an unsolved problem in computer science: <https://tug.org/docs/liang/liang-thesis.pdf>.

marks potential hyphenation points in “insalubrious”, and prevents “alpha” from being hyphenated at all.

Besides the space character, any character whose hyphenation code is zero can be used to separate the arguments (see the **hcode** request below).

Hyphenation points specified with **hw** are not subject to the within-word placement restrictions imposed by the **hy** request (see below).

Hyphenation exception words are associated with the hyphenation language (see the **hla** request below); invoking the **hw** request in the absence of a hyphenation language is an error. Each hyphenation language maintains an independent set of hyphenation exception words.

The formatter ignores the request if it lacks arguments.⁶⁶

Obtain a report of hyphenation exception words on the standard error stream with the **phw** request. See Section 5.38 [Debugging], page 231.

These are known as *hyphenation exception words* in the expectation that most users will avail themselves of automatic hyphenation; these exceptions override any rules that would normally apply to a word matching a hyphenation exception word defined with **hw**.

Situations also arise when only a specific occurrence of a word needs its hyphenation altered or suppressed, or when a URL or similar specialized text needs to be breakable in sensible places without hyphenation.

<code>\%</code>	[Escape sequence]
<code>\:</code>	[Escape sequence]

To tell GNU **troff** how to hyphenate words as they occur in input, use the `\%` escape sequence; it is the default *hyphenation character*. Each instance within a word indicates to GNU **troff** that the word may be hyphenated at that point, while prefixing a word with this escape sequence prevents it from being otherwise hyphenated. This mechanism affects only that occurrence of the word; to change the hyphenation of a word for the remainder of input processing, use the **hw** request.

GNU **troff** regards the escape sequences `\X` and `\Y` as starting a word; that is, the `\%` escape sequence in, say, `'\X'...\%foobar'` or `'\Y'...\%foobar'` no longer prevents hyphenation of `'foobar'` but inserts a hyphenation point just prior to it; most likely this isn't what you want. See Section 5.35 [Postprocessor Access], page 226.

`\:` inserts a non-printing break point; that is, a word can break there, but the soft hyphen glyph (see below) is not written to the output if it does. The remainder of the word is subject to hyphenation as normal.

You can combine `\:` and `\%` to control breaking of a file name or URL, or to permit hyphenation only after certain explicit hyphens within a word.

⁶⁶ GNU **troff** emits a warning in category `'missing'`. See Section 5.38.1 [Warnings], page 236.

The `\%Lethbridge-Stewart-\:\%Sackville-Baggins` divorce was, in retrospect, inevitable once the contents of `\%/var/log/\:\%httpd/\:\%access_log` on the family web server came to light, revealing visitors from Hogwarts.

`.hc [char]` [Request]

Change the hyphenation character to *char*. This character then works as the `\%` escape sequence normally does, and thus no longer appears in the output.⁶⁷ Without an argument, `hc` resets the hyphenation character to `\%` (the default). The hyphenation character is associated with the environment (see Section 5.32 [Environments], page 216).

`.shc [c]` [Request]

Set the *soft hyphen character*, inserted when a word is hyphenated automatically or at a hyphenation character, to the ordinary or special character *c*.⁶⁸ If the argument is omitted, the soft hyphen character is set to the default, `\[hy]`. If no glyph for *c* exists in the font in use at a potential hyphenation point, then the line is not broken there. Neither character definitions (specified with the `char` and similar requests) nor translations (specified with the `tr` request) are applied to *c*.

Several requests influence automatic hyphenation. Because conventions vary, a variety of hyphenation modes is available to the `hy` request; these determine whether hyphenation will apply to a word prior to breaking a line at the end of a page (more or less; see below for details), and at which positions within that word automatically determined hyphenation points are permissible. The places within a word that are eligible for hyphenation are determined by language-specific data and lettercase relationships. Furthermore, hyphenation of a word might be suppressed due to a limit on consecutive hyphenated lines (`hlm`), a minimum line length threshold (`hym`), or because the line can instead be adjusted with additional inter-word space (`hys`).

`.hy [mode]` [Request]
`\n[.hy]` [Register]

Set automatic hyphenation mode to *mode*, an integer encoding conditions for hyphenation; if omitted, the configured hyphenation mode default (see below) is implied. The hyphenation mode is available in the read-only register `‘.hy’`; it is associated with the environment (see Section 5.32 [Environments], page 216). The hyphenation mode default depends on the localization file loaded when GNU `troff` starts up; see the `hpf` request below. If no localization file is loaded, the default is `‘1’`.

Typesetting practice generally does not avail itself of every opportunity for hyphenation, but the details differ by language and site mandates.

⁶⁷ `\%` itself stops marking hyphenation points but still produces no output glyph.

⁶⁸ “Soft” because it appears in output only where a hyphenation break is performed; a “hard” hyphen, as in “long-term”, always appears.

The hyphenation modes of AT&T `troff` were implemented with English-language publishing practices of the 1970s in mind, not a scrupulous enumeration of conceivable parameters. GNU `troff` extends those modes such that finer-grained control is possible, favoring compatibility with older implementations over a more intuitive arrangement. The means of hyphenation mode control is a set of numbers that can be added up to encode the behavior sought.⁶⁹ The entries in the following table are termed *values*; the sum of the desired values is the *mode*.

0	disables hyphenation.
1	enables hyphenation except after the first and before the last character of a word.

The remaining values “imply” 1; that is, they enable hyphenation under the same conditions as ‘.hy 1’, and then apply or lift restrictions relative to that basis.

2	disables hyphenation of the last word on a page or column, ⁷⁰ even for explicitly hyphenated words.
4	disables hyphenation before the last two characters of a word.
8	disables hyphenation after the first two characters of a word.
16	enables hyphenation before the last character of a word.
32	enables hyphenation after the first character of a word.

Apart from value 2, restrictions imposed by the hyphenation mode are *not* respected for words whose hyphenations have been specified with the hyphenation character (‘\%’ by default) or the `hw` request.

Nonzero values in the previous table are additive. For example, mode 12 causes GNU `troff` to hyphenate neither the last two nor the first two characters of a word. Some values cannot be used together because they contradict; for instance, values 4 and 16, and values 8 and 32. As noted, it is superfluous to add 1 to any non-zero even mode.

The automatic placement of hyphens in words is determined by *pattern files*, which are derived from `TEX` and available for several languages. These files are named `hyphen.xx` (for the patterns) and `hyphenex.xx` (for a list of exceptions in languages that require them) where `xx` is an ISO 639 language code; see the table below.

⁶⁹ The mode is a vector of Boolean values encoded as an integer. To a programmer, this fact is easily deduced from the exclusive use of powers of two for the configuration parameters; they are computationally easy to “mask off” and compare to zero. To almost everyone else, the arrangement seems recondite and unfriendly.

⁷⁰ The formatter prevents hyphenation if the next page location trap is closer to the vertical drawing position than the next text baseline would be. See Section 5.29.1.1 [Page Location Traps], page 198. A macro package might also employ value ‘2’ to prevent hyphenation before a display; recall Section 3.2.5 [Displays and Keeps], page 21.

The number of characters at the beginning of a word after which the first hyphenation point should be inserted is determined by the patterns themselves; it can't be reduced further without introducing additional, invalid hyphenation points (unfortunately, this information is not part of a pattern file—you have to know it in advance). The same is true for the number of characters at the end of a word before the last hyphenation point should be inserted. For example, you can supply the following input to `'echo $(nroff)'`.

```
.ll 1
.hy 48
splitting
```

You will get

```
s-plit- t- in- g
```

instead of the correct `'split-ting'`. English patterns as distributed with GNU `troff` need two characters at the beginning and three characters at the end; this means that value 4 of `hy` is mandatory. Value 8 is possible as an additional restriction, but values 16 and 32 should be avoided, as should mode 1. Modes 4 and 6 are typical.

A table of left and right minimum character counts for hyphenation as needed by the patterns distributed with GNU `troff` follows.⁷¹

language	pattern name	left min	right min
Czech	cs	2	2
English	en	2	3
French	fr	2	3
German traditional	det	2	2
German reformed	den	2	2
Italian	it	2	2
Polish	pl	2	2
Russian	ru	2	2
Spanish	es	2	2
Swedish	sv	1	2

Hyphenation exceptions within pattern files (that is, the words within a `TeX \hyphenation` group) obey hyphenation restrictions imposed by `hy`.

`.nh`

[Request]

Disable automatic hyphenation; i.e., set the hyphenation mode to 0 (see above). The hyphenation mode of the last call to `hy` is not remembered, but invoking `hy` without an argument restores the hyphenation mode default; `groff`'s localization macro files do so for the languages listed above.

⁷¹ See subsection “Localization packages” of `groff.tmac(5)`.

`.hydefault` [*mode*] [Request]
`\n[.hydefault]` [Register]

Set hyphenation mode default to *mode*, configuring the value the automatic hyphenation mode takes if `hy` is invoked without an argument. The hyphenation mode default is available in the read-only register `‘.hydefault’`; it is associated with the environment.⁷²

`.hpf` ["*pattern-file*] [Request]
`.hpfa` ["*pattern-file*] [Request]

Read hyphenation patterns from *pattern-file*, which is sought in the same way that macro files are with the `mso` request or the `-m mac` command-line option to `groff`. The *pattern-file* should have the same format as (simple) T_EX pattern files. More specifically, the following scanning rules are implemented.

- A percent sign starts a comment (up to the end of the line) even if preceded by a backslash.
- “Digraphs” like `\$` are not supported.
- `^^xx` (where each *x* is 0–9 or a–f) and `^^c` (character *c* in the code point range 0–127 decimal) are recognized; other uses of `^` cause an error.
- No macro expansion is performed.
- `hpf` checks for the expression `\patterns{...}` (possibly with white-space before or after the braces). Everything between the braces is taken as hyphenation patterns. Consequently, `{` and `}` are not allowed in patterns.
- Similarly, `\hyphenation{...}` gives a list of hyphenation exceptions.
- `\endinput` is recognized also.
- For backward compatibility, if `\patterns` is missing, the whole file is treated as a list of hyphenation patterns (except that the `%` character is recognized as the start of a comment).

The `hpfa` request appends a file of patterns to the current list.

GNU `troff` ties the set of hyphenation patterns to the hyphenation language code selected by the `hla` request (see below). The `hpf` request is usually invoked by a localization file loaded by the `troffrc` file.⁷³

A second call to `hpf` (for the same language) replaces the hyphenation patterns with the new ones. Invoking `hpf` or `hpfa` causes an error if there is no hyphenation language. If no `hpf` request is specified (either in the document, in a file loaded at startup, or in a macro package), GNU `troff` won’t automatically hyphenate at all.

Caution: The `hpf` and `hpfa` requests interpret the remainder of the input line as the file name argument, including any spaces, up to a newline

⁷² See Section 5.32 [Environments], page 216.

⁷³ For more detail on localization, see `groff.tmac(5)`.

or comment escape sequence. Suffixing the file name with a comment, even an empty one, prevents unwanted space from creeping into it during source document maintenance.⁷⁴

For automatic hyphenation to work, the formatter must know which letters are equivalent. For example, the letter ‘E’ behaves like ‘e’; only the latter typically appears in hyphenation pattern files. GNU **troff** expects characters that participate in automatic hyphenation to be assigned *hyphenation codes* that define these equivalence classes. At startup, GNU **troff** assigns hyphenation codes to the letters ‘a’–‘z’, applies the same codes to ‘A’–‘Z’ in one-to-one correspondence, and assigns a code of zero to all other characters.

The **hcode** request enables application of hyphenation codes to characters outside the Unicode basic Latin set; without doing so, words containing such letters won’t hyphenate properly even if the corresponding hyphenation patterns contain them. Localization files for the input character set and language configure hyphenation codes; see *groff.tmac*(5).

.hcode *dst1 src1* [*dst2 src2*] . . . [Request]

Set the hyphenation code of ordinary or special character *dst1* to that of *src1*, and so on. *dst1* must be an ordinary character (other than a numeral) or a special character, and *src1* must be an ordinary character (other than a numeral) or a special character to which a hyphenation code has already been applied. Assigning the code of an ordinary character to itself effectively creates a unique hyphenation code (which can then be copied to others). **hcode** ignores spaces between arguments. If any argument is invalid, **hcode** reports an error and stops reading them.

For example, the following **hcode** requests are necessary to assign hyphenation codes to the letters ‘ÄäÖöÜüß’, needed for German.

```
.hcode ä ä  Ä ä
.hcode ö ö  Ö ö
.hcode ü ü  Ü ü
.hcode ß ß
```

Without these assignments, GNU **troff** treats the German word ‘Kindergärten’ (the plural form of ‘kindergarten’) as two words ‘kinderg’ and ‘rten’ because the hyphenation code of the umlaut a is zero by default, just like a space. There is a German hyphenation pattern that covers ‘kinder’, so GNU **troff** finds the hyphenation ‘kin-der’. The other two hyphenation points (‘kin-der-gär-ten’) are missed.

To remove a character’s hyphenation code, copy the code of a character with a hyphenation code value of zero to it. For example, ‘**.hcode ß \$**’ removes the hyphenation code from ‘ß’ (unless ‘\$’ has already been assigned a different one).

⁷⁴ See the discussion of the **ds** request in Section 5.22 [Strings], page 163.

The **pchar** request may be helpful to troubleshoot hyphenation code assignments. See Section 5.38 [Debugging], page 231.

.hpfcodes *a b [c d]* . . . [Request]

Caution: This request will be withdrawn in a future **groff** release. Use **hcode** instead.

The **hpfcodes** request defines mapping values for character codes in pattern files. It is an older mechanism no longer used by GNU **troff**'s own macro files. **hpf** or **hpfa** apply the mapping after reading the patterns but before replacing or appending to the active list of patterns. Its arguments are pairs of character codes—integers from 0 to 255. The request maps character code *a* to code *b*, code *c* to code *d*, and so on. Character codes that would otherwise be invalid in GNU **troff** can be used.

.hla [*lang*] [Request]

\n[.hla] [Register]

Set the hyphenation language to *lang*, or clear it if there is no argument. Hyphenation exceptions specified with the **hw** request and hyphenation patterns and exceptions specified with the **hpf** and **hpfa** requests are associated with the hyphenation language. The **hla** request is usually invoked by a localization file, which is then loaded by the **troffrc** or **troffrc-end** file; see the **hpf** request above.

The hyphenation language is available in the read-only string-valued register **'hla'**; it is associated with the environment (see Section 5.32 [Environments], page 216).

If no hyphenation language is set or no patterns are loaded, GNU **troff** does not perform automatic hyphenation.

.hlm [*n*] [Request]

\n[.hlm] [Register]

\n[.hlc] [Register]

Set the maximum quantity of consecutive hyphenated lines to *n*. If *n* is negative, there is no maximum. If omitted, *n* is -1 . This value is associated with the environment (see Section 5.32 [Environments], page 216). Only lines output from a given environment count toward the maximum associated with that environment. Hyphens resulting from **\%** are counted; explicit hyphens are not.

The **.hlm** read-only register stores this maximum. The count of immediately preceding consecutive hyphenated lines is available in the read-only register **.hlc**.

.hym [*length*] [Request]

\n[.hym] [Register]

Set the (right) hyphenation margin to *length*. If the adjustment mode is not **'b'** or **'n'**, the line is not hyphenated if it is shorter than *length*. Without an argument, the hyphenation margin is reset to its default value, 0.

The default scaling unit is ‘m’. The hyphenation margin is associated with the environment (see Section 5.32 [Environments], page 216).

A negative argument resets the hyphenation margin to zero.⁷⁵

The hyphenation margin is available in the `.hym` read-only register.

`.hys` [*hyphenation-space*] [Request]
`\n[.hys]` [Register]

Suppress hyphenation of the line in adjustment modes ‘b’ or ‘n’ if that adjustment can be achieved by adding no more than *hyphenation-space* extra space to each inter-word space. Without an argument, the hyphenation space adjustment threshold is set to its default value, 0. The default scaling unit is ‘m’. The hyphenation space adjustment threshold is associated with the environment (see Section 5.32 [Environments], page 216). A negative argument resets the hyphenation space adjustment threshold to zero.⁷⁶

The hyphenation space adjustment threshold is available in the `.hys` read-only register.

5.11 Manipulating Spacing

A break causes the formatter to update the vertical drawing position at which the new text baseline is placed; you can alter this location.

`.sp` [*vertical-distance*] [Request]

Break and move the next text baseline down by *distance*, or until springing a page location trap.⁷⁷ If invoked with the no-break control character, `sp` moves the text baseline applicable to the entire pending output line by *vertical-distance*.⁷⁸ A negative *vertical-distance* cannot reduce the position of the text baseline below zero. Inside a diversion, the formatter ignores any argument. The default scaling unit is ‘v’. Omitting *vertical-distance* implies ‘1v’.

⁷⁵ GNU `troff` also emits a warning in category ‘range’. See Section 5.38.1 [Warnings], page 236.

⁷⁶ GNU `troff` also emits a warning in category ‘range’. See Section 5.38.1 [Warnings], page 236.

⁷⁷ See Section 5.29.1.1 [Page Location Traps], page 198.

⁷⁸ To shift the text baseline for *part* of an output line—to set super- or subscripts, for instance—use the `\v` escape sequence. See Section 5.25 [Page Motions], page 184.

```

.pl 5v \" Set page length to 5 vees.
.de xx
\-\-\-
. br
..
.wh 0 xx \" Set a trap at the top of the page.
foo on page \n%
.sp 2v
bar on page \n%
.sp 50v \" This will cause a page break.
baz on page \n%
.pl \n(nlu \" Truncate page to current position.
⇒ ---
⇒ foo on page 1
⇒
⇒
⇒ bar on page 1
⇒ ---
⇒ baz on page 2

```

The following macros place the next text baseline relative to the page top or bottom. We subtract one line height (`\n[.v]`) because the `|` operator moves the drawing position relative to the first baseline on the page (recall Section 5.4 [Numeric Expressions], page 78).

```

.de y-from-top-down
. sp |\n[.v]u
..
.de y-from-bot-up
. sp |\n[.p]u-\n[.v]u
..

```

The input `.y-from-bot-up 10c` sets the next text baseline 10 cm from the bottom edge of the paper.

Applying the boundary-relative measurement operator `|` operator to *vertical-distance*, as in `|N`, moves to a position relative to the page top for positive N , and the bottom if N is negative.

<code>.ls [count]</code>	[Request]
<code>\n[.L]</code>	[Register]

Set the line spacing; add *count*−1 blank lines after each line of text. With no argument, GNU troff uses the previous value before the last `ls` call. The default is 1.

The read-only register `.L` contains the current line spacing; it is associated with the environment (see Section 5.32 [Environments], page 216).

The `ls` request is a coarse mechanism. See Section 5.20.1 [Changing the Type Size], page 156, for the requests `vs` and `pvs` as alternatives to `ls`.

```

.de SetNewLineSpacing
.  if r *old-vs .ab cannot nest SetNewLineSpacing
.  nr *old-vs \n[.v]
.  vs (\n[.v] * \[$1)
..
.
.de RestoreOldLineSpacing
.  vs \n[*old-vs]
.  rr *old-vs
..

```

`\x'spacing'` [Escape sequence]
`\n[.a]` [Register]

Sometimes, an output line requires additional vertical spacing, for instance to allow room for a tall construct like an inline equation with exponents or subscripts (particularly if they are iterated). The `\x` escape sequence takes a delimited measurement (like `'\x'3p'`) to increase the vertical spacing of the pending output line. The default scaling unit is `'v'`. If the measurement is positive, extra vertical space is inserted below the current line; a negative measurement adds space above. If `\x` is applied to the pending output line multiple times, the maxima of the positive and negative adjustments are separately applied. The delimiter need not be a neutral apostrophe; see Section 5.6.5 [Delimiters], page 91.

The `.a` read-only register contains the extra vertical spacing *after* the text baseline of the most recently emitted output line. (In other words, it is the largest positive argument to `\x` encountered on that line.) This quantity is exposed via a register because if an output line requires this “extra post-vertical line spacing”, and the subsequent output line requires “extra pre-vertical line spacing” (a negative argument to `\x`), then applying both can lead to excessive spacing between the output lines. Text that is piling high on line n might not require (as much) extra pre-vertical line spacing if line $n-1$ carries extra post-vertical line spacing.

Use of `\x` can be necessary in combination with the bracket-building escape sequence `\b`,⁷⁹ as the following example shows.

⁷⁹ See Section 5.27 [Drawing Geometric Objects], page 192.

```
.nf
This is a test of \[rs]b (1).
This is a test of \[rs]b (2).
This is a test of \b'xyz'\x'-1m'\x'1m' (3).
This is a test of \[rs]b (4).
This is a test of \[rs]b (5).
    ⇒ This is a test of \b (1).
    ⇒ This is a test of \b (2).
    ⇒
    x
    ⇒ This is a test of y (3).
    ⇒
    z
    ⇒ This is a test of \b (4).
    ⇒ This is a test of \b (5).
```

Without `\x`, the backslashes on the lines marked ‘(2)’ and ‘(4)’ would be overprinted.

```
.ns [Request]
.rs [Request]
\n[.ns] [Register]
```

Enable *no-space mode*. Vertical spacing, whether by `sp` requests or blank input lines, is disabled. The `bp` request to advance to the next page is also disabled, unless it is accompanied by a page number (see Section 5.18 [Page Control], page 131). No-space mode ends automatically when text⁸⁰ is formatted for output⁸¹ or the `rs` request is invoked, which ends no-space mode. The read-only register `.ns` interpolates a Boolean value indicating the enablement of no-space mode.

A paragraphing macro might ordinarily insert vertical space to separate paragraphs. A section heading macro could invoke `ns` to suppress this spacing for the first paragraph in a section.

5.12 Tabs and Fields

A tab character (code point 9) causes a horizontal movement to the next tab stop, if any.

```
\t [Escape sequence]
Interpolate a tab in copy mode; see Section 5.24.2 [Copy Mode], page 180.
```

```
.ta [[n1 n2 ... nn ]T r1 r2 ... rn] [Request]
\n[.tabs] [Register]
```

Set tab stop positions. This request takes a series of tab specifiers as arguments (optionally divided into two groups with the letter ‘T’) that indicate where each tab stop is to be, overriding any previous settings.

⁸⁰ or geometric objects; see Section 5.27 [Drawing Geometric Objects], page 192

⁸¹ to the top-level diversion; see Section 5.30 [Diversions], page 208

The default scaling unit is ‘m’. Invoking `ta` without arguments removes all tab stops. GNU `troff`’s startup value is ‘T 0.5i’.

Tab stops can be specified absolutely—as distances from the left margin. The following example sets six tab stops, one every inch.

```
.ta 1i 2i 3i 4i 5i 6i
```

Tab stops can also be specified using a leading ‘+’, which means that the specified tab stop is set relative to the previous tab stop. For example, the following is equivalent to the previous example.

```
.ta 1i +1i +1i +1i +1i +1i
```

GNU `troff` supports an extended syntax to specify repeating tab stops. These stops appear after a ‘T’ argument. Their values are always taken as distances relative to the previous tab stop. This is the idiomatic way to specify tab stops at equal intervals in `groff`. The following is, yet again, the same as the previous examples. It does more, in fact, since it defines an infinite number of tab stops at one-inch intervals.

```
.ta T 1i
```

Now we are ready to interpret the full syntax given above. The `ta` request sets tabs at positions $n1$, $n2$, $\dots$, nn , then at $nn+r1$, $nn+r2$, $\dots$, $nn+rn$, then at $nn+rn+r1$, $nn+rn+r2$, $\dots$, $nn+rn+rn$, and so on. For example, ‘4c +6c T 3c 5c 2c’ is equivalent to ‘4c 10c 13c 18c 20c 23c 28c 30c $\dots$ ’.

Text between two tab stops may be aligned to the right or left, or centered. This alignment is determined by appending ‘R’, ‘L’, or ‘C’ to the tab specifier. The default is ‘L’.

```
.ta 1i 2iC 3iR
```

The beginning of an output line is not a tab stop; the text that begins an output line is placed according to the configured alignment and indentation; see Section 5.9 [Manipulating Filling and Adjustment], page 101, and Section 5.15 [Line Layout], page 126.

A tab stop becomes a non-breakable horizontal movement that cannot be adjusted.

```
.ll 2i
.ta T 1i
a→b→c
[error] warning: cannot adjust line; overset by 1n
⇒ a      b      c
```

The above creates a single output line that is a bit longer than two inches. Now consider the following.

```
.ll 2i
.ta T 1i
a→b c→d
[error] warning: cannot adjust line; underset by 9n
⇒ a      b
⇒ c      d
```

GNU **troff** first converts the line’s tab stops into unbreakable horizontal movements, then breaks after ‘b’. This usually isn’t what you want.

Superfluous tab characters—those that do not correspond to a tab stop—are ignored except for the first, which delimits the characters belonging to the last tab stop for right-alignment or centering.

```
.nf
.ta 2i 4iR
\l'4i\&-'
foo→bar
foo→bar→baz
foo→bar→bazqux
foo→bar→baz→qux
⇒ -----
⇒ foo                bar
⇒ foo                bar          baz
⇒ foo                bar          bazqux
⇒ foo                bar          bazqux
```

We see that “bar” is between the first and second tab stops, not the second and (nonexistent) third. The first “baz” is right-aligned within the second tab stop. The second is catenated with “qux” and right-aligned within it. The third “baz” is aligned like the first because the tab character after it determines the right boundary of the tab stop.

Tab stops are associated with the environment (see Section 5.32 [Environments], page 216).

The read-only register `.tabs` contains a string representation of the current tab settings suitable for use as an argument to the `ta` request.⁸²

```
.ds tab-string \n[.tabs]
\[tab-string]
⇒ T120u
```

.tc [*c*] [Request]

Set the tab repetition character to the ordinary or special character *c*; normally, no glyph is written when moving to a tab stop (and some output devices may output space characters to achieve this motion). A *tab repetition character* causes the formatter to write as many instances of *c* as are necessary to occupy the interval from the horizontal drawing position to the next tab stop. With no argument, GNU **troff** reverts to the default behavior. The tab repetition character is associated with the environment (see Section 5.32 [Environments], page 216). Only a single character of *c* is recognized; any excess is ignored.

⁸² Plan 9 **troff** uses the register `.S` for this purpose.

`.linetabs [b]` [Request]
`\n[.linetabs]` [Register]

Activate or deactivate line-tabs in the environment per Boolean expression *b*. They are inactive by default, and activated if *b* is omitted. When line-tabs are active, tab stops are computed relative to the start of the pending output line instead of the drawing position corresponding to the start of the input line.

```
.ta 1i 3i
a→\c
b→\c
c
.br
.linetabs
a→\c
b→\c
c
      ⇒ a      b      c
      ⇒ a      b      c
```

The read-only register `.linetabs` interpolates 1 if line-tabs are active, and 0 otherwise.

5.12.1 Leaders

Sometimes it is desirable to fill a tab stop with a given glyph, but also use tab stops normally on the same output line. An example is a table of contents entry that uses dots to bridge the entry name with its page number, which is itself aligned between tab stops. The `roff` language provides *leaders* for this purpose.⁸³

A leader character (code point 1, also known as SOH or “start of heading”), behaves similarly to a tab character: it moves to the next tab stop. The difference is that for this movement, the default fill character is a period ‘.’.

`\a` [Escape sequence]
 Interpolate a leader in copy mode; see Section 5.24.2 [Copy Mode], page 180.

`.lc [c]` [Request]
 Set the leader repetition character to the ordinary or special character *c*. Recall Section 5.1.6 [Tabs and Leaders], page 67: when encountering a leader character in the input, the formatter writes as many dots ‘.’ as are necessary until reaching the next tab stop; this is the *leader definition character*. Omitting *c* unsets the leader character. With no argument,

⁸³ Pronounce “leader” to rhyme with “feeder”; it refers to how the glyphs “lead” the eye across the page to the corresponding page number or other datum.

GNU **troff** treats leaders the same as tabs. The leader repetition character is associated with the environment (see Section 5.32 [Environments], page 216). Only a single *c* is recognized; any excess is ignored.

A table of contents, for example, may define tab stops after a section number, a title, and a gap to be filled with leader dots. The page number follows the leader, after a right-aligned final tab stop wide enough to house the largest page number occurring in the document.

```
.ds entry1 19.\tThe Prophet\a\t98
.ds entry2 20.\tAll Astir\a\t101
.ta .5i 4.5i +.5iR
.nf
\[entry1]
\[entry2]
⇒ 19.  The Prophet..... 98
⇒ 20.  All Astir..... 101
```

5.12.2 Fields

Fields are a more general way of laying out tabular data. A field is defined as the data between a pair of *delimiting characters*. It contains substrings that are separated by *padding characters*. The width of a field is the distance on the *input* line from the position where the field starts to the next tab stop. A padding character inserts an adjustable space similar to T_EX's `\hss` command (thus it can even be negative) to make the sum of all substring lengths plus the adjustable space equal to the field width. If more than one padding character is inserted, the available space is evenly distributed among them.

`.fc [delim-char [padding-char]]` [Request]

Define a delimiting and a padding character for fields. If the latter is missing, the padding character defaults to a space character. If there is no argument at all, the field mechanism is disabled (which is the default). In contrast to, e.g., the tab repetition character, delimiting and padding characters are *not* associated with the environment (see Section 5.32 [Environments], page 216).

```
.fc # ^
.ta T 3i
#foo^bar^smurf#
.br
#foo^^bar^smurf#
⇒ foo          bar          smurf
⇒ foo          bar          smurf
```

5.13 Character Translations

A *translation* is a mapping of an input character to an output glyph. The mapping occurs at output time, i.e., the input character gets assigned the metric information of the mapped output character right before tokens are converted to nodes (see Section 5.37 [GNU troff Internals], page 228, for more on this process).

`.tr abcd...` [Request]
`.trln abcd...` [Request]

Translate character *a* to glyph *b*, character *c* to glyph *d*, and so on. If there is an odd number of characters in the argument, the last one is translated to a fixed-width space (the same one obtained by the `\SPC` escape sequence).

The `trln` request works as does `tr`, except that `asciify` (see Section 5.30 [Diversion], page 208) ignores the translation when a diversion is interpolated.

Some notes:

- Special characters (`\(xx`, `\[xxx]`, `\C'xxx'`, `\'`, `\``, `\-`, `\_`), glyphs defined with the `char` request, and numbered glyphs (`\N'xxx'`) can be translated also.
- The `\e` escape can be translated also.
- Characters can be mapped onto the `\%` and `\~` escape sequences (but `\%` and `\~` can't be mapped onto another glyph).
- The following characters can't be translated: space (with one exception, see below), backspace, newline, leader (and `\a`), tab (and `\t`).
- Translations are not considered for finding the soft hyphen character set with the `shc` request.
- The pair `'c\&'` (an arbitrary character *c* followed by the dummy character) maps this character to “nothing”.

```
.tr a\&
foo bar
⇒ foo br
```

Even the space character can be mapped to the dummy character.

```
.tr aa \&
foo bar
⇒ foobar
```

As shown in the example, the space character can't be the first character/glyph pair as an argument of `tr`. Additionally, it is not possible to map the space character to any other glyph; requests like `'.tr aa x'` undo `'.tr aa \&'` instead.

If adjustment is enabled, it occurs in spite of the ‘empty’ space character; but no minimum distance—no minimum inter-word space—separates words).

- After an output glyph has been constructed (this happens at the moment immediately before the glyph is appended to an output glyph list, either by direct output, in a macro, diversion, or string), it is no longer affected by **tr**.
- Translating character to glyphs where one of them or both are undefined is possible also; **tr** does not check whether the elements of its argument exist.

See Section 5.37 [GNU **troff** Internals], page 228.

- Without an argument, the **tr** request is ignored.

.trnt *abcd*... [Request]

trnt is the same as the **tr** request except that the translations do not apply to text that is transparently throughput into a diversion with **\!**. See Section 5.30 [Diversions], page 208.

For example,

```
.tr ab
.di x
\!.tm a
.di
.x
```

prints ‘b’ to the standard error stream; if **trnt** is used instead of **tr** it prints ‘a’.

5.14 **troff** and **nroff** Modes

Historically, **nroff** and **troff** were two separate programs; the former for terminal output, the latter for typesetters. GNU **troff** merges both functions into one executable⁸⁴ that sends its output to a device driver (**grotty** for terminal devices, **grops** for PostScript, and so on) that interprets its output. When discussing AT&T **troff**, it makes sense to talk about **nroff mode** and **troff mode** since the differences are hard-coded. GNU **troff** takes information from device and font description files without handling requests specially if a terminal output device is used, so such a strong distinction is unnecessary.

Usually, a macro package can be used with all output devices. Nevertheless, it is sometimes necessary to make a distinction between terminal and non-terminal devices: GNU **troff** provides two built-in conditions ‘**n**’ and ‘**t**’ for the **if**, **ie**, and **while** requests to decide whether GNU **troff** shall behave like **nroff** or like **troff**.⁸⁵

⁸⁴ A GNU **nroff** program is available for convenience; it runs GNU **troff** to perform formatting; see *nroff(1)*.

⁸⁵ See Section 5.23 [Conditionals and Loops], page 168, for more on built-in conditions.

.troff [Request]

Make the ‘t’ built-in condition true (and the ‘n’ built-in condition false) for **if**, **ie**, and **while** conditional requests. This is the default if GNU **troff** (*not groff*) is started with the **-R** switch to avoid loading of the startup files **troffrc** and **troffrc-end**. Without **-R**, GNU **troff** stays in **troff** mode if the output device is not a terminal (e.g., ‘ps’).

.nroff [Request]

Make the ‘n’ built-in condition true (and the ‘t’ built-in condition false) for **if**, **ie**, and **while** conditional requests. This is the default if GNU **troff** uses a terminal output device; the code for switching to **nroff** mode is in the file **tty.tmac**, which is loaded by the startup file **troffrc**.

5.15 Line Layout

The following drawing shows the dimensions that GNU **troff** uses to arrange a line of output on the page. Each dimension is labeled with the name of the request that configures it.

```

-->| in |<--
    |<-----ll----->|
+---+---+---+---+---+---+
|   :   :                   :   |
+---+---+---+---+---+---+
-->| po |<--
    |<-----paper width----->|

```

The dimensions are defined as follows.

po The *page offset* is the leftmost position of running text.

in *Indentation* is the distance from the page offset at which text is set.

ll *Line length* is the maximum extent of unindented running text.

The page offset can be thought of as the “left margin”. The right margin is not explicitly configured; the combination of page offset and line length provides the information necessary to derive it.

```

.ll 3i
This is text without indentation.
The line length has been set to 3\~inches.
.in +.5i
.ll -.5i
Now the left and right margins are both increased.
.in
.ll
Calling .in and .ll without parameters restores
the previous values.

```

```

⇒ This is text without indenta-
⇒ tion. The line length has
⇒ been set to 3 inches.
⇒ Now the left and
⇒ right margins are
⇒ both increased.
⇒ Calling .in and .ll without
⇒ parameters restores the previ-
⇒ ous values.

```

Requests exist to place line numbers and margin characters beyond the page margins; Section 5.36 [Miscellaneous], page 228.

<code>.po [offset]</code>	[Request]
<code>.po +offset</code>	[Request]
<code>.po -offset</code>	[Request]
<code>\n[.o]</code>	[Register]

Set page offset to *offset*; if *offset* is signed, adjust the page offset by its value. The default scaling unit is ‘m’. The default offset is 1i on typesetters and zero on terminals.

If *offset* is omitted, the page offset is reset to that before the previous invocation of `po`.

The page offset can be found in the read-only register ‘.o’. This request is incorrectly documented in the AT&T `troff` manual as using a default scaling unit of ‘v’.

```

.po 3i
\n[.o]
⇒ 720

.po -1i
\n[.o]
⇒ 480

.po
\n[.o]
⇒ 720

```

<code>.in [indent]</code>	[Request]
<code>.in +indent</code>	[Request]
<code>.in -indent</code>	[Request]
<code>\n[.i]</code>	[Register]

Set indentation to *indent*; if *indent* is signed, adjust the indentation by its value. The default scaling unit is ‘m’. Initially, there is no indentation. This request causes a break.

If *indent* is omitted, the indentation is reset to that before the previous invocation of `in`, and zero if there is none. If *indent* is negative, GNU `troff` emits a warning in category ‘range’ and sets the indentation to zero; a temporary indentation (see below) is reset to zero as well.

The formatter delays the effect of `in` until it has emitted any partially collected line. In other words, `in` does not change a pending output line's indentation.

The read-only register `‘.i’` interpolates the indentation amount, ignoring temporary indentation (see below). The indentation amount is associated with the environment (see Section 5.32 [Environments], page 216).

<code>.ti <i>offset</i></code>	[Request]
<code>.ti +<i>offset</i></code>	[Request]
<code>.ti -<i>offset</i></code>	[Request]
<code>\n[.in]</code>	[Register]

Temporarily indent the next output line by *offset*; if *offset* is signed, adjust the temporary indentation relative to the value set by the `in` request. The default scaling unit is ‘m’. This request causes a break.

Omitting *offset* causes a warning in category ‘missing’.

The effect of `ti` is delayed until a partially collected line (if it exists) is output. In other words, it does not change a pending output line's indentation.

The read-only register `.in` reports the indentation that applies to the pending output line. The temporary indentation is associated with the environment (see Section 5.32 [Environments], page 216).

<code>.ll [<i>length</i>]</code>	[Request]
<code>.ll +<i>length</i></code>	[Request]
<code>.ll -<i>length</i></code>	[Request]
<code>\n[.l]</code>	[Register]
<code>\n[.ll]</code>	[Register]

Change (increase or decrease) the line length per the numeric expression *length*. The default scaling unit is ‘m’. If not otherwise configured (see see Section 2.5 [Paper Format], page 15), the default line length is 6.5i. If *length* is invalid, GNU `troff` emits a warning in category ‘number’ and ignores the request. If *length* is nonpositive, GNU `troff` emits a warning in category ‘range’ and sets the line length to the device's horizontal motion quantum; recall Section 5.3.1 [Motion Quanta], page 77. The line length is associated with the environment (see Section 5.32 [Environments], page 216). If *length* is omitted, GNU `troff` restores the environment's previous line length.

The effect of `ll` is delayed until a partially collected line (if it exists) is output. In other words, it does not change a pending output line's length.

The line length as set by `ll` can be found in the read-only register `‘.l’`. The read-only register `.ll` is the line length that applies to the pending output line.

Similarly to `.i` and `.in`, the difference between `.l` and `.ll` is that the latter takes into account whether a partially collected line still uses the previous length.

5.16 Line Continuation

When filling is enabled, input and output line breaks generally do not correspond. The **roff** language therefore distinguishes input and output line continuation.

`\RET` [Escape sequence]

`\RET` (a backslash immediately followed by a newline) suppresses the effects of that newline in the input. The next input line thus retains the classification of its predecessor as a control or text line. `\RET` is useful for managing line lengths in the input during document maintenance; you can even break an input line in the middle of a word, request invocation, macro call, or escape sequence. Input line continuation is invisible to the formatter, with two exceptions: the `|` operator recognizes the new input line (see Section 5.4 [Numeric Expressions], page 78), and the input line counter register `.c` increments. `\RET` is interpreted even in copy mode.⁸⁶

```
.ll 50n
.de I
.  ft I
.  nop \\$*
.  ft
```

```
..
```

Our film class watched

.I The Effect of Gamma Rays on Man-in-the-Moon

Marigolds. \" whoops, the input line wrapped

```
.br
```

.I My own opus begins on line `\n[.c]` \

and ends on line `\n[.c]`.

⇒ Our film class watched *The Effect of Gamma Rays on*

⇒ *Man-in-the-Moon* Marigolds.

⇒ *My own opus begins on line 11 and ends on line 12.*

`\c` [Escape sequence]

`\n[.int]` [Register]

`\c` continues an output line. Nothing after it on the input line is formatted. In contrast to `\RET`, a line after `\c` remains a new input line, so a control character is recognized at its beginning. The visual results depend on whether filling is enabled; see Section 5.9 [Manipulating Filling and Adjustment], page 101.

- If filling is enabled, a word interrupted with `\c` is continued with the text on the next input text line, without an intervening space.

```
This is a te\c
```

```
st.
```

⇒ This is a test.

⁸⁶ See Section 5.24.2 [Copy Mode], page 180.

- If filling is disabled, the next input text line after `\c` is handled as a continuation of the same input text line.

```
.nf
This is a \c
test.
⇒ This is a test.
```

An intervening control line that causes a break overrides `\c`, flushing out the pending output line in the usual way.

The `.int` register interpolates a positive value only if the pending output line has been continued with `\c`; this datum is associated with the environment (see Section 5.32 [Environments], page 216).⁸⁷

5.17 Page Layout

The formatter permits configuration of the page length and page number.

<code>.pl [<i>length</i>]</code>	[Request]
<code>.pl +<i>length</i></code>	[Request]
<code>.pl -<i>length</i></code>	[Request]
<code>\n[.p]</code>	[Register]

Change (increase or decrease) the page length per the numeric expression *length*. The default scaling unit is ‘v’. If *length* is invalid, GNU **troff** emits a warning in category ‘**number**’. If *length* is absent or invalid, ‘11i’ is assumed. If *length* is nonpositive, GNU **troff** emits a warning in category ‘**range**’ and sets the page length to the device’s vertical motion quantum; recall Section 5.3.1 [Motion Quanta], page 77.

The read-only register ‘.p’ interpolates the current page length.

<code>.pn <i>num</i></code>	[Request]
<code>.pn +<i>num</i></code>	[Request]
<code>.pn -<i>num</i></code>	[Request]
<code>\n[.pn]</code>	[Register]

Change (increase or decrease) the page number of the *next* page per the numeric expression *num*. If *num* is invalid, GNU **troff** emits a warning in category ‘**number**’ and ignores the request. Without an argument, **pn** is ignored.

The read-only register `.pn` interpolates *num* if set by **pn** on the current page, or the current page number plus 1.

The formatter offers special support for typesetting headers and footers, collectively termed *titles*. Titles have an independent line length, and their placement on the page is not restricted.

⁸⁷ Historically, the `\c` escape sequence has proven challenging to characterize. Some sources say it “connects the next input text” (to the input line on which it appears); others describe it as “interrupting” text, on the grounds that a text line is interrupted without breaking, perhaps to inject a request invocation or macro call.

`.tl 'left'center'right'` [Request]

Format an output line as a title consisting of *left*, *center*, and *right*, each aligned accordingly. The delimiter need not be a neutral apostrophe: `tl` accepts the same delimiters as most escape sequences; see Section 5.6.5 [Delimiters], page 91. If not used as the delimiter, any *page number character* character is replaced with the current page number; the default is `%`; see the `pc` request below. Without an argument, `tl` is ignored. `tl` writes the title line immediately, ignoring any partially collected line. It is not an error to omit delimiters after the first. For example, `.tl /Thesis` is interpreted as `.tl /Thesis//`: it sets a title line comprising only the left-aligned word `Thesis`.

`.lt [length]` [Request]

`.lt +length` [Request]

`.lt -length` [Request]

`\n[.lt]` [Register]

Change (increase or decrease) the line length used by titles per the numeric expression *length*. The default scaling unit is `m`. The formatter's default title length is `6.5i`. If *length* is invalid, GNU `troff` emits a warning in category `number` and ignores the request. If *length* is non-positive, GNU `troff` emits a warning in category `range` and sets the title line length to the device's horizontal motion quantum; recall Section 5.3.1 [Motion Quanta], page 77. The title length is associated with the environment (see Section 5.32 [Environments], page 216). If *length* is omitted, GNU `troff` restores the environment's previous title length.

The read-only register `.lt` interpolates the title line length.

`.pc [char]` [Request]

Set the page number character to *char*. With no argument, the page number character is disabled. `pc` does not affect the register `%`.

The following example exercises title features.

```
.lt 50n
This is my partially collected
.tl 'Isomers 2023%'Dextrose Edition'
line.
⇒ Isomers 2023           1           Dextrose Edition
⇒ This is my partially collected line.
```

We most often see titles used in page header and footer traps. See Section 5.29 [Traps], page 197.

5.18 Page Control

Discretionary page breaks can prevent the unwanted separation of content. A new page number takes effect during page ejection; see Section 5.29.1.2 [The Implicit Page Trap], page 202.

<code>.bp [page-number]</code>	[Request]
<code>.bp +page-number</code>	[Request]
<code>.bp -page-number</code>	[Request]
<code>\n[%]</code>	[Register]

Break the page and change (increase or decrease) the next page number per the numeric expression *page-number*. If *page-number* is invalid, GNU **troff** emits a warning in category ‘**number**’ and ignores the argument. This request causes a break. A page break advances the vertical drawing position to the bottom of the page, springing traps. See Section 5.29.1.1 [Page Location Traps], page 198. **bp** has effect only if invoked within the top-level diversion.⁸⁸ This request is incorrectly documented in the AT&T **troff** manual as having a default scaling unit of ‘v’.

The register % interpolates the page number.

```
.de BP
' bp \" schedule page break once current line is output
..
```

Caution: Interpolations occur before formatting operations. The process of filling, breaking, and adjusting a line can change the page number. % is a register like any other, not a placeholder that is rewritten after the line it appears on is formatted. Consider, for example, an extremely long page number at the end of the last line on the page; numbers aren’t hyphenated, so the word containing the page number might break the line and the page, causing the reported page number to lag by one. This sequencing also means that interpolating the % register inside a diversion (such as a footnote) records the page number at the time the diversion is populated, not when it is output.

<code>.ne [space]</code>	[Request]
--------------------------	-----------

Force a page break if insufficient vertical space is available (it asserts “needed” space). **ne** tests the distance to the next page location trap; see Section 5.29.1.1 [Page Location Traps], page 198, and breaks the page if that amount is less than *space*. The default scaling unit is ‘v’. If *space* is invalid, GNU **troff** emits a warning in category ‘**number**’ and ignores the argument. If *space* is not specified, ‘1v’ is assumed.

We can require space for at least the first two output lines of a paragraph, preventing its first line from being isolated at the page bottom.

⁸⁸ See Section 5.30 [Diversion], page 208.

```
.ne 2v
Considering how common illness is,
how tremendous the spiritual change that it brings,
how astonishing,
when the lights of health go down,
the undiscovered countries that are then disclosed,
what wastes and deserts of the soul a slight attack
of influenza brings to view,
what precipices and lawns sprinkled with bright flowers
a little rise of temperature reveals,
what ancient and obdurate oaks are uprooted in us
in the act of sickness,
how we go down into the pit of death
and feel the waters of annihilation
close above our heads.\|. \|.
.sp
```

Virgina Woolf, \[lq]On Being Ill\[rq], 1926

This method is reliable only if no output line is pending when **ne** is invoked. When macro packages are used, this is often not the case: their paragraphing macros perform the break. You may need to experiment with placing the **ne** after the paragraphing macro, or **br** and **ne** before it. **ne** is also useful to force grouping of section headings with their subsequent paragraphs, or tables with their captions and/or explanations. Macro packages often use **ne** with diversions to implement keeps and displays; see Section 5.30 [Diversions], page 208. They may also offer parameters for widow and orphan management.

.sv [*space*] [Request]
.os [Request]

sv requires vertical space as **ne** does, but also saves it for later output by the **os** request. If *space* is available before the next page location trap, it is output immediately. Both requests ignore a partially collected line, taking effect at the next break. **sv** and **os** ignore no-space mode (recall Section 5.11 [Manipulating Spacing], page 116). While the **sv** request allows negative values for *space*, **os** ignores them. The default scaling unit is ‘v’. If *space* is not specified, ‘1v’ is assumed.

\n[*nl*] [Register]

nl interpolates the vertical drawing position as of the most recently typeset output line. It does not necessarily (and often does not) represent that of the pending output line, because the formatter does not determine the position of its baseline until it is output; recall Section 5.11 [Manipulating Spacing], page 116. Assigning a value to **nl** sets the vertical drawing position in advance of further modifications to baseline positioning arising from alterations to type size, changes to vertical spacing, or application of extra pre- or post-vertical spacing.

When the formatter starts, the transition to the first page has not yet happened—`nl` is negative. If you plant a page location trap at vertical position ‘0’ (idiomatically to format a header), you can assign a negative value to `nl` to spring that trap even if the page has already started (see Section 5.29.1.1 [Page Location Traps], page 198).

```
.de HD
.  sp
.  tl 'Goldbach Solution'
.  sp
..
.
First page.
.bp
.wh 0 HD \" plant header trap at top of page
.nr nl (-1)
Second page.
⇒ First page.
⇒
⇒ (blank lines elided)
⇒
⇒ Goldbach Solution
⇒
⇒ (blank lines elided)
⇒
⇒ Second page.
```

Without resetting `nl` to a negative value, the trap just planted would be active beginning with the *next* page, not the current one.

See Section 5.30 [Divisions], page 208, for a comparison of `nl` with the `.h` and `.d` registers.

5.19 Using Fonts

In digital typography, a *font* is a collection of characters in a specific typeface that a device can render as glyphs at a desired size.⁸⁹ A **roff** formatter can change typefaces at any point in the text. The basic faces are a set of *styles* combining *upright* and *slanted* (italic or oblique) shapes with normal and heavy stroke weights: ‘R’, ‘I’, ‘B’, and ‘BI’—these stand for *roman*, *italic*, *bold*, and *bold-italic*. For linguistic text, GNU **troff** groups typefaces into *families* containing each of these styles.⁹⁰ A *text font* is thus often a family combined with a style, but it need not be: consider the **ps** and **pdf** devices’ ZCMI (Zapf Chancery Medium italic)—often, no other style of Zapf Chancery

⁸⁹ Terminals and some typesetters have fonts that render at only one or two sizes. As examples, take the **groff** **lj4** device’s Lineprinter, and **lp**’s Courier and Elite faces.

⁹⁰ Font designers prepare families such that the styles share esthetic properties.

Medium is provided. On typesetters, at least one *special font* is available, comprising *unstyled* glyphs for mathematical operators and other purposes.

Like the AT&T **troff** formatter, GNU **troff** does not itself load or manipulate a digital font file;⁹¹ instead it works with a *font description file* that characterizes it, including its glyph repertoire and the *metrics* (dimensions) of each glyph.⁹² This information permits the formatter to accurately place glyphs with respect to each other. Before using a font description, the formatter associates it with a *mounting position*, a place in an ordered list of available typefaces. So that a document need not be strongly coupled to a specific font family, in GNU **troff** an output device can associate a style in the abstract sense with a mounting position. Thus the default family can be combined with a style dynamically, producing a *resolved font name*. A user-specified font name that combines family and style, or refers to a font that is not a member of a family, is already “resolved”.

Fonts often have trademarked names, and even Free Software fonts can require renaming upon modification. **groff** maintains a convention that a device’s serif font family is given the name ‘T’ (“Times”), its sans-serif family ‘H’ (“Helvetica”), and its monospaced family ‘C’ (“Courier”). Historical inertia has driven **groff**’s font identifiers to short uppercase abbreviations of font names, as with ‘TR’, ‘TI’, ‘TB’, ‘TBI’, and a special font ‘S’.

The default family used with abstract styles is initially ‘T’. Typically, abstract styles are arranged in the first four mounting positions in the order shown above. The default mounting position, and therefore style, is always ‘1’ (‘R’). By issuing appropriate formatter instructions, you can override these defaults before your document writes its first glyph.

Terminals cannot change font families and lack special fonts. They support style changes by overstriking, or by altering ISO 6429/ECMA-48 *graphic renditions* (character cell attributes).

5.19.1 Selecting Fonts

We use *font* to refer to any of several means of identifying a typeface: by its mounting position (‘3’), by its identifier (‘TB’), or by an abstract style (‘B’) to be combined with the default family.

.ft [<i>font</i>]	[Request]
\ff	[Escape sequence]
\f (<i>fn</i>)	[Escape sequence]
\f [<i>font</i>]	[Escape sequence]
\n [.fn]	[Register]

The **ft** request selects the typeface *font*. If the argument is absent or ‘P’, it selects the previously used typeface; if there is none, the formatter ignores the request. If *font* is an integer, the formatter interprets it as a mounting

⁹¹ Historically, the fonts **troffs** dealt with were not Free Software or, as with the Graphic Systems C/A/T, did not even exist in the digital domain.

⁹² See Section 6.1.2 [Font Description File Format], page 250.

position; the font mounted there is selected. If that position refers to an abstract style, GNU **troff** combines it with the default family (see **fam** and **\F** below) to make a resolved font name. If *font* is ‘DESC’, if the mounting position is not an abstract style and no font is mounted there, or the mounting position is negative, GNU **troff** ignores the request.⁹³

If *font* matches a style name, it is combined with the default family to make a resolved font name. If not, *font* is assumed to be resolved already.

The resolved font name is subject to translation (see request **ftr** below). Next, the (possibly translated) font name’s mounting position is looked up; if not mounted, *font* is sought on the file system as a font description file and, if located, automatically mounted at the next available position (see register **.fp** below). If the font was mounted using an identifier different from its font description file name (see request **fp** below), that file name is then sought. If a font description file for the resolved font name is not found, GNU **troff** emits a warning in category ‘font’ and ignores the request.

The **\f** escape sequence is similar, accepting names or mounting positions of one character *f*, two characters *fn*, or arbitrary length *font*. ‘**\f []**’ selects the previous font. The syntax form ‘**\fP**’ is supported for backward compatibility, and ‘**\f [P]**’ for consistency.

```
eggs, bacon,
.ft I
spam,
.ft
and sausage.
.br
eggs, bacon, \fIspam,\fP and sausage.
⇒ eggs, bacon, spam, and sausage.
⇒ eggs, bacon, spam, and sausage.
```

The currently and previously selected fonts are properties of the environment (see Section 5.32 [Environments], page 216).

The read-only string-valued register **.fn** contains the resolved font name of the selected font. Copy its value to a string to save it for later use.

```
.ds saved-font \n[.fn]
... text involving many font changes ...
.ft \*[saved-font]
```

GNU **troff** does not tokenize **\f** when reading it; the escape sequence updates the environment. It thus can be used in requests that expect a single-character argument. We can assign a font to a margin character as follows (see Section 5.36 [Miscellaneous], page 228).

```
.mc \f[I]x\f[]
```

⁹³ It also emits a warning in category ‘font’ or ‘range’, as appropriate. See Section 5.38.1 [Warnings], page 236.

.ftr *f* [*g*] [Request]

Translate font name *f* to *g*. Where the `\f` escape sequence, the **F** and **S** conditional expression operators, and the **ft**, **ul**, **bd**, **cs**, **tkf**, **special**, **fspecial**, **fp**, or **sty** requests refer to *f*, GNU **troff** uses *g* instead. Omit *g* or repeat *f* as *g* to untranslate *f*. *f* and *g* need not be mounted fonts.

You can obtain a report of font translations defined by **ftr** on the standard error stream with the **pftr** request. See Section 5.38 [Debugging], page 231.

.fzoom *font* [*zoom*] [Request]
`\n[.zoom]` [Register]

Set magnification of mounted *font* to factor *zoom*, a multiplier applied to the type size in thousandths. *zoom* must be non-negative. **fzoom** applies to glyphs when they are formatted, altering a font's apparent size in relation to others. A missing or zero *zoom* is treated as '1000'—no magnification. *font* must be a resolved font name, not an abstract style.

Font magnification is transparent to some aspects of GNU **troff**. A change of the zoom factor affects scaling of glyph sizes, inter-word and inter-sentence spaces, and kerning adjustments on the output device, but *not* vertical spacing. It is not reflected in registers that report the requested or current type size, or the minimum inter-word and supplemental inter-sentence space sizes. It *is* reflected in measurements of formatted output: the horizontal drawing position register **hp**, interpolation of the `\w` escape sequence, and the registers updated by that escape sequence or the formatting of a glyph in the environment. See Section 5.32 [Environments], page 216.

fzoom can harmonize the apparent cap-heights of fonts from different families when formatted on the same baseline at the same type size.

```
.fzoom HR 900
.fzoom CR 1150
.fzoom PR 950
Times, \F[H]Helvetica\F[], \F[C]Courier\F[],
and \F[P]Palatino\F[] .
.sp
M\F[H]M\F[C]M\F[P]M
```

The zoom factor of the currently selected font is available in the read-only register `' .zoom'`. It interpolates zero if there is no magnification.

5.19.2 Font Families

To accommodate the wide variety of fonts available, GNU **troff** distinguishes *font families* and *font styles*. A resolved font name is the catenation of a font family and a style. Selecting an abstract style causes GNU **troff** to combine it with the default font family.

You can thus compose a document using abstract styles exclusively for its body or running text—selecting a specific family only for titles or examples, for instance—and change the default family on the command line.

<code>.fam</code>	<code>[family]</code>	[Request]
<code>\n[.fam]</code>		[Register]
<code>\Ff</code>		[Escape sequence]
<code>\F(fm</code>		[Escape sequence]
<code>\F[family]</code>		[Escape sequence]

Set the default font family, used in combination with abstract styles to construct a resolved font name, to *family* (one-character name *f*, two-character name *fm*). If no argument is given, GNU **troff** selects the previous font family; if there are none, it falls back to the device's default⁹⁴ or its own ('T').

The `\F` escape sequence works similarly. In disanalogy to `\f`, '`\FP`' makes 'P' the default family. Use '`\F[]`' to select the previous default family. The default font family is available in the read-only string-valued register `.fam`; it is associated with the environment (see Section 5.32 [Environments], page 216).

```
spam,      \" startup defaults are T (Times) R (roman)
.fam H     \" make Helvetica the default family
spam,      \" family H + style R = HR
.ft B      \" family H + style B = HB
spam,
.ft CR     \" Courier roman (default family not changed)
spam,
.ft        \" back to Helvetica bold
spam,
.fam T     \" make Times the default family
spam,      \" family T + style B = TB
.ft AR     \" font AR (not a style)
baked beans,
.ft R      \" family T + style R = TR
and spam.
```

GNU **troff** does not tokenize `\F` when reading it; the escape sequence updates the environment. It thus can be used in requests that expect a single-character argument. We can assign a font family to a margin character as follows (see Section 5.36 [Miscellaneous], page 228).

```
.mc \F[P]x\F[]
```

<code>.sty</code>	<code>pos style</code>	[Request]
<code>\n[.sty]</code>		[Register]

Associate an abstract style *style* with mounting position *pos*, which must be a non-negative integer. Applying the requests `cs`, `bd`, `tkf`, `uf`, or

⁹⁴ See Section 6.1.1 [DESC File Format], page 247.

fspecial to an abstract style affects the member of the default family corresponding to that style.

The default family can be set with the **-f** option (see Section 2.1 [Groff Options], page 7). The **styles** command in the **DESC** file controls which font positions (if any) are initially associated with abstract styles rather than fonts.

Caution: The *style* argument is not validated. Errors may occur later, when the formatter attempts to construct a resolved font name, or format a character for output.

```
.nr BarPos \n[.fp]
.sty \n[.fp] Bar
.fam Foo
.ft \n[BarPos]
.tm .f=\n[.f]
A
```

```
error error: no font family named 'Foo' exists
error .f=41
error error: cannot format glyph: no current font
```

When an abstract style has been selected, the read-only string-valued register **‘.sty’** interpolates its name; this datum is associated with the environment (see Section 5.32 [Environments], page 216). Otherwise, **‘.sty’** interpolates nothing.

5.19.3 Font Positions

To support typeface indirection through abstract styles, and for compatibility with AT&T **troff**, the formatter maintains a list of font *positions* at which fonts required by a document are *mounted*. An output device’s description file **DESC** typically configures a set of pre-mounted fonts; see Section 6.1 [Device and Font Description Files], page 247. A font need not be explicitly mounted before it is selected; GNU **troff** will search **GROFF_FONT_PATH** for a file name matching the identifier and mount it on demand.

```
.fp pos id [font-description-file-name] [Request]
\n[.f] [Register]
\n[.fp] [Register]
```

Mount a font under the name *id* at mounting position *pos*, a non-negative integer. When the formatter starts up, it reads the output device’s description to mount an initial set of faces, and selects font position 1. Position 0 is unused by default. Unless the *font-description-file-name* argument is given, *id* should be the name of a font description file stored in a directory corresponding to the selected output device. GNU **troff** does not traverse directories to locate the font description file.

The optional third argument enables font names to be aliased, which can be necessary in compatibility mode since AT&T **troff** syntax affords no means of identifying fonts with names longer than two characters, like

‘TBI’ or ‘ZCMI’, in a font selection escape sequence. See Section 5.39.2 [Compatibility Mode], page 238. You can also alias fonts on mounting for convenience or abstraction. (See below regarding the `.fp` register.)

```
.fp \n[.fp] SC ZCMI
Send a \f(Schand-written\fp thank-you note.
.fp \n[.fp] Emph TI
.fp \n[.fp] Strong TB
Are \f[Emph]these names\f[] \f[Strong]comfortable\f[]?
```

‘DESC’, ‘P’, and non-negative integers are not usable as font identifiers.

You can obtain a report of occupied font mounting positions (whether configured by the ‘DESC’ file, the `fp` request, or automatic mounting) on the standard error stream with the `pdf` request. See Section 5.38 [Debugging], page 231.

The position of the currently selected font (or abstract style) is available in the read-only register ‘`.f`’. It is associated with the environment (see Section 5.32 [Environments], page 216).

Copy the value of `.f` to another register to save it for later use.

```
.nr sF \n(.f
... text involving many font changes ...
.ft \n(sF
```

The index of the next (non-zero) free font position is available in the read-only register ‘`.fp`’. Fonts not listed in the DESC file are automatically mounted at position ‘`\n[.fp]`’ when selected with the `ft` request or `\f` escape sequence. When mounting a font at a position explicitly with the `fp` request, this same practice should be followed, although GNU `troff` does not enforce this strictly.

5.19.4 Characters and Glyphs

A glyph is a graphical representation of a character. Whereas a *character* is an abstraction of semantic information, a *glyph* is an intelligible mark visible on screen or paper. A character has many possible representation forms; for example, the character ‘A’ can be written in an upright or slanted typeface, producing distinct glyphs. Sometimes, a sequence of characters map to a single glyph: this is a *ligature*—the most common is ‘fi’.

Space characters never become glyphs in GNU `troff`. If not discarded (as when trailing text lines), horizontal motions represent them in the output.

In a `troff` system, a font description file (recall Section 2.4 [Font Directories], page 14) lists all of the glyphs a particular font provides. If the user requests a glyph not available in the currently selected font, the formatter looks it up an ordered list of *special fonts*. By default, the ‘`ps`’ (PostScript) and ‘`pdf`’ output devices support the two special fonts ‘`SS`’ (slanted symbol) and ‘`S`’ (symbol); and these devices’ DESC files arrange them such that the formatter searches the former before the latter. Other output devices use different names for special fonts. Fonts mounted with the `fonts` keyword in

the DESC file are globally available. GNU **troff**'s **special** and **fspecial** requests alter the list of fonts treated as special on a general basis, or only when a certain font is currently selected, respectively.

The formatter supports three kinds of character. An *ordinary character* is the most commonly used, has no special syntax, and typically represents itself.⁹⁵ Interpolate a *special character* with the `'\[xxx]'` or `'\C'xxx'` escape sequence syntax, where *xxx* is an identifier. An *indexed character* bypasses most character-to-glyph resolution logic, uses the `'\N'i'` syntax, and selects a glyph from the currently selected font by its integer-valued position *i* in the output device's representation of that font.⁹⁶

User-defined characters are similar to string definitions,⁹⁷ and permit extension of or substitution within the character repertoire. Any ordinary, special, or indexed character can be user-defined. The **char**, **fchar**, **schar**, and **fschar** requests create user-defined characters employed at various stages of the character-to-glyph resolution process.

GNU **troff** employs the following procedure to resolve an input character into a glyph. User-defined characters make this resolution process recursive. The first step that succeeds ends the resolution procedure for the character being formatted, which may not be the last in the sequence interpolated by a user-defined character.

- Interpolate the definition of any character defined by the **char** request and apply this procedure to each character in its definition.
- Check the current font for a glyph corresponding to the character.
- Interpolate the definition of any user-defined character matching defined by the **fchar** request and apply this procedure to each character in its definition.
- Check whether the current font has a font-specific list of special fonts; if so, check the each font therein, in the order determined by the last applicable **fspecial** request, for a glyph corresponding to the character.
- Interpolate the definition of any character defined by the **fschar** request for the currently selected font, and apply this procedure to each character in its definition.
- Check each font in the list configured by the most recently issued **special** request for a glyph corresponding to the character.
- Interpolate the definition of any character defined by the **sschar** request and apply this procedure to each character in its definition.
- Finally, iterate through the list of mounted fonts by position; recall See Section 5.19.3 [Font Positions], page 139. For each mounted font, if that

⁹⁵ Depending on the breadth of the output device's glyph repertoire, the characters `'`, `-`, `^`, ```, and `~` can be exceptions to this rule. `"` and `\` are not exceptions, but because they are syntactically meaningful to the formatter, access to their glyphs may require use of special characters (or changing or disabling the escape character). See *groff_char*(7).

⁹⁶ Fonts do not necessarily arrange their glyphs per a standard character encoding.

⁹⁷ See Section 5.22 [Strings], page 163.

font bears the **special** directive,⁹⁸ check it for a glyph corresponding to the character. This stage of the resolution process can sometimes lead to surprising results since the **fonts** directive in the DESC file often contains empty positions that are filled by a macro file or document employing the **fp** request after the formatter initializes.

For example, consider the following:

```
fonts 3 0 0 F00
```

This mounts font **foo** at font position 3. We assume that **F00** is a special font, containing glyph **foo**, and that no font has been loaded yet. The line

```
.fspecial BAR BAZ
```

makes font **BAZ** special only if font **BAR** is active. We further assume that **BAZ** is really a special font, i.e., the font description file contains the **special** keyword, and that it also contains glyph **foo** with a special shape fitting to font **BAR**. After executing **fspecial**, font **BAR** is loaded at font position 1, and **BAZ** at position 2.

We now switch to a new font **XXX**, trying to access glyph **foo** that is assumed to be missing. There are neither font-specific special fonts for **XXX** nor any other fonts made special with the **special** request, so the formatter starts the search for special fonts in the list of already mounted fonts, with increasing font positions. Consequently, it finds **BAZ** before **F00** even before **XXX**, which is not the intended behaviour.

See Section 6.1 [Device and Font Description Files], page 247, and Section 5.19.6 [Special Fonts], page 149, for more details.

The *groff_char(7)* man page houses a complete list of predefined special character names, but the availability of any as a glyph is device- and font-dependent. For example, say

```
man -T dvi groff_char > groff_char.dvi
```

to obtain those available with the DVI device and default font configuration.⁹⁹ If you want to use an additional macro package to change the fonts used, you must run **groff** (or **troff**) directly.

```
groff -T dvi -m ec -m an groff_char.7 > groff_char.dvi
```

Special character names not listed in *groff_char(7)* are derived algorithmically, using a simplified version of the Adobe Glyph List (AGL) algorithm, which is described in <https://github.com/adobe-type-tools/agl-aglfn>. The (frozen) set of names that can't be derived algorithmically is called the *groff glyph list (GGL)*.

- A glyph for Unicode character U+XXXX[X[X]], which is not a composite character is named **uXXXX[X[X]]**. *X* must be an uppercase hexadecimal digit. Examples: **u1234**, **u008E**, **u12DB8**. The largest Unicode value

⁹⁸ See Section 6.1 [Device and Font Description Files], page 247.

⁹⁹ Not all versions of the **man** program support the **-T** option; use the subsequent example for an alternative.

is 0x10FFFF. There must be at least four **X** digits; if necessary, add leading zeroes (after the ‘u’). No zero padding is allowed for character codes greater than 0xFFFF. Surrogates (i.e., Unicode values greater than 0xFFFF represented with character codes from the surrogate area U+D800-U+DFFF) are not allowed either.

- A glyph representing more than a single input character is named

‘u’ *component1* ‘_’ *component2* ‘_’ *component3* ...

Example: `u0045_0302_0301`.

For simplicity, all Unicode characters that are composites must be maximally decomposed to NFD;¹⁰⁰ for example, `u00CA_0301` is not a valid glyph name since U+00CA (LATIN CAPITAL LETTER E WITH CIRCUMFLEX) can be further decomposed into U+0045 (LATIN CAPITAL LETTER E) and U+0302 (COMBINING CIRCUMFLEX ACCENT). `u0045_0302_0301` is thus the glyph name for U+1EBE, LATIN CAPITAL LETTER E WITH CIRCUMFLEX AND ACUTE.

- **groff** maintains a table to decompose all algorithmically derived glyph names that are composites itself. For example, `u0100` (LATIN LETTER A WITH MACRON) is automatically decomposed into `u0041_0304`. Additionally, a glyph name of the GGL is preferred to an algorithmically derived glyph name; **groff** also automatically does the mapping. Example: The glyph `u0045_0302` is mapped to `^E`.
- glyph names of the GGL can’t be used in composite glyph names; for example, `^E_u0301` is invalid.

<code>\(nm</code>	[Escape sequence]
<code>\[name]</code>	[Escape sequence]
<code>\[base-glyph combining-component ...]</code>	[Escape sequence]

Typeset a special character *name* (two-character name *nm*) or a composite glyph consisting of *base-glyph* overlaid with one or more *combining-components*. For example, ‘`\[A ho]`’ is a capital letter “A” with a “hook accent” (ogonek).

There is no special syntax for one-character names—the analogous form ‘`\n`’ would collide with other escape sequences. However, the four escape sequences `\'`, `\-`, `\_`, and `\``, are translated on input to the special character escape sequences `\[aa]`, `\[-]`, `\[u1]`, and `\[ga]`, respectively. A special character name of length one is not the same thing as an ordinary character: that is, the character **a** is not the same as `\[a]`.

If *name* is undefined, a warning in category ‘**char**’ is produced and the escape is ignored. See Section 5.38.1 [Warnings], page 236, for information about the enablement and suppression of warnings.

GNU **troff** resolves `\[...]` with more than a single component as follows:

¹⁰⁰ This is “Normalization Form D” as documented in Unicode Standard Annex #15 (<https://unicode.org/reports/tr15/>).

- Any component that is found in the GGL is converted to the `uXXXX` form.
- Any component `uXXXX` that is found in the list of decomposable glyphs is decomposed.
- The resulting elements are then catenated with ‘_’ in between, dropping the leading ‘u’ in all elements but the first.

No check for the existence of any component (similar to `tr` request) is done.

Examples:

`\[A ho]` ‘A’ maps to `u0041`, ‘ho’ maps to `u02DB`, thus the final glyph name would be `u0041_02DB`. This is not the expected result: the ogonek glyph ‘ho’ is a spacing ogonek, but for a proper composite a non-spacing ogonek (U+0328) is necessary. Looking into the file `composite.tmac`, one can find ‘`.composite ho u0328`’, which changes the mapping of ‘ho’ while a composite glyph name is constructed, causing the final glyph name to be `u0041_0328`.

`\[^E u0301]`

`\[^E aa]`

`\[E a^ aa]`

`\[E ^ ']` ‘^E’ maps to `u0045_0302`, thus the final glyph name is `u0045_0302_0301` in all forms (assuming proper calls of the `composite` request).

It is not possible to define glyphs with names like ‘A ho’ within a **groff** font file. This is not really a limitation; instead, you have to define `u0041_0328`.

`\C'xxx'` [Escape sequence]

Typeset the special character `xxx`. Normally, it is more convenient to use ‘`\[xxx]`’, but `\C` has some advantages: it is compatible with AT&T device-independent **troff** (and therefore available in compatibility mode¹⁰¹) and can interpolate special characters with ‘`]`’ in their names. The delimiter need not be a neutral apostrophe; recall Section 5.6.5 [Delimiters], page 91.

`.composite c1 c2` [Request]

Map ordinary or special character name `c1` to `c2` when `c1` is a combining component in a composite character. See above for examples. This is a strict rewriting of the special character name; no check is performed for the existence of a glyph for either. Typically, `composite` is used to map a spacing character to a combining one. A set of default mappings for many accents can be found in the file `composite.tmac`, loaded by the default `troffrc` at startup.

¹⁰¹ See Section 5.39.2 [Compatibility Mode], page 238.

You can obtain a report of mappings defined by **composite** on the standard error stream with the **pcomposite** request. See Section 5.38 [Debugging], page 231.

\N'n' [Escape sequence]

Format indexed character numbered *n* in the current font (*n* is *not* the input character code). *n* can be any non-negative decimal integer. Most devices number glyphs with codes between 0 and 255 only; the **utf8** output device uses codes in the range 0–65535. If the current font does not contain a glyph with that code, special fonts are *not* searched. The **\N** escape sequence can be conveniently used in conjunction with the **char** request.

.char \[phone] \f[ZD]\N'37'

The code of each glyph is given in the fourth column in the font description file after the **charset** command. It is possible to include unnamed glyphs in the font description file by using a name of ‘---’; the **\N** escape sequence is the only way to use these.

No kerning is applied to glyphs accessed with **\N**. The delimiter need not be a neutral apostrophe; see Section 5.6.5 [Delimiters], page 91.

A few escape sequences are also special characters.

\' [Escape sequence]

An escaped neutral apostrophe is a synonym for **\[aa]** (acute accent).

\` [Escape sequence]

An escaped grave accent is a synonym for **\[ga]** (grave accent).

\- [Escape sequence]

An escaped hyphen-minus is a synonym for **\[-]** (minus sign).

_ [Escape sequence]

An escaped underscore (“low line”) is a synonym for **\[ul]** (underrule). On typesetting devices, the underrule is font-invariant and drawn lower than the underscore ‘_’.

.cflags n c... [Request]

Assign properties encoded by non-negative integer *n* to each character or class¹⁰². *c*. Spaces need not separate *c* arguments.

Characters, whether ordinary, special, or indexed, have certain associated properties. The first argument is the sum of the desired flags and the remaining arguments are the characters to be assigned those properties. arguments.

The non-negative integer *n* is the sum of any of the following. Some combinations are nonsensical, such as ‘33’ (1 + 32).

¹⁰² See Section 5.19.5 [Character Classes], page 148.

- 1 Recognize the character as ending a sentence if followed by a newline or two spaces. Initially, characters ‘.?!’ have this property.
- 2 Enable breaks before the character. A line is not broken at a character with this property unless the characters on each side both have non-zero hyphenation codes. This exception can be overridden by adding 64. Initially, no characters have this property.
- 4 Enable breaks after the character. A line is not broken at a character with this property unless the characters on each side both have non-zero hyphenation codes. This exception can be overridden by adding 64. Initially, characters ‘\-\[hy]\[em]’ have this property.
- 8 Mark the glyph associated with this character as overlapping other instances of itself horizontally. Initially, characters ‘\[ul]\[rn]\[ru]\[radicallex]\[sqrtext]’ have this property.
- 16 Mark the glyph associated with this character as overlapping other instances of itself vertically. Initially, the character ‘\[br]’ has this property.
- 32 Mark the character as transparent for the purpose of end-of-sentence recognition. In other words, an end-of-sentence character followed by any number of characters with this property is treated as the end of a sentence if followed by a newline or two spaces. This is the same as having a zero space factor in T_EX. Initially, characters ‘’’)*\[dg]\[dd]\[rq]\[cq]’ have this property.
- 64 Ignore hyphenation codes of the surrounding characters. Use this in combination with values 2 and 4 (initially, no characters have this property).
 For example, if you need an automatic break point after the en-dash in numeric ranges like “3000–5000”, insert
 `.cflags 68 \[en]`
 into your document. However, this practice can lead to bad layout if done thoughtlessly; in most situations, a better solution instead of changing the `cflags` value is to insert `\:` right after the hyphen at the places that really need a break point.

The remaining values were implemented for East Asian language support; those who use alphabetic scripts exclusively can disregard them.

- 128 Prohibit a line break before the character, but allow a line break after the character. This works only in combination

with flags 256 and 512 and has no effect otherwise. Initially, no characters have this property.

- 256 Prohibit a line break after the character, but allow a line break before the character. This works only in combination with flags 128 and 512 and has no effect otherwise. Initially, no characters have this property.
- 512 Allow line break before or after the character. This works only in combination with flags 128 and 256 and has no effect otherwise. Initially, no characters have this property.

In contrast to values 2 and 4, the values 128, 256, and 512 work pairwise. If, for example, the left character has value 512, and the right character 128, no break will be automatically inserted between them. If we use value 6 instead for the left character, a break after the character can't be suppressed since the neighboring character on the right doesn't get examined.

<code>.char c ["][contents]</code>	[Request]
<code>.fchar c ["][contents]</code>	[Request]
<code>.fschar f c ["][contents]</code>	[Request]
<code>.schar c ["][contents]</code>	[Request]

Define an ordinary, special, or indexed character *c* as *contents*.

Omitting *contents* gives *c* an empty definition.

GNU **troff** removes a leading neutral double quote “” from *contents*, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. See Section 5.24.2 [Copy Mode], page 180.

Defining (or redefining) a character *c* creates a formatter object that GNU **troff** recognizes like any other ordinary, special, or indexed character on input, and produces *contents* on output. When formatting *c*, GNU **troff** processes *contents* in a temporary environment and encapsulates the result in a node;¹⁰³ disabling compatibility mode and setting the escape character to \ while interpreting *contents*. Any emboldening, constant spacing, or track kerning applies to this object rather than to individual glyphs resulting from the formatting of *contents*.

A character defined by these requests can be used just like a glyph provided by the output device. In particular, other characters can be translated to it with the **tr** and **trin** requests; it can be made the tab or leader fill character with the **tc** and **lc** requests, respectively; sequences of it can be drawn with the **\l** and **\L** escape sequences; and, if the **hcode** request is used on *c*, it is subject to automatic hyphenation.

However, a user-defined character *c* does not participate at its boundaries in kerning adjustments or italic corrections.

¹⁰³ See Section 5.37 [GNU **troff** Internals], page 228.

The formatter prevents infinite recursion by treating an occurrence of a character in its own definition as if it were undefined; when interpolating such a character, GNU **troff** emits a warning in category ‘**char**’.¹⁰⁴

The **tr** and **trin** requests take precedence if **char** accesses the same symbol.

```
.tr XY
X
    ⇒ Y
.char X Z
X
    ⇒ Y
.tr XX
X
    ⇒ Z
```

The **fchar** request defines a fallback glyph: **troff** checks for glyphs defined with **fchar** only if it cannot find the glyph in the current font. **troff** performs this test before checking special fonts.

fschar defines a fallback glyph for font *f*: **troff** checks for glyphs defined with **fschar** after the list of fonts declared as font-specific special fonts with the **fspecial** request, but before the list of fonts declared as global special fonts with the **special** request.

Finally, the **schar** request defines a global fallback glyph: **troff** checks for glyphs defined with **schar** after the list of fonts declared as global special fonts with the **special** request, but before the already mounted special fonts.

See Section 5.19.5 [Character Classes], page 148.

Caution: These requests remove a leading neutral double quote “” and treat the remainder of the input line as their second argument, including any spaces, up to a newline or comment escape sequence. See the discussion of the **ds** request in Section 5.22 [Strings], page 163.

```
.rchar c ... [Request]
.rfschar f c ... [Request]
```

Remove definition of each ordinary, special, or indexed character *c*, undoing the effect of a **char**, **fchar**, or **schar** request. Spaces need not separate *c* arguments. The character definition removed (if any) is the first encountered in the resolution process documented above. Glyphs, which are defined by font description files, cannot be removed.

rfschar removes character definitions created by **fschar** for font *f*.

5.19.5 Character Classes

GNU **troff** can group characters into *classes*, making manipulation of their breaking and/or sentential properties convenient; recall the **cflags** request

¹⁰⁴ Mutually recursive character definitions are handled similarly.

in Section 5.19.4 [Characters and Glyphs], page 140. Classes are particularly useful for East Asian languages such as Chinese, Japanese, and Korean, which have much larger character repertoires than the Latin, Greek, Cyrillic, or Thai scripts. In such large character sets, many characters share the same properties. Only **class** and **cflags** requests can operate on character classes.

.class *ident* *c* . . . [Request]

Define a character class (or simply “class”) *ident* comprising the members *c* . . ., where each *c* is an ordinary, special, or indexed character; or a *range expression*. A class thus defined can then be referred to in a **cflags** request in lieu of listing all the characters within it.

```
.class [quotes] ' \[aq] \[dq] \[oq] \[cq] \[lq] \[rq]
```

Since class and special character names share the same name space, we recommend starting and ending the class name with ‘[’ and ‘]’, respectively, to avoid collisions with existing special character names defined by GNU **troff** or the user (with **char** and related requests). This practice applies the presence of ‘]’ in the class name to prevent the use of the special character escape form ‘\[. . .]’, you must therefore access a class thus named via the **\C** escape sequence.

An argument *c* can alternatively be a *range expression* consisting of a start character followed by ‘-’ and then an end character. Internally, GNU **troff** converts these two symbol names to Unicode code points (according to the **groff** glyph list [GGL]), which determine the start and end values of the range. If that conversion fails, GNU **troff** skips the range expression and any remaining arguments.

If you want to include ‘-’ in a class, it must be the first character in a *c* argument; otherwise GNU **troff** interprets the argument as a range expression.

5.19.6 Special Fonts

Special fonts are those that the formatter searches, in mounting position order, when it cannot find a requested glyph in the selected font. Typically, they are declared as such in their description files,¹⁰⁵ and contain unstyled glyphs. The “Symbol” and “Zapf Dingbats” fonts of the PostScript and PDF standards are examples. Ordinarily, only typesetters have special fonts.

GNU **troff**’s **special** and **fspecial** requests permit a document to supplement the set of fonts the device configures for glyph search without having to use the **fp** request to manipulate the list of mounting positions, which can be tedious—by default, GNU **troff** mounts 40 fonts at startup when using the **ps** device.

¹⁰⁵ See Section 6.1.2 [Font Description File Format], page 250.

`.special` [*s* ...] [Request]
`.fspecial` *f* [*s* ...] [Request]

`special` declares each font *s* as special, irrespective of its description file, populating a list that GNU `troff` searches, in order, to find the glyph demanded. GNU `troff` mounts each font *s*. Invoking `special` without arguments empties the list. A font is not automatically unmounted if a subsequent `special` request removes it from the list. Initially, the list is empty.

`fspecial` is similar; it designates each font *s* as special only when font *f* is selected. Initially, a font *f*'s list of associated special fonts is empty for all *f*.

Invoking `special` (or `fspecial`, for a given font *f*) again overwrites the previous list; if you invoke them without arguments, GNU `troff` empties the corresponding list.

5.19.7 Artificial Fonts

There are a number of requests and escape sequences for artificially creating fonts. These are largely vestiges of the days when output devices did not have a wide variety of fonts, and when `nroff` and `troff` were separate programs. Most of them are no longer necessary in GNU `troff`. Nevertheless, they are supported.

`\H'height'` [Escape sequence]
`\H'+height'` [Escape sequence]
`\H'-height'` [Escape sequence]
`\n[.height]` [Register]

Set (increment, decrement) the height of the current font, but not its width. If *height* is zero, the formatter uses the font's inherent height for its type size. The default scaling unit is 'z'.

Changing the font height does not affect vertical spacing; dramatic changes may be better accompanied by an `\x` escape sequence to add extra pre-vertical space to the output line. Recall Section 5.11 [Manipulating Spacing], page 116.

The read-only register `.height` interpolates the font height.

As of this writing, only the `ps` and `pdf` output devices support this feature.

The formatter does not tokenize `\H` when reading it; the escape sequence updates the environment.¹⁰⁶ It thus can be used in requests that expect a single-character argument. We can alter the font height of a margin character¹⁰⁷ as follows.

```
.mc \H'+5z'x\H'0'
```

¹⁰⁶ See Section 5.32 [Environments], page 216.

¹⁰⁷ See Section 5.36 [Miscellaneous], page 228.

In compatibility mode, GNU **troff** behaves differently: it applies an increment or decrement to the current type size and not to the previously selected font height.

```
.cp 1
\H'+5'test \H'+5'test
```

prints the word ‘**test**’ twice with the same font height—five points larger than the current font size.

\S'*slant*' [Escape sequence]
\n[.*slant*] [Register]

Slant the glyphs of the currently selected font by *slant* degrees. Positive values slant in the direction of text flow. Only integer values are possible. The read-only register *.slant* interpolates the font slant.

As of this writing, only the **ps** and **pdf** output devices support this feature. The formatter does not tokenize **\S** when reading it; the escape sequence updates the environment.¹⁰⁸ It thus can be used in requests that expect a single-character argument. We can apply a slant to a margin character¹⁰⁹ as follows.

```
.mc \S'20'x\S'0'
```

This escape sequence is incorrectly documented in the AT&T **troff** manual: the slant is only assigned, never incremented or decremented.

.ul [*lines*] [Request]

The **ul** request normally underlines subsequent lines if a TTY output device is used. Otherwise, the lines are printed in italics (only the term ‘underlined’ is used in the following). The single argument is the quantity of input lines to be underlined; with no argument, the next line is underlined. If *lines* is zero or negative, stop the effects of **ul** (if it was active). Requests and empty lines do not count for computing the number of underlined input lines, even if they produce some output like **tl**. Lines inserted by macros (e.g., invoked by a trap) do count.

At the beginning of **ul**, the current font is stored and the underline font is activated. Within the span of a **ul** request, it is possible to change fonts, but after the last line affected by **ul** the saved font is restored.

This number of lines still to be underlined is associated with the environment (see Section 5.32 [Environments], page 216). The underline font can be changed with the **uf** request.

The **ul** request does not underline spaces.

.cu [*lines*] [Request]

The **cu** request is similar to **ul** but underlines spaces as well (if a TTY output device is used).

¹⁰⁸ See Section 5.32 [Environments], page 216.

¹⁰⁹ See Section 5.36 [Miscellaneous], page 228.

.uf *font* [Request]
 Set the underline font (globally) used by **ul** and **cu**. By default, this is the font at position 2. *font* can be either a non-negative font position or the name of a font.

.bd *font* [*offset*] [Request]
.bd *font1 font2* [*offset*] [Request]
\n[.b] [Register]

Embolden *font* by overstriking its glyphs offset by *offset* units minus one. Two syntax forms are available.

- Imitate a bold font unconditionally. The first argument specifies the font to embolden, and the second is the number of basic units, minus one, by which the two glyphs are offset. If the second argument is missing, emboldening is turned off.

font can be either a non-negative font position or the name of a font. *offset* is available in the **.b** read-only register if a special font is active; in the **bd** request, its default unit is ‘u’.

- Imitate a bold form conditionally. Embolden *font1* by *offset* only if font *font2* is the current font. This request can be issued repeatedly to set up different emboldening values for different current fonts. If the second argument is missing, emboldening is turned off for this particular current font.

Because the emboldening is conditional, it applies only if the glyph to be formatted is not available in the current font. *font1* must therefore be a special font, configured either with the **special** directive in its font description file or with the **fspecial** request).

.cs *font* [*width* [*em-size*]] [Request]
 Switch to and from *constant glyph spacing mode*. If activated, the width of every glyph is *width*/36 ems. The em size is given absolutely by *em-size*; if this argument is missing, the em value is taken from the current font size (as set with the **ps** request) when the font is effectively in use. Without second and third argument, constant glyph spacing mode is deactivated.

Default scaling unit for *em-size* is ‘z’; *width* is an integer.

5.19.8 Ligatures and Kerning

Proportional fonts commonly employ two techniques to improve the esthetics of typeset text. *Ligatures* are sequences of glyphs that are visually connected or “tied”, overlapping them and slightly altering their shapes. *Kerning* is the adjustment of horizontal spacing between glyphs. Neither is employed on terminals.¹¹⁰

¹¹⁰ A monospaced font may possess glyphs for ligatures, but they nevertheless seldom see use to set text.

Most typesetters support ligatures for the sequences ‘fi’, ‘fl’, ‘ff’, ‘ffi’, and ‘ffl’, and **troff** does likewise. Some fonts may include others, but GNU **troff** does not (yet) support them.

The formatter checks only the current font for ligatures and kerning adjustments; neither glyphs from special fonts nor special characters defined with the **char** request (and its siblings) are considered for these processes.

.lg [*flag*] [Request]
\n[**.lg**] [Register]

Switch the ligature mechanism on or off; if the parameter is non-zero or missing, ligatures are enabled, otherwise disabled. Default is on. The current ligature mode can be found in the read-only register **.lg** (set to 1 or 2 if ligatures are enabled, 0 otherwise).

Setting the ligature mode to 2 enables the two-character ligatures (fi, fl, and ff) and disables the three-character ligatures (ffi and ffl).

Pairwise kerning is another subtle typesetting mechanism that modifies the distance between adjacent glyphs in a pair to improve readability. In most cases (but not always) the distance is decreased. For example, compare the combination of the letters ‘V’ and ‘A’. With kerning, ‘VA’ is printed. Without kerning it appears as ‘VA’. Monospaced (typewriter-like) fonts and terminals don’t use kerning.

.kern [*flag*] [Request]
\n[**.kern**] [Register]

Enable or disable pairwise kerning of glyphs in the environment per *b*. It is enabled by default, and if *b* is omitted.

The read-only register **.kern** interpolates 1 if pairwise kerning is enabled, 0 otherwise.

If the font description file contains pairwise kerning information, glyphs from that font are kerned. Kerning between two glyphs can be inhibited by placing **&** between them: ‘V**&**A’.

See Section 6.1.2 [Font Description File Format], page 250.

Track kerning expands or reduces the space between glyphs. This can be handy, for example, if you need to squeeze a long word onto a single line or spread some text to fill a narrow column. It must be used with great care since it is usually considered bad typography if the reader notices the effect.

.tkf *f s1 n1 s2 n2* [Request]

Enable track kerning for font *f*. If the current font is *f* the width of every glyph is increased by an amount between *n1* and *n2* (*n1*, *n2* can be negative); if the current type size is less than or equal to *s1* the width is increased by *n1*; if it is greater than or equal to *s2* the width is increased by *n2*; if the type size is greater than or equal to *s1* and less than or equal to *s2* the increase in width is a linear function of the type size.

The default scaling unit is ‘z’ for *s1* and *s2*, ‘p’ for *n1* and *n2*.

The track kerning amount is added even to the rightmost glyph in a line; for large values it is thus recommended to increase the line length by the same amount to compensate.

5.19.9 Italic Corrections

When typesetting adjacent glyphs from typefaces of different slants, the space between them may require adjustment.

`\/` [Escape sequence]
 Apply an *italic correction*: modify the spacing of the preceding glyph so that the distance between it and the following glyph is correct if the latter is of upright shape. For example, if an italic ‘f’ is followed immediately by a roman right parenthesis, then in many fonts the top right portion of the ‘f’ overlaps the top of the right parenthesis, which is ugly. Use `\/` whenever a slanted glyph is followed immediately by an upright glyph without any intervening space.

`\,` [Escape sequence]
 Apply a *left italic correction*: modify the spacing of the following glyph so that the distance between it and the preceding glyph is correct if the latter is of upright shape. For example, if a roman left parenthesis is immediately followed by an italic ‘f’, then in many fonts the bottom left portion of the ‘f’ overlaps the bottom of the left parenthesis, which is ugly. Use `\,` whenever an upright glyph is followed immediately by a slanted glyph without any intervening space.

5.19.10 Dummy Characters

As discussed in Section 5.1.7 [Requests and Macros], page 67, the first character on an input line is treated specially. Further, formatting a glyph has many consequences on formatter state (see Section 5.32 [Environments], page 216). Occasionally, we want to escape this context or embrace some of those consequences without actually rendering a glyph to the output.

`\&` [Escape sequence]
 Interpolate a dummy character, which is constitutive of output but invisible.¹¹¹ Its presence alters the interpretation context of a subsequent input character, and enjoys several applications.

- Prevent insertion of extra space after an end-of-sentence character.

¹¹¹ Opinions of this escape sequence’s best name abound. “Zero-width space” is a popular misnomer: `roff` formatters do not treat it like a space; when filling, they do not break a line where `\&` appears. Ossanna called it a “non-printing, zero-width character”, but the character causes *output* even though it does not “print”. If no output line is pending, the dummy character starts one. Contrast an empty input document with one containing only `\&`. The former produces no output; the latter, a blank page.

```
Test.
Test.
    ⇒ Test. Test.
Test.\&
Test.
    ⇒ Test. Test.
```

- Prevent recognition of a control character.

```
.Test
    error warning: name 'Test' not defined
\&.Test
    ⇒ .Test
```

- Prevent kerning between two glyphs.

```
VA
    ⇒ VA
V\&A
    ⇒ VA
```

- Translate a character to “nothing”.

```
.tr JIjIk\&k\&UVuv
Post universitum, alea jacta est, OK?
    ⇒ Post vniversitvm, alea iacta est, 0?
```

- Stop the interpretation of a numerical expression.

```
\l'4i-'
    error warning: expected numeric expression,
    error got character "'"
\l'4i\&-'
    ⇒ -----
```

The dummy character escape sequence sees use in macro definitions as a means of ensuring that arguments are treated as text even if they begin with spaces or control characters.

```
.de HD \" typeset a simple bold heading
. sp
. ft B
\&\$1 \" exercise: remove the \&
. ft
. sp
..
.HD .\|.|\|.|\surprised?
```

One way to think about the dummy character is to imagine placing the symbol ‘&’ in the input at a certain location; if doing so has all the side effects on formatting that you desire except for sticking an ugly ampersand in the midst of your text, the dummy character is what you want in its place.

`\)` [Escape sequence]

Interpolate a *transparent* dummy character—one that is transparent to end-of-sentence detection. It behaves as `\&`, except that `\&` is treated as letters and numerals normally are after ‘.’, ‘?’ and ‘!’; `\&` cancels end-of-sentence detection, and `\)` does not.

```
.de Suffix-&
.  nop \&\\$1
..
.
.de Suffix-)
.  nop \\$1
..
.
Here's a sentence.\c
.Suffix-& '
Another one.\c
.Suffix-) '
And a third.
⇒ Here's a sentence.' Another one.' And a third.
```

5.20 Manipulating Type Size and Vertical Spacing

These concepts were introduced in Section 5.2 [Page Geometry], page 75. The height of a font’s tallest glyph is one em, which is equal to the type size in points.¹¹² A vertical spacing of less than 120% of the type size can make a document hard to read. Larger proportions can be useful to spread the text for annotations or proofreader’s marks. By default, GNU `troff` uses 10 point type on 12 point spacing. Typographers call the difference between type size and vertical spacing *leading*.¹¹³ Both properties are associated with the environment; see Section 5.32 [Environments], page 216)

5.20.1 Changing the Type Size

<code>.ps</code> <i>[size]</i>	[Request]
<code>.ps +size</code>	[Request]
<code>.ps -size</code>	[Request]
<code>\n[.s]</code>	[Register]

Set (increase, decrease) the type size to (by) *size* points. `ps` with no argument restores the previous size. The `ps` request’s default scaling unit is ‘z’; recall Section 5.3 [Measurements], page 76, and see Section 5.20.3

¹¹² In text fonts, parentheses are often the tallest glyphs, but a font’s glyphs may not match the nominal type size! In the standard PostScript font families, 10-point Times sets better with 9-point Helvetica and 11-point Courier than if all were used at 10 points. Recall the `fzoom` request in Section 5.19.1 [Selecting Fonts], page 135, for a remedy.

¹¹³ Rhyme with “sledding”; mechanical typography used lead metal (Latin *plumbum*).

[Using Fractional Type Sizes], page 159). The formatter rounds the requested size to the nearest valid size (with ties rounding down) within the limits supported by the device, and if the requested size is non-positive, treats it as 1 u.

Type size alteration is incorrectly documented in the AT&T **troff** manual, which claims “if [the requested size] is invalid, the next larger valid size will result, with a maximum of 36”.¹¹⁴

The read-only string-valued register `.s` interpolates the type size in points as a decimal fraction. To obtain the type size in scaled points, interpolate the `.ps` register instead (see Section 5.20.3 [Using Fractional Type Sizes], page 159).

`\ssize` [Escape sequence]
The `\s` escape sequence also determines the type size, but handles a zero argument differently. It supports a variety of syntax forms.

`\sn` Set the type size to *n* typographical points. *n* must be a single digit.¹¹⁵ If *n* is ‘0’, restore the previous size.

`\s+n`

`\s-n` Increase or decrease the type size by *n* typographical points. *n* must be exactly one digit.

`\s(nn` Set the type size to *nn* typographical points. *nn* must be exactly two digits. If *n* is ‘00’, restore the previous size.

`\s+(nn`

`\s-(nn`

`\s(+nn`

`\s(-nn` Alter the type size in scaled points by the *nn* typographical points. *nn* must be exactly two digits.

See Section 5.20.3 [Using Fractional Type Sizes], page 159, for further syntactical forms of the `\s` escape sequence that additionally accept decimal fractions.

`snap, snap,`

`.ps +2`

`grin, grin,`

`.ps +2`

`wink, wink, \s+2nudge, nudge, \s+8 say no more!`

`.ps 10`

The formatter does not tokenize `\s` when reading its input; it instead updates the environment. It thus can be used in requests that expect a

¹¹⁴ The claim appears to have been true of Ossanna **troff** for the C/A/T device; Kernighan made device-independent **troff** more flexible.

¹¹⁵ In compatibility mode only, a non-zero *n* must be in the range 4–39. See Section 5.39.2 [Compatibility Mode], page 238.

single-character argument. We might alter the type size when writing a margin character as follows (see Section 5.36 [Miscellaneous], page 228).

```
.mc \s[20]x\s[0]
```

```
.sizes s1 s2 ... sn [0] [Request]
```

The **DESC** file specifies which type sizes are allowed by the output device; see Section 6.1.1 [DESC File Format], page 247. Use the **sizes** request to change this set of permissible sizes. Arguments are in scaled points; see Section 5.20.3 [Using Fractional Type Sizes], page 159. Each can be a single type size (such as ‘12000’), or a range of sizes (such as ‘4000–72000’). You can optionally end the list with a ‘0’.

5.20.2 Changing the Vertical Spacing

```
.vs [space] [Request]
```

```
.vs +space [Request]
```

```
.vs -space [Request]
```

```
\n[.v] [Register]
```

Set the vertical spacing to, or alter it by, *space*. The default scaling unit is ‘p’. If **vs** is invoked without an argument, the vertical spacing is reset to the previous value before the last call to **vs**. GNU **troff** emits a warning in category ‘**range**’ if *space* is negative; the vertical spacing is then set to the smallest possible positive value, the vertical motion quantum (as found in the **.V** register).

‘**.vs 0**’ isn’t saved in a diversion since it doesn’t result in a vertical motion. You must explicitly issue this request before interpolating the diversion.

The read-only register **.v** contains the vertical spacing.

When a break occurs, GNU **troff** performs the following procedure.

- Move the drawing position vertically by the *extra pre-vertical line space*, the minimum of all negative **\x** escape sequence arguments in the pending output line.
- Move the drawing position vertically by the vertical line spacing.
- Write out the pending output line.
- Move the drawing position vertically by the *extra post-vertical line space*, the maximum of all positive **\x** escape sequence arguments in the line that has just been output.
- Move the drawing position vertically by the *post-vertical line spacing* (see below).

Prefer **vs** or **pvs** over **ls** to produce double-spaced documents. **vs** and **pvs** have finer granularity than **ls**; moreover, some preprocessors assume single spacing. See Section 5.11 [Manipulating Spacing], page 116, regarding the **\x** escape sequence and the **ls** request.

<code>.pvs [<i>space</i>]</code>	[Request]
<code>.pvs +<i>space</i></code>	[Request]
<code>.pvs -<i>space</i></code>	[Request]
<code>\n[.pvs]</code>	[Register]

Set the post-vertical spacing to, or alter it by, *space*. The default scaling unit is ‘p’. If **pvs** is invoked without an argument, the post-vertical spacing is reset to the previous value before the last call to **pvs**. GNU **troff** emits a warning in category ‘**range**’ if *space* is negative; the post-vertical spacing is then set to zero.

The read-only register `.pvs` interpolates the post-vertical spacing.

5.20.3 Using Fractional Type Sizes

When configuring the type size, AT&T **troff** ignored scaling units and interpreted all measurements in points. Combined with integer arithmetic, this design choice made it impossible to support, for instance, ten-and-a-half-point type. In GNU **troff**, an output device can select a scaling factor that subdivides a point into “scaled points”. A type size expressed in scaled points can thus represent a non-integral size in points.

A *scaled point*, scaling unit **s**, is equal to $1/\text{sizescale}$ points, where the device description file, DESC, specifies *sizescale* and otherwise defaults to 1.¹¹⁶ GNU **troff** also defines the *typographical point*, scaling unit **z**, which explicitly specifies a type size of potentially non-integral measure. The program multiplies typographical points by *sizescale* and converts the value to an integer. Arguments GNU **troff** interprets in **z** units by default comprise those to the escape sequences `\H` and `\s`, to the request **ps**, the third argument to the **cs** request, and the second and fourth arguments to the **tkf** request.

For example, if *sizescale* is 1000, then a scaled point is one thousandth of a point. The request ‘`.ps 10.5`’ is synonymous with ‘`.ps 10.5z`’; both set the type size to 10,500 scaled points, or 10.5 typographical points.

<code>\n[.ps]</code>	[Register]
This read-only register interpolates the type size in scaled points. ‘ <code>\n[.ps]s</code> ’, ‘ <code>\n[.s]z</code> ’, and ‘ <code>1m</code> ’ are co-equal by definition.	

¹¹⁶ See Section 6.1 [Device and Font Description Files], page 247.

```
.tm device=*[.T]
.tm A: .s=\n[.s]z, .ps=\n[.ps]s
.ps 10.5
.tm B: .s=\n[.s]z, .ps=\n[.ps]s
.ps 12.3p
.tm C: .s=\n[.s]z, .ps=\n[.ps]s
.ps 8.1z
.tm D: .s=\n[.s]z, .ps=\n[.ps]s
.ps 10500s
.tm E: .s=\n[.s]z, .ps=\n[.ps]s
    ⇒ device=ps
    ⇒ A: .s=10z, .ps=10000s
    ⇒ B: .s=10.5z, .ps=10500s
    ⇒ C: .s=12.3z, .ps=12300s
    ⇒ D: .s=8.1z, .ps=8100s
    ⇒ E: .s=10.5z, .ps=10500s
```

It makes no sense to use the ‘z’ scaling unit in a numeric expression whose default scaling unit is neither ‘u’ nor ‘z’, so GNU **troff** disallows this. Similarly, it is nonsensical to use scaling units other than ‘p’, ‘s’, ‘z’, or ‘u’ in a numeric expression whose default scaling unit is ‘z’, and so GNU **troff** disallows those as well.

<code>\n[.psr]</code>	[Register]
<code>\n[.sr]</code>	[Register]

Output devices may be limited in the type sizes they can employ. The `.s` and `.ps` registers represent the type size selected by the formatter as it understands a device’s capability. The last *requested* type size is interpolated in scaled points by the read-only register `.psr` and in points as a decimal fraction by the read-only string-valued register `.sr`.

For example, if a document requests a type size of 10.95 points, and the nearest size permitted by a `sizes` request (or by the `sizes` or `sizescale` directives in the device’s DESC file) is 11 points, **groff** uses the latter value.

The `\s` escape sequence offers the following syntax forms that work with fractional type sizes and accept scaling units. The delimited forms need not use the neutral apostrophe; see Section 5.6.5 [Delimiters], page 91.

<code>\s[n]</code>	
<code>\s'n'</code>	Set the type size to <i>n</i> typographical points; <i>n</i> is a numeric expression with a default scaling unit of ‘z’.

<code>\s[+n]</code>	
<code>\s[-n]</code>	
<code>\s+[n]</code>	
<code>\s-[n]</code>	
<code>\s'+n'</code>	
<code>\s'-n'</code>	
<code>\s+'n'</code>	
<code>\s-'n'</code>	Increase or decrease the type size by n typographical points; n is a numeric expression with a default scaling unit of ‘z’. If n is ‘0’, restore the previous size.

5.21 Colors

GNU `troff` supports color output with a variety of color spaces and up to 16 bits per channel. Some devices, particularly terminals, may be more limited. When color support is enabled, two colors are current at any given time: the *stroke color*, with which glyphs, rules (lines), and geometric objects like circles and polygons are drawn, and the *fill color*, which can be used to paint the interior of a closed geometric figure.

<code>.color [b]</code>	[Request]
<code>\n[.color]</code>	[Register]

Enable or disable output of color-related device-independent output commands per Boolean expression b . It is enabled by default, and if b is omitted.

The read-only register `.color` interpolates 1 if color support is enabled, 0 otherwise.

Color can also be disabled with the `-c` command-line option.

<code>.defcolor <i>ident scheme color-component</i> . . .</code>	[Request]
--	-----------

Define a color named *ident*. *scheme* selects a color space and determines the quantity of required *color-components*; it must be one of ‘**rgb**’ (three components), ‘**cmy**’ (three), ‘**cmyk**’ (four), or ‘**gray**’ (one). ‘**grey**’ is accepted as a synonym of ‘**gray**’. The color components can be encoded as a single hexadecimal value starting with ‘#’ or ‘##’. The former indicates that each component is in the range 0–255 (0–FF), the latter the range 0–65,535 (0–FFFF).

```
.defcolor half gray #7f
.defcolor pink rgb #FFC0CB
.defcolor magenta rgb ##ffff0000ffff
```

Alternatively, each color component can be specified as a decimal fraction in the range 0–1, interpreted using a default scaling unit of **f**, which multiplies its value by 65,536 (but clamps it at 65,535).

```
.defcolor gray50 rgb 0.5 0.5 0.5
.defcolor darkgreen rgb 0.1f 0.5f 0.2f
```

You can obtain a report of colors defined by **defcolor** on the standard error stream with the **pcolor** request. See Section 5.38 [Debugging], page 231.

Each output device has a color named ‘**default**’, which cannot be redefined. A device’s default stroke and fill colors are not necessarily the same. For the **dvi**, **html**, **pdf**, **ps**, and **xhtml** output devices, GNU **troff** automatically loads a macro file defining many color names at startup. By the same mechanism, the devices supported by **gro**ttty recognize the eight standard ISO 6429/ECMA-48 color names.¹¹⁷

.gcolor [<i>col</i>]	[Request]
\mc	[Escape sequence]
\m(<i>co</i>	[Escape sequence]
\m[<i>col</i>]	[Escape sequence]
\n[.m]	[Register]

Select *col* as the stroke color for glyphs, rules, and objects drawn with **\D'...'** escape sequences. The escape sequence **\M[]** restores the previous stroke color, or the default if there is none, as does a **gcolor** request without an argument.

```
.gcolor red
The next words
.gcolor
\m[red]are in red\m[]
and these words are in the previous color.
```

The current environment’s stroke color selection is available in the read-only string-valued register ‘.m’ (see Section 5.32 [Environments], page 216). The default strike color is named ‘**default**’.

GNU **troff** does not tokenize **\m** when reading it; the escape sequence updates the environment. It thus can be used in requests that expect a single-character argument. We can assign a stroke color to a margin character as follows (see Section 5.36 [Miscellaneous], page 228).

```
.mc \m[red]x\m[]
```

.fcolor [<i>col</i>]	[Request]
\Mc	[Escape sequence]
\M(<i>co</i>	[Escape sequence]
\M[<i>col</i>]	[Escape sequence]
\n[.M]	[Register]

Select *col* as the fill color for objects drawn with **\D'...'** escape sequences. The escape sequence **\M[]** restores the previous fill color, or the default if there is none, as does an **fcolor** request without an argument.

GNU **troff** does not tokenize **\F** when reading it; the escape sequence updates the environment. It thus can be used in requests that expect a

¹¹⁷ These are known vulgarly as “ANSI” colors, after its X3.64 standard, now withdrawn.

single-character argument. We can assign a fill color to a margin character as follows (see Section 5.36 [Miscellaneous], page 228); **grotty** interprets the fill color as a character cell background color.

```
.mc \m[black]\M[green]x\M[]\m[]
```

The current environment's fill color selection is available in the read-only string-valued register `‘.M’` (see Section 5.32 [Environments], page 216). The default fill color is named `‘default’`.

Create an ellipse with a red interior as follows.

```
\M[red]\h'0.5i'\D'E 2i 1i'\M[]
```

5.22 Strings

GNU **troff** supports strings primarily for user convenience. Conventionally, if one would define a macro only to interpolate a small amount of text, without invoking requests or calling any other macros, one defines a string instead. Only one string is predefined by the language.

`\*[.T]` [String]
Contains the name of the output device (for example, `‘utf8’` or `‘pdf’`).

The `ds` request creates a string with a specified name and contents and the `\*` escape sequence dereferences its name, interpolating its contents. If the string named by the `\*` escape sequence does not exist, it is defined as empty, nothing is interpolated, and a warning in category `‘mac’` is emitted. See Section 5.38.1 [Warnings], page 236, regarding the enablement and suppression of warnings.

<code>.ds name [["]contents]</code>	[Request]
<code>.ds1 name [["]contents]</code>	[Request]
<code>*n</code>	[Escape sequence]
<code>*(nm</code>	[Escape sequence]
<code>*[name [arg1 arg2 . . .]]</code>	[Escape sequence]

Define a string called *name* with contents *contents*. If *name* already exists as an alias, the target of the alias is redefined; see `als` and `rm` below. If `ds` is invoked with only one argument, *name* is defined as an empty string. Otherwise, GNU **troff** stores *contents* in copy mode. `\*` is itself interpreted even in copy mode.¹¹⁸

The `\*` escape sequence interpolates a previously defined string *name* (one-character name *n*, two-character name *nm*). The bracketed interpolation form accepts arguments that are handled as macro arguments are; recall Section 5.6.3 [Calling Macros], page 87. In contrast to macro calls, however, if a closing bracket `‘]’` occurs in a string argument, that argument must be enclosed in double quotes. When defining strings, argument interpolations must be escaped if they are to reference parameters from the calling context; see Section 5.24.1 [Parameters], page 178.

¹¹⁸ See Section 5.24.2 [Copy Mode], page 180.

```
.ds cite (\\$1, \\$2)
```

Gray codes are explored in *[cite Morgan 1998].

⇒ Gray codes are explored in (Morgan, 1998).

Caution: After the formatter has read the space character that ends the first argument, it treats the remainder of the input line as the second argument, including any spaces, up to a newline or comment escape sequence. Ending string definitions (and appendments) with a comment, even an empty one, prevents unwanted space from creeping into them during source document maintenance.

```
.ds Si silicon \" use chemical symbol
```

We observed a *[Si]-based life form.

⇒ We observed a silicon-based life form.

Instead, place the comment on another line or put the comment escape sequence immediately adjacent to the last character of the string.

```
.ds Si silicon\" use chemical symbol
```

We observed a *[Si]-based life form.

⇒ We observed a silicon-based life form.

Because the first space after the string name separates the arguments, you can retain it while using a comment to document an empty string.

```
.ds author Alice Pleasance Liddell\"
```

```
.ds friends \" empty; append to with .as
```

The formatter removes a leading neutral double quote “” from *contents*, permitting initial embedded spaces in it. It interprets any other “” literally, but the wise author uses the special character escape sequence `\[dq]` instead if the string might be interpolated as part of a macro argument; recall Section 5.6.3 [Calling Macros], page 87.

```
.ds salutation "           Yours in a white wine sauce,\"
```

```
.ds c-var-defn "   char mydate[]=\[dq]2020-07-29\[dq];\"
```

Strings are not limited to a single input line of text. `\RET` works just as it does elsewhere. The resulting string is stored *without* the newlines. When filling is disabled, care is required to avoid overrunning the line length when interpolating strings.

```
.ds foo This string contains \
```

```
text on multiple lines \
```

```
of input.
```

Conversely, when filling is enabled, it is not necessary to append `\c` to a string interpolation to prevent a break afterward, as might be required in a macro argument. Nor does a string require use of the GNU **troff** **chop** request to excise a trailing newline as is often done with diversions. It is not possible to embed a newline in a string that will be interpreted as such when the string is interpolated. To achieve that effect, use `\*` to interpolate a macro instead; see Section 5.31 [Punning Names], page 214. Because strings are similar to macros, they too can be defined so as to suppress AT&T **troff** compatibility mode when used; see Section 5.24

[Writing Macros], page 175, and Section 5.39.2 [Compatibility Mode], page 238. The `ds1` request defines a string such that compatibility mode is off when the string is later interpolated. To be more precise, GNU `troff` inserts a *compatibility save* token at the beginning of *contents*, and a *compatibility restore* token at the end.

```
.nr xxx 12345
.ds aa The value of xxx is \n[xxx].
.ds1 bb The value of xxx is \n[xxx].
.
.cp 1
.
\*(aa
    [error] warning: register '[' not defined
    ⇒ The value of xxx is 0xxx].
\*(bb
    ⇒ The value of xxx is 12345.
```

```
.as name [["]contents] [Request]
.as1 name [["]contents] [Request]
```

The `as` request is similar to `ds` but appends *contents* to the string stored as *name* instead of redefining it. If *name* doesn't exist yet, it is created. If `as` is invoked with only one argument, no operation is performed (beyond dereferencing the string).

```
.as salutation " with shallots, onions and garlic,\"
```

Caution: The formatter reads the second argument to the end of the line in copy mode, omitting any leading neutral double quote “” character. See the discussion of the `ds` request above.

The `as1` request works as does `as`, but like `ds1`, it brackets *contents* with *compatibility save* and *restore* tokens.

Several requests exist to perform rudimentary string operations. Strings can be queried (`length`) and modified (`chop`, `substring`, `stringup`, `stringdown`), and their names can be manipulated through renaming, removal, and aliasing (`rn`, `rm`, `als`).

```
.length reg [["]contents] [Request]
```

Compute the number of characters in *contents* and store the count in the register *reg*. If *reg* doesn't exist, GNU `troff` creates it.

GNU `troff` removes a leading neutral double quote “” from *contents*, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. See Section 5.24.2 [Copy Mode], page 180.

```
.ds xxx abcd\h'3i'efgh
.length yyy \*[xxx]
\n[yyy]
⇒ 14
```

Caution: The formatter reads the second argument to the end of the line in copy mode, omitting any leading neutral double quote “” character. See the discussion of the `ds` request above.

Caution: If you interpolate a macro or diversion in *contents* (see Section 5.31 [Punning Names], page 214), the `length` request counts characters (or nodes) only up to the first newline, and leaves the rest on the input stream. In conventional circumstances, that means the remainder is interpreted, and may be formatted. To discover the length of any string, macro, or diversion, use the `pm` request. See Section 5.38 [Debugging], page 231.

.chop *object* [Request]

Remove the last character from the macro, string, or diversion named *object*. This is useful for removing the newline from the end of a diversion that is to be interpolated as a string. This request can be used repeatedly on the same *object*; see Section 5.37 [GNU troff Internals], page 228, for details on nodes inserted additionally by GNU troff.

.substring *str start [end]* [Request]

Replace the string named *str* with its substring bounded by the indices *start* and *end*, inclusively. The first character in the string has index 0. If *end* is omitted, it is implicitly set to the largest valid value (the string length minus one). Negative indices count backward from the end of the string: the last character has index -1 , the character before the last has index -2 , and so on.

```
.ds xxx abcdefgh
.substring xxx 1 -4
\[xxx]
⇒ bcde
.substring xxx 2
\[xxx]
⇒ de
```

.stringdown *str* [Request]

.stringup *str* [Request]

Alter the string named *str* by replacing each of its bytes with its lowercase (`stringdown`) or uppercase (`stringup`) version (if one exists). Special characters in the string will often transform in the expected way due to the regular naming convention for accented characters. When they do not, use substrings and/or catenation.

```
.ds resume R\[ 'e]sum\[ 'e]\[ "
\[resume]
.stringdown resume
\[resume]
.stringup resume
\[resume]
⇒ Résumé résumé RÉSUMÉ
```

.rn *old new* [Request]
 Rename the request, macro, diversion, or string *old* to *new*.

.rm *name* ... [Request]
 Remove each request, macro, diversion, or string *name*. GNU **troff** treats subsequent invocations as if the name had never been defined.
 This request is incorrectly documented in the AT&T **troff** manual as accepting only one argument.

.als *new-name existing-name* [Request]
 Create alias (additional name) *new-name* of request, string, macro, or diversion *existing-name*, causing the names to refer to the same stored object. If *existing-name* is undefined, the formatter ignores the request.¹¹⁹ If *new-name* already exists, its contents are lost unless already aliased.

To understand how the **als** request works, consider two different storage pools: one for objects (macros, strings, etc.), and another for names. As soon as an object is defined, GNU **troff** adds it to the object pool, adds its name to the name pool, and creates a link between them. When **als** creates an alias, it adds a new name to the name pool that gets linked to the same object as the old name.

Now consider this example.

```
.de foo
..
.
.als bar foo
.
.de bar
.  foo
..
.
.bar
      [error] input stack limit exceeded (probable infinite
      [error] loop)
```

In the above, **bar** remains an *alias*—another name for—the object referred to by **foo**, which the second **de** request replaces. Alternatively, imagine that the **de** request *dereferences* its argument before replacing it. Either way, the result of calling **bar** is a recursive loop that finally leads to an error. See Section 5.24 [Writing Macros], page 175.

To remove an alias, call **rm** on its name. The object itself is not destroyed until it has no more names.

When a request, macro, string, or diversion is aliased redefinitions and appendments “write through” alias names. To replace an alias with a separately defined object, remove its name first.

¹¹⁹ GNU **troff** emits a warning in category ‘**mac**’. See Section 5.38.1 [Warnings], page 236.

5.23 Conditionals and Loops

groff has **if** and **while** control structures like other languages. However, the syntax for grouping multiple input lines in the branches or bodies of these structures is unusual.

5.23.1 Operators in Conditionals

The **if**, **ie**, and **while** requests test the truth values of numeric expressions. They also support several additional Boolean operators; the members of this expanded class are termed *conditional expressions*; their truth values are as shown below.

c <i>chr</i>	True if a character <i>chr</i> is available; <i>chr</i> is an ordinary, special or indexed character, whether defined by a font description file or a request.
d <i>name</i>	True if a string, macro, diversion, or request called <i>name</i> exists.
e	True if the current page is even-numbered.
F <i>font</i>	True if <i>font</i> exists. <i>font</i> is handled as if it were an argument to the ft request (that is, the default family is combined with an abstract style and font translation is applied), but <i>font</i> cannot be a mounting position, and no font is mounted.
m <i>color</i>	True if <i>color</i> is defined.
n	True if the document is being processed in nroff mode.
o	True if the current page is odd-numbered.
r <i>register</i>	True if <i>register</i> exists.
S <i>style</i>	True if <i>style</i> is available for the current font family. Font translation is applied.
t	True if the document is being processed in troff mode.
v	Always false. This condition exists for compatibility with certain other troff implementations. ¹²⁰

If the first argument to an **if**, **ie**, or **while** request begins with a non-alphanumeric character apart from **!** (see below) and is not a numeric expression, the formatter performs an *output comparison test*.¹²¹

¹²⁰ We refer to **vtroff**, which converted the C/A/T command stream produced by early-vintage AT&T **troff** to input suitable for Versatec and Benson-Varian plotters.

¹²¹ Strictly, letters not otherwise recognized *are* treated as output comparison delimiters. A portable document avoids using letters not in the list above; for example, Plan 9 **troff** uses **'h'** to test a mode it calls **htmlroff**, and GNU **troff** may provide additional operators in the future.

'xxx'yyy'

This *output comparison operator* interpolates a true value if formatting the comparands xxx and yyy produces the same output commands. The delimiter need not be a neutral apostrophe: the output comparison operator accepts the same delimiters as most escape sequences; see Section 5.6.5 [Delimiters], page 91. **troff** formats xxx and yyy in separate scratch buffers; after comparison, it discards the resulting data.

```
.ie "|"\"fR|\"fP" true
.el false
⇒ true
```

The resulting glyph properties, including font family, style, size, and slant, must match, but not necessarily the requests and/or escape sequences used to obtain them. In the previous example, 'l' and 'fR|fP' result in 'l' glyphs in the same typefaces at the same positions, so the comparands are equal. If '.ft I' had been added before the '.ie', they would differ: the first 'l' would produce an italic 'l', not a roman one. Motions must match in orientation and magnitude to within the applicable horizontal and vertical motion quanta of the device, after rounding. '.if "\u\d"\v'0'" is false even though both comparands result in zero net motion, because motions are not interpreted or optimized but sent as-is to the output.¹²² On the other hand, '.if "\d"\v'0.5m'" is true, because \d is defined as a downward motion of one-half em.¹²³

Surround the comparands with \? to avoid formatting them; this causes them to be compared character by character, as with string comparisons in other programming languages.

```
.ie "\?|\"?\?\"fR|\"fP\"?" true
.el false
⇒ false
```

Since GNU **troff** reads comparands protected with \? in copy mode,¹²⁴ they need not even be syntactically valid. The escape character is still lexically recognized, however, and consumes the next character.

¹²² Because formatting of the comparands takes place in a dummy environment, vertical motions within them cannot spring traps. See Section 5.29 [Traps], page 197.

¹²³ All of this is to say that the lists of nodes created by formatting xxx and yyy must be identical. See Section 5.37 [GNU **troff** Internals], page 228.

¹²⁴ See Section 5.24.2 [Copy Mode], page 180.

```
.ds a \[
.ds b \[
.if '\?\'*a\?'\'?\'*b\?' a and b equivalent
.if '\?\'\'?\'\'?\'\'?\'\'?' backslashes equivalent
.if '\?\'P\?'\'?\'P\?' backslash-P and P equivalent
⇒ a and b equivalent
```

The above operators can't be combined with most others, but a leading '!', not followed immediately by spaces or tabs, complements an expression.

```
.nr x 1
.ie !r x register x is not defined
.el      register x is defined
⇒ register x is defined
```

Spaces and tabs are optional immediately after the 'c', 'd', 'F', 'm', 'r', and 'S' operators, but right after '!', they end the predicate and the conditional evaluates true.¹²⁵

```
.nr x 1
.ie ! r x register x is not defined
.el      register x is defined
⇒ r x register x is not defined
```

The unexpected 'r x' in the output is a clue that our conditional was not interpreted as we planned, but matters may not always be so obvious.

Conditional operators do not create **roff** language objects as interpolations with \n and * escape sequences do.

5.23.2 if-then

.if *cond-expr input* [Request]

Evaluate the conditional expression *cond-expr*, and if it evaluates true (or to a positive value), interpret the remainder of the line *input* as if it were an input line. Recall from Section 5.6.2 [Invoking Requests], page 86, that any quantity of spaces between arguments to requests serves only to separate them; leading spaces in *input* are thus not seen. *input* effectively *cannot* be omitted; if *cond-expr* is true and *input* is empty, the formatter interprets the newline at the end of the control line as a blank input line (and therefore a blank text line).

```
super\c
tanker
.nr force-word-break 1
super\c
.if ((\n[force-word-break] = 1) & \n[.int])
tanker
⇒ supertanker super tanker
```

¹²⁵ This bizarre behavior maintains compatibility with AT&T **troff**.

`.nop` [*input*] [Request]

Interpret *input* as if it were an input line. `nop` resembles `.if 1`; it puts a break on the output if *input* is empty. Unlike `if`, it cannot govern conditional blocks. Its application is to maintain consistent indentation within macro definitions even when formatting output.

```
.als real-MAC MAC
.de wrapped-MAC
.  tm MAC: called with arguments \\$@
.  nop \\*[real-MAC]\\
..
.als MAC wrapped-MAC
\\# Later...
.als MAC real-MAC
```

In the above, we've used aliasing, `nop`, and the interpolation of a macro as a string to interpose a wrapper around the macro `'MAC'` (perhaps to debug it).

5.23.3 if-else

`.ie` *cond-expr* *input* [Request]

`.el` *input* [Request]

Use the `ie` and `el` requests to write an if-then-else. The first request is the “if” part and the latter is the “else” part. Unusually among programming languages, any number of non-conditional requests may be interposed between the `ie` branch and the `el` branch.

```
.nr a 0
.ie \na a is non-zero.
.nr a +1
.el a was not positive but is now \na.
    ⇒ a was not positive but is now 1.
```

Another way in which `el` is an ordinary request is that it does not lexically “bind” more tightly to its `ie` counterpart than it does to any other request. This fact can surprise C programmers.

```
.nr a 1
.nr z 0
.ie \nz \
.  ie \na a is true
.  el    a is false
.el z is false
    ⇒ a is false
```

To conveniently nest conditionals, keep reading.

5.23.4 Conditional Blocks

It is frequently desirable for a control structure to govern more than one request, macro call, text line, or combination of the foregoing. The opening

and closing brace escape sequences `\{` and `\}` define such groups. These *conditional blocks* can furthermore be nested.

<code>\{</code>	[Escape sequence]
<code>\}</code>	[Escape sequence]

`\{` begins a conditional block; it must appear (after optional spaces and tabs) immediately subsequent to the conditional expression of an `if`, `ie`, or `while` request,¹²⁶ or as the argument to an `el` request.

`\}` ends a conditional block and should appear on a line with other occurrences of itself as necessary to match `\{` sequences. It can be preceded by a control character, spaces, and tabs. Input after any quantity of `\}` sequences on the same line is processed only if all of the preceding conditions to which they correspond are true. Furthermore, a `\}` closing the body of a `while` request must be the last such escape sequence on an input line.

Brace escape sequences outside of control structures have no meaning and produce no output.

Caution: Input lines using `\{` often end with `\RET`, especially in macros that consist primarily of control lines. Forgetting to use `\RET` on an input line after `\{` is a common source of error.

We might write the following in a page header macro. If we delete `\RET`, the header will carry an unwanted extra empty line (except on page 1).

```
.if (\n[%] != 1) \{\
.  ie ((\n[%] % 2) = 0) .tl \*[even-numbered-page-title]
.  el                  .tl \*[odd-numbered-page-title]
.\}
```

Let us take a closer look at how conditional blocks nest.

```
A
.if 0 \{ B
C
D
\}E
F
    ⇒ A F

N
.if 1 \{ 0
.  if 0 \{ P
Q
R\} S\} T
U
    ⇒ N 0 U
```

The above behavior may challenge the intuition; it was implemented to retain compatibility with AT&T `troff`. For clarity, it is idiomatic to end

¹²⁶ See Section 5.23.5 [while], page 173.

input lines with `\{` (followed by `\RET` if appropriate), and to precede `\}` on an input line with nothing more than a control character, spaces, tabs, and other instances of itself.

We can use `ie`, `el`, and conditional blocks to simulate the multi-way “switch” or “case” control structures of other languages. The following example is adapted from the **groff** `man` package. Indentation is used to clarify the logic.

```
.\" Simulate switch/case in roff.
.      ie '\\$2'1' .ds title General Commands\"
.el \{.ie '\\$2'2' .ds title System Calls\"
.el \{.ie '\\$2'3' .ds title Library Functions\"
.el \{.ie '\\$2'4' .ds title Kernel Interfaces\"
.el \{.ie '\\$2'5' .ds title File Formats\"
.el \{.ie '\\$2'6' .ds title Games\"
.el \{.ie '\\$2'7' .ds title Miscellaneous Information\"
.el \{.ie '\\$2'8' .ds title System Management\"
.el \{.ie '\\$2'9' .ds title Kernel Development\"
.el              .ds title \" empty
.\}\}\}\}\}\}\}\}\}
```

5.23.5 while

GNU **troff** provides a looping construct: the **while** request. Its syntax matches the **if** request.

.while *cond-expr input* [Request]

Evaluate the conditional expression *cond-expr*, and repeatedly execute *input* unless and until *cond-expr* evaluates false. *input*, which is often a conditional block, is referred to as the **while** request’s *body*.

```
.nr a 0 1
.while (\na < 9) \{\
\n+a,
.\}
\n+a
⇒ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
```

GNU **troff** treats the body of a **while** request similarly to that of a **de** request (albeit one not read in copy mode¹²⁷), but stores it under an internal name and deletes it when the loop finishes. The operation of a macro containing a **while** request can slow significantly if its body is large. Each time GNU **troff** interpolates the macro, it parses and stores the **while** body again.

¹²⁷ See Section 5.24.2 [Copy Mode], page 180.

```
.de xxx
.  nr num 10
.  while (\n[num] > 0) \{\
.    \" many lines of code
.    nr num -1
.  \}
..
```

An often better solution—and one that is more portable, since AT&T **troff** lacked the **while** request—is to instead write a recursive macro, which is parsed only once.¹²⁸

```
.de yy
.  if (\n[nm] > 0) \{\
.    \" many lines of code
.    nr nm -1
.    yy
.  \}
..
.
.de xx
.  nr nm 10
.  yy
..
```

To prevent infinite loops, GNU **troff** limits the default number of available recursion levels to 1,000 or somewhat less.¹²⁹ You can disable this protective measure, or alter the limit, by setting the **slimit** register. See Section 5.38 [Debugging], page 231.

As noted above, if a **while** body begins with a conditional block, its closing brace must end an input line.

```
.if 1 \{\
.  nr a 0 1
.  while (\n[a] < 10) \{\
.    nop \n+[a]
.\}\}
```

error unbalanced brace escape sequences

.break [Request]

Exit a **while** loop. Do not confuse this request with a typographical break or the **br** request.

.continue [Request]

Skip the remainder of a **while** loop's body, immediately retesting its conditional expression.

¹²⁸ unless you redefine it

¹²⁹ “somewhat less” because things other than macro calls can be on the input stack

5.24 Writing Macros

A *macro* is a stored collection of text and control lines that can be interpolated multiple times. Use macros to define common operations. Macros are called in the same way that requests are invoked. While requests exist for the purpose of creating macros, simply calling an undefined macro, or interpolating it as a string, will cause it to be defined as empty. See Section 5.5 [Identifiers], page 82.

`.de name [end]` [Request]
 Define a macro *name*, replacing the definition of any existing request, macro, string, or diversion called *name*. If *name* already exists as an alias, the target of the alias is redefined; recall Section 5.22 [Strings], page 163. GNU `troff` enters copy mode,¹³⁰ storing subsequent input lines as the macro definition. If the optional second argument is not specified, the definition ends with the control line `..` (two dots). Alternatively, *end* identifies a macro whose call syntax at the start of a control line ends the definition of *name*; *end* is then called normally. A macro definition must end in the same conditional block (if any) in which it began (recall see Section 5.23.4 [Conditional Blocks], page 171). Spaces or tabs are permitted after the control character in the line containing this ending token (either `.` or `end`), but a tab immediately after the token prevents its recognition as the end of a macro definition. The macro *end* can be called with arguments.¹³¹

Here is a small example macro called `'P'` that causes a break and inserts some vertical space. It could be used to separate paragraphs.

```
.de P
.  br
.  sp .8v
..
```

We can define one macro within another. Attempting to nest `..` naïvely will end the outer definition because the inner definition isn't interpreted as such until the outer macro is later interpolated. We can use an end macro instead. Each level of nesting should use a unique end macro.

An end macro need not be defined until it is called. This fact enables a nested macro definition to begin inside one macro and end inside another. Consider the following example.¹³²

¹³⁰ See Section 5.24.2 [Copy Mode], page 180.

¹³¹ While it is possible to define and call a macro `..`, you can't use it as an end macro: during a macro definition, `..` is never handled as calling `..`, even if `.de name ..` explicitly precedes it.

¹³² Its structure is adapted from, and isomorphic to, part of a solution by Tadeusz Hoffman to the problem of reflowing text multiple times to find an optimal configuration for it. <https://lists.gnu.org/archive/html/groff/2008-12/msg00006.html>

```

.de m1
.  de m2 m3
you
..
.de m3
Hello,
Joe.
..
.de m4
do
..
.m1
know?
.  m3
What
.m4
.m2
⇒ Hello, Joe.  What do you know?

```

A nested macro definition *can* be terminated with ‘.’ and nested macros *can* reuse end macros, but these control lines must be escaped multiple times for each level of nesting. The necessity of this escaping and the utility of nested macro definitions will become clearer when we employ macro parameters and consider the behavior of copy mode in detail.

de defines a macro that inherits the compatibility mode enablement status of its context (see Section 5.39 [Implementation Differences], page 238). Often it is desirable to make a macro that uses **groff** features callable from contexts where compatibility mode is on; for instance, when writing extensions to a historical macro package. To achieve this, compatibility mode needs to be switched off while such a macro is interpreted—without disturbing that state when it is finished.

.de1 *name* [*end*] [Request]

The **de1** request defines a macro to be interpreted with compatibility mode disabled. When *name* is called, compatibility mode enablement status is saved; it is restored when the call completes. Observe the extra backlash before the interpolation of register ‘xxx’; we’ll explore this subject in Section 5.24.2 [Copy Mode], page 180.

```
.nr xxx 12345
.de aa
The value of xxx is \n[xxx].
. br
..
.de1 bb
The value of xxx is \n[xxx].
..
.cp 1
.aa
[error] warning: register '[' not defined
⇒ The value of xxx is 0xxx].
.bb
⇒ The value of xxx is 12345.
```

```
.dei name [end] [Request]
.dei1 name [end] [Request]
```

The **dei** request defines a macro with its name and end macro indirected through strings. That is, it interpolates strings named *name* and *end* before performing the definition.

The following examples are equivalent.

```
.ds xx aa
.ds yy bb
.dei xx yy
.de aa bb
```

The **dei1** request bears the same relationship to **dei** as **de1** does to **de**; it temporarily turns compatibility mode off when *name* is called.

```
.am name [end] [Request]
.am1 name [end] [Request]
.ami name [end] [Request]
.ami1 name [end] [Request]
```

am appends subsequent input lines to macro *name*, extending its definition, and otherwise working as **de** does.

To make the previously defined ‘P’ macro set indented instead of block paragraphs, add the necessary code to the existing macro.

```
.am P
.ti +5n
..
```

The other requests are analogous to their ‘**de**’ counterparts. The **am1** request turns off compatibility mode during interpretation of the appendment. The **ami** request appends indirectly, meaning that strings *name* and *end* are interpolated with the resulting names used before appending. The **ami1** request is similar to **ami**, disabling compatibility mode during interpretation of the appended lines.

Using `trace.tmac`, you can trace calls to `de`, `de1`, `am`, and `am1`. You can also use the `backtrace` request at any point desired to troubleshoot tricky spots (see Section 5.38 [Debugging], page 231).

See Section 5.22 [Strings], page 163, for the `als`, `rm`, and `rn` requests to create an alias of, remove, and rename a macro, respectively.

Macro identifiers share their name space with requests, strings, and diversions; see Section 5.5 [Identifiers], page 82. The `am`, `as`, `da`, `de`, `di`, and `ds` requests (together with their variants) create a new object only if the name of the macro, diversion, or string is currently undefined or if it is defined as a request; normally, they modify the value of an existing object. See [the description of the `als` request], page 167, for pitfalls when redefining a macro that is aliased.

.return [*input*] [Request]

Stop interpreting an interpolated macro, skipping to the end of its definition. Do not confuse `return` with `rt`. If called with an argument *input*, GNU `troff` performs the skip twice—once within the macro being interpreted and once in an enclosing macro, permitting a macro to wrap the request.¹³³

5.24.1 Parameters

Macro calls and string interpolations optionally accept a list of arguments; recall Section 5.6.3 [Calling Macros], page 87. At the time such an interpolation takes place, these *parameters* can be examined using a register and a variety of escape sequences starting with ‘`\$`’. All such escape sequences are interpreted even in copy mode, a fact we shall motivate and explain below (see Section 5.24.2 [Copy Mode], page 180).

\n[. \$] [Register]

The count of parameters available to a macro or string is kept in this read-only register. The `shift` request can change its value.

Any individual parameter can be accessed by its position in the list of arguments to the macro call, numbered from left to right starting at 1, with one of the following escape sequences.

\\$n	[Escape sequence]
\\$(nn	[Escape sequence]
\\$[nnn]	[Escape sequence]

Interpolate the *n*th, *nn*th, or *nnn*th parameter. The first form expects only a single digit ($1 \leq n \leq 9$), the second two digits ($01 \leq nn \leq 99$), and the third any positive integer *nnn*. Macros and strings accept an unlimited number of parameters. `\$` is interpreted even in copy mode.¹³⁴

¹³³ as `trace.tmac` does

¹³⁴ See Section 5.24.2 [Copy Mode], page 180.

.shift [*n*] [Request]

Shift macro or string parameters *n* places (by 1 if *n* omitted): argument *i* becomes argument *i-n*; arguments 1 to *n* become unavailable. Shifting by a non-positive amount, or outside of a macro or string definition, performs no operation. The register `.$` adjusts its value accordingly.

In practice, parameter interpolations are usually seen prefixed with an extra escape character. This is because the `\$` family of escape sequences is interpreted even in copy mode.¹³⁵

<code>\\$*</code>	[Escape sequence]
<code>\\$@</code>	[Escape sequence]
<code>\\$^</code>	[Escape sequence]

In some cases it is convenient to interpolate all of the parameters at once (to pass them to a request, for instance). The `\$*` escape catenates the parameters, separating them with spaces. `\$@` is similar, surrounding each parameter with double quotes and separating them with spaces. If not in compatibility mode, the interpolation depth of double quotes is preserved (see Section 5.6.3 [Calling Macros], page 87). `\$^` interpolates all parameters as if they were arguments to the `ds` request.

```
.de foo
. tm $1='\\$1'
. tm $2='\\$2'
. tm $*='\\$*'
. tm $@='\\$@'
. tm $^='\\$^'
..
.foo " This is a "test"
    error $1=' This is a '
    error $2='test"'
    error $*=' This is a test"'
    error $@='" This is a " "test"'
    error $^='" This is a "test"'
```

`\$*` is useful when writing a macro that doesn't need to distinguish its arguments, or even to not interpret them; examples include macros that produce diagnostic messages by wrapping the `tm` or `ab` requests. Use `\$@` when writing a macro that may need to shift its parameters and/or wrap a macro or request that finds the count significant. If in doubt, prefer `\$@` to `\$*`. An application of `\$^` is seen in `trace.tmac`, which redefines some requests and macros for debugging purposes.

¹³⁵ If they were not, parameter interpolations would be similar to command-line parameters—fixed for the entire duration of a `roff` program's run. The advantage of interpolating `\$` escape sequences even in copy mode is that they can interpolate different contents from one call to the next, like function parameters in a procedural language. The additional escape character is the price of this power.

`\$0` [Escape sequence]

Interpolate the name by which the macro being interpreted was called. The `als` request can cause a macro to have more than one name. Applying string interpolation to a macro does not change this name.

```
.de foo
.  tm \$0
..
.als bar foo
.
.de aaa
.  foo
..
.de bbb
.  bar
..
.de ccc
\\*[foo]\\
..
.de ddd
\\*[bar]\\
..
.
.aaa
      error  foo
.bbb
      error  bar
.ccc
      error  ccc
.ddd
      error  ddd
```

5.24.2 Copy Mode

GNU `troff` processes certain requests in *copy mode*: it copies ordinary, special, and indexed characters as-is; interpolates the escape sequences `\n`, `\g`, `\$`, `\*`, `\V`, and `\?` normally; discards comments `\"` and `\#`; interpolates `\a`, `\e`, and `\t`, as the current leader, escape, or tab character, respectively; represents `\RET`, `\&`, `\_`, `\|`, `\^`, `\{`, `\}`, `\``, `\'`, `\-`, `\!`, `\c`, `\%`, `\SPC`, `\E`, `\)`, `\~`, and `\:` in an encoded form, and copies other escape sequences as-is. The term “copy mode” reflects its most visible application in requests that populate macros and strings, but other requests also use it when interpreting arguments that can’t meaningfully represent typesetting operations. For example, a font selection escape sequence has no meaning in a hyphenation pattern file name (`\hpf`) or a diagnostic message written to the terminal (`\tm`).

The complement of copy mode—a `roff` formatter’s behavior when not defining or appending to a macro, string, or diversion—where all macros are

interpolated, requests invoked, and valid escape sequences processed immediately upon recognition, can be termed *interpretation mode*.

**** [Escape sequence]

The escape character (**** by default) when used before itself *quotes* an escape character for later interpretation in an enclosing context. Escape character quotation enables you to control whether the formatter interprets a given **\n**, **\g**, **\\$**, *****, **\V**, or **\?** escape sequence at the time the macro containing it is defined, or later when the macro is called.¹³⁶

```
.nr x 20
.de y
.nr x 10
\&\nx
\&\nx
..
.y
⇒ 20 10
```

You can think of **** as a “delayed” backslash; it is the escape character followed by a backslash from which the escape character has removed its special meaning. Consequently, **** is not best considered an escape sequence, but a quoted escape character. In any escape sequence **‘\X’** that GNU **troff** does not recognize, the formatter discards the escape character and outputs **X**. An unrecognized escape sequence causes a warning in category **‘escape’**, with two exceptions—**** is the first.

\. [Escape sequence]

\. quotes the control character. It is similar to **** in that it isn’t a true escape sequence. It is used to permit nested macro definitions to end without a named macro call to conclude them. Without a syntax for quoting the control character, this would not be possible.

```
.de m1
foo
.
. de m2
bar
\\..
.
..
.m1
.m2
⇒ foo bar
```

The first backslash is consumed while the macro is read, and the second is interpreted when macro **m1** is called.

¹³⁶ Compare this to the **\def** and **\edef** commands in **T_EX**.

Outside of copy mode, **roff** documents should not use the `\\` or `\.` character sequences; they serve only to obfuscate the input. Use `\e` to represent the escape character, `\[rs]` to obtain a backslash glyph, and `\&` before `'.'` and `'\'` where GNU **troff** expects them as control characters if you mean to use them literally (recall Section 5.1.7 [Requests and Macros], page 67).

Macro definitions can be nested to arbitrary depth. The mechanics of parsing the escape character have significant consequences for this practice.

```
.de M1
\\$1
.  de M2
\\\\$1
.    de M3
\\\\\\\\$1
\\\\\\..
.      M3 hand.
\\..
.  M2 of
..
This understeer is getting
.M1 out
⇒ This understeer is getting out of hand.
```

As seen above, the formatter interprets each escape character in multiple contexts; once, when populating the macro or string, where the first `'\'` serves its quotation function^[em] thus only one `'\'` is stored in the definition. (Verify this fact with the **pm** request.) The formatter interprets the second `'\'` as an escape character (assuming the escape character hasn't been changed in the meantime) each time it interpolates the macro or string definition. This fact leads to exponential growth in the quantity of escape characters required to quote and thereby delay interpolation of `\n`, `\g`, `\$`, `\*`, `\V`, and `\?` at each nesting level, which can be daunting. GNU **troff** offers a solution.

`\E` [Escape sequence]
`\E` represents an escape character that is not interpreted in copy mode. You can use it to ease the writing of nested macro definitions.

```

.de M1
.  nop \E$1
.  de M2
.    nop \E$1
.    de M3
.      nop \E$1
\\\\\..
.    M3 better.
\\..
.  M2 bit
..
This vehicle handles
.M1 a
⇒ This vehicle handles a bit better.

```

Observe that because `\.` is not a true escape sequence, we can't use `\E` to keep `'..'` from ending a macro definition prematurely. If the multiplicity of backslashes complicates maintenance, use end macros.

`\E` is also convenient to define strings containing escape sequences that need to work when used in copy mode (for example, as macro arguments), or which will be interpolated at varying macro nesting depths. We might define strings to begin and end superscripting as follows.¹³⁷

```

.ds { \v'-.9m\s'\En[.s]*7u/10u'+.7m'
.ds } \v'-.7m\s0+.9m'

```

When the `ec` request is used to redefine the escape character, `\E` also makes it easier to distinguish the semantics of an escape character from the other meaning(s) its character might have. Consider the use of an unusual escape character, `'-'`.

```

.nr a 1
.ec -
.de xx
--na
..
.xx
⇒ -na

```

This result may surprise you; some people expect `'1'` to be output since register `'a'` has clearly been defined with that value. What has happened? The robotic replacement of `'\'` with `'-'` has led us astray. You might recognize the sequence `--` more readily with the default escape character as `'\-'`, the special character escape sequence for the minus sign glyph.

¹³⁷ These are lightly adapted from the `groff` implementation of the `ms` macros.

```
.nr a 1
.ec -
.de xx
-Ena
..
.xx
⇒ 1
```

5.25 Page Motions

See Section 5.11 [Manipulating Spacing], page 116, for a discussion of the most commonly used request for vertical motion, `sp`.

```
.mk [reg] [Request]
.rt [dist] [Request]
```

You can *mark* a location on a page for subsequent *return*. `mk` takes an argument, a register name in which to store the current page location. If given no argument, it stores the location in an internal register. This location can be used later by the `rt` or the `sp` requests (or the `\v` escape sequence).

The `rt` request returns *upward* to the location marked with the last `mk` request. If used with an argument, it returns to a vertical position *dist* from the top of the page (no previous call to `mk` is necessary in this case). The default scaling unit is ‘v’.

If a page break occurs between a `mk` request and its matching `rt` request, the `rt` request is silently ignored.

A simple implementation of a macro to set text in two columns follows. This example also defines a macro to be called when a trap is sprung;¹³⁸ this trap macro performs the motion to the next column.

¹³⁸ See Section 5.29.1.1 [Page Location Traps], page 198.

```
.nr column-length 1.5i
.nr column-gap 4m
.nr bottom-margin 1m
.
.de 2c
.  br
.  mk
.  ll \n[column-length]u
.  wh -\n[bottom-margin]u 2c-trap
.  nr right-side 0
..
.
.de 2c-trap
.  ie \n[right-side] \{\
.    nr right-side 0
.    po -(\n[column-length]u + \n[column-gap]u)
.    \" remove trap
.    wh -\n[bottom-margin]u
.  \}
.  el \{\
.    \" switch to right side
.    nr right-side 1
.    po +(\n[column-length]u + \n[column-gap]u)
.    rt
.  \}
..
```

Now let us apply our two-column macro.

```
.pl 1.5i
.ll 4i
This is a small test that shows how the
rt request works in combination with mk.

.2c
Starting here, text is typeset in two columns.
Note that this implementation isn't robust
and thus not suited for a real two-column
macro.
⇒ This is a small test that shows how the
⇒ rt request works in combination with mk.
⇒
⇒ Starting here,      isn't      robust
⇒ text is typeset    and      thus not
⇒ in two columns.    suited for a
⇒ Note that this     real two-column
⇒ implementation     macro.
```

Several escape sequences enable fine control of movement about the page.

`\v'expr'` [Escape sequence]

Vertically move the drawing position. *expr* indicates the magnitude of motion: positive is downward and negative upward. The default scaling unit is ‘v’. The motion is relative to the current drawing position unless *expr* begins with the boundary-relative measurement operator ‘|’. See Section 5.4 [Numeric Expressions], page 78.

Text processing continues at the new drawing position; usually, vertical motions should be in balanced pairs to avoid a confusing page layout.

`\v` does not spring a vertical position trap. This can be useful; for example, consider a page bottom trap macro that prints a mark in the margin to indicate continuation of a footnote. See Section 5.29 [Traps], page 197.

A few escape sequences that produce vertical motion are unusual. They are thought to originate early in AT&T **nroff** history to achieve super- and subscripting by half-line motions on line printers and teletypewriters before the phototypesetter made more precise positioning available. They are reckoned in ems—not vees—to maintain continuity with their original purpose of moving relative to the size of the type rather than the distance between text baselines (vees).¹³⁹

`\r` [Escape sequence]

`\u` [Escape sequence]

`\d` [Escape sequence]

Move upward 1 m, upward .5 m, and downward .5 m, respectively.

Let us see these escape sequences in use.

Obtain 100 cm3_d of $\text{K}^{92}\text{H}^1\text{Na}^{233}\text{D}$.

In the foregoing we have paired `\u` and `\d` to typeset a superscript, and later a full em negative (“reverse”) motion to place a superscript above a subscript. A numeral-width horizontal motion escape sequence aligns the proton and nucleon numbers, while `\k` marks a horizontal position to which `\h` returns so that we could stack them. (We shall discuss these horizontal motion escape sequences presently.) In serious applications, we often want to alter the type size of the -scripts and to fine-tune the vertical motions, as the **groff ms** package does with its super- and subscripting string definitions.

`\h'expr'` [Escape sequence]

Horizontally move the drawing position. *expr* indicates the magnitude of motion: positive is rightward and negative leftward. The default scaling unit is ‘m’. The motion is relative to the current drawing position unless *expr* begins with the boundary-relative measurement operator ‘|’. See Section 5.4 [Numeric Expressions], page 78.

¹³⁹ At the **groff** defaults of 10-point type on 12-point vertical spacing, the difference between half a vee and half an em can be subtle: large spacings like ‘.vs .5i’ make it obvious.

The following string definition sets the $\mathrm{T}_{\mathrm{E}}\mathrm{X}$ logo. Recall Section 5.22 [Strings], page 163, regarding the trailing ‘\’.

```
.ds TeX T\h'-.1667m'\v'.224m'E\v'-.224m'\h'-.125m'X\"
```

An input backspace becomes a negative horizontal motion of one word space; recall Section 5.9 [Manipulating Filling and Adjustment], page 101. This feature persists for backward compatibility with early formatters that predate **nroff** and even Unix itself, and which used it to facilitate user-directed overstriking for character composition, boldfacing, and underlining. GNU **troff** has explicit features to support each of these; use them instead.

Several escape sequences support special cases of horizontal motion.

\SPC [Escape sequence]

Move right one word space. (The input is a backslash followed by a space.) This escape sequence can be thought of as a non-adjustable, unbreakable space. Usually you want $\backslash\sim$ instead; see Section 5.9 [Manipulating Filling and Adjustment], page 101.

\| [Escape sequence]

Move one-sixth em to the right on typesetting output devices. If a glyph named ‘\|’ is defined in the current font, its width is used instead, even on terminal output devices.

\^ [Escape sequence]

Move one-twelfth em to the right on typesetting output devices. If a glyph named ‘\^’ is defined in the current font, its width is used instead, even on terminal output devices.

\0 [Escape sequence]

Move right by the width of a numeral in the current font.

Horizontal motions are not discarded at the end of an output line as word spaces are; recall Section 5.1.4 [Breaking], page 66.

\w'input' [Escape sequence]

\n[st] [Register]

\n[sb] [Register]

\n[rst] [Register]

\n[rsb] [Register]

\n[ct] [Register]

\n[ssc] [Register]

\n[skw] [Register]

Interpolate the width of *input*, as interpreted, in basic units. This escape sequence allows several properties of formatted output to be measured without writing it out.

The length of the string 'abc' is $\backslash\mathrm{w}'\mathrm{abc}'\mathrm{u}$.

⇒ The length of the string 'abc' is 72u.

The formatter processes *input* in a dummy environment: this means that font and type size changes, for example, may occur within it without affecting subsequent output.

After each use, `\w` sets several registers.

st
sb The maximum vertical displacements of the text baseline above and below, respectively. The sign convention is opposite that of relative vertical motions; that is, depth below the (original) baseline is negative. These registers are incorrectly documented in the AT&T **troff** manual as “the highest and lowest extent of [the argument to `\w`] relative to the baseline”.

rst
rsb Like **st** and **sb**, but taking account of the heights and depths of glyphs. In other words, these registers store the highest and lowest vertical positions attained by *input*, doing what AT&T **troff** documented **st** and **sb** as doing.

ct Characterizes the geometry of glyphs occurring in *input*.

0	only short glyphs, no descenders or tall glyphs
1	at least one descender
2	at least one tall glyph
3	at least one each of a descender and a tall glyph

ssc The amount of horizontal space (possibly negative) that should be added to the last glyph before a subscript.

skw How far to right of the center of the last glyph in the `\w` argument, the center of an accent from a roman font should be placed over that glyph.

<code>\kp</code>	[Escape sequence]
<code>\k(ps</code>	[Escape sequence]
<code>\k[<i>position</i>]</code>	[Escape sequence]

Store the horizontal drawing position, relative to that corresponding to the start of the input line (ignoring page offset and indentation), in a register with the name *position* (one-character name *p*, two-character name *ps*). Use this, for example, to later move to the beginning of a word for highlighting or other decoration.

<code>\n[hp]</code>	[Register]
---------------------	------------

The horizontal position relative to that at the start of the input line.

<code>\n[.k]</code>	[Register]
---------------------	------------

A read-only register containing the current horizontal output position (relative to the current indentation).

`\o'abc...'` [Escape sequence]

Overstrike the glyphs of characters *a*, *b*, *c*, ...; the glyphs are centered, written, and the drawing position advanced by the widest of the glyphs.

`\zc` [Escape sequence]

Format the character *c* with zero width; that is, without advancing the drawing position. Use `\z` to overstrike glyphs aligned to their left edges, in contrast to `\o`'s centering.

`\Z` [Escape sequence]

Save the drawing position, format *input*, then restore it. GNU **troff** ignores tabs and leaders in *input* with an error diagnostic.

We might implement a strike-through macro thus.

```
.de strikeouts
.nr width \w'\@\\$1'
\Z@\v'-.25m'\l'\@\\n[width]u'@\@\\$1
..
.
This is
.strikeout "a test"
an actual emergency!
```

5.26 Output Line Annotation

After an output line is broken (and adjusted, if applicable), it can be annotated in the margins. You can indicate line numbers on the left, and apply a margin character on the right.

`.nm [start [increment [space [indentation]]]]` [Request]
`\n[ln]` [Register]
`\n[.nm]` [Register]

Begin (or, with no arguments, cease) numbering output lines. *start* assigns the number of the *next* output line. Only line numbers divisible by *increment* (default: '1') bear marks. The formatter reckons the third and fourth arguments in numeral widths (`\0`): *space* configures the horizontal spacing between the number and the text (default: '1'). Any given *indentation* applies to the numbers (default: '0'). *start* must be non-negative and *increment* positive.

The formatter aligns the number to the right in a space of three numeral widths plus *indentation*, then catenates *space* and the output line. The line length is *not* reduced. Depending on the value of the page offset (recall Section 5.15 [Line Layout], page 126) numbers wider than the allocated space protrude into the left margin, or shift the output line to the right.

Line numbering parameters corresponding to missing arguments are not altered. After numbering is disabled, `.nm +0` resumes it using the previously active parameters.

The parameters of `nm` are associated with the environment (see Section 5.32 [Environments], page 216).

While numbering is enabled, the output line number register `ln` is updated as each line is output, even if no line number is formatted with it because it is being skipped (it is not a multiple of *increment*) or because numbering is suppressed (see the `nn` request below).

The `.nm` register tracks the enablement status of numbering. Temporary suspension of numbering with the `nn` request does *not* alter its value.

```
.po 5n
.ll 44n
Programming,
when stripped of all its circumstantial irrelevancies,
.nm 999 1 1 -4
boils down to no more and no less than
.nm +0 3
very effective thinking so as to avoid unmastered
.nn 2
complexity,
to very vigorous separation of your many
different concerns.
.br
\ (em Edsger Dijkstra
.sp
.nm 1 1 1
This guy's arrogance takes your breath away.
.br
\ (em John Backus
⇒      Programming, when stripped of all its cir-
⇒ 999  cumstantial irrelevancies, boils down to no
⇒      more and no less than very effective think-
⇒      ing so as to avoid unmastered complexity, to
⇒      very vigorous separation of your many dif-
⇒      ferent concerns.
⇒ 1002 -- Edsger Dijkstra
⇒
⇒      1 This guy's arrogance takes your breath away.
⇒      2 -- John Backus
```

<code>.nn</code>	[<i>skip</i>]	[Request]
<code>\n</code>	[<code>.nn</code>]	[Register]

Suppress numbering of the next *skip* output lines counted by the `nm` request. If *skip* is '0', cancel suppression. The default is 1. `nn` can be invoked when line numbering is not active; suppression of numbering takes effect for *skip* lines once `nm` enables it.

The `.nn` register stores the count of lines remaining in the environment for which numbering is suppressed while output line numbering is enabled.

This count is associated with the environment (see Section 5.32 [Environments], page 216).

To test whether the current output line will be numbered, you must check both the `.nm` and `.nn` registers.

```
.de is-numbered
.  nop This line
.  ie (\\n[.nm] & (1-\\n[.nn])) IS
.  el                                ISN'T
.  nop numbered.
.  br
..
Test line numbering.
.is-numbered
.nm 1
.nn 1
.is-numbered
.is-numbered
.nm
.is-numbered
⇒ Test line numbering.  This line ISN'T numbered.
⇒ This line ISN'T numbered.
⇒ 1 This line IS numbered.
⇒ This line ISN'T numbered.
```

`.mc` [*margin-character* [*distance*]] [Request]

Begin (or, with no arguments, cease) writing a *margin-character* to the right of each output line. The *distance* argument separates *margin-character* from the right margin. If absent, the most recent value is used; the default is 10 points. If an output line exceeds the line length, the margin character is appended to it. No margin character is written on lines produced by the `tl` request.

The margin character is a property of the output line. Only one margin character is in effect at one time; the most recent `mc` call determines its value. If the margin character is disabled before an output line breaks, none is output (but see below).

The margin character is associated with the environment (see Section 5.32 [Environments], page 216).

```
.ll 5i
.nf
.mc \[br]
This paragraph is marked with a margin character.
.sp
As seen above, vertical space isn't thus marked.
\&
An output line that is present, but empty, is.
    ⇒ This paragraph is marked with a margin character. |
    ⇒
    ⇒ As seen above, vertical space isn't thus marked. |
    ⇒
    ⇒ An output line that is present, but empty, is. |
```

For compatibility with AT&T **troff**, a call to **mc** to set the margin character can't be undone immediately; at least one line gets a margin character.

```
.ll 10n
.nf
.mc |
.mc *
.mc
foo
bar
    ⇒ foo          *
    ⇒ bar
```

The margin character mechanism is commonly used to annotate changes in documents. The **groff** distribution ships a program, **gdiffmk**, to assist with this task.¹⁴⁰

5.27 Drawing Geometric Objects

A few of the formatter's escape sequences draw lines and other geometric objects. Combined with each other and with page motion commands (see Section 5.25 [Page Motions], page 184), a wide variety of figures is possible. For complex drawings, these operations can be cumbersome: the preprocessors **pic** or **grn** are typically used instead.

The **\l** and **\L** escape sequences draw horizontal and vertical sequences of glyphs, respectively. Even the simplest of output devices supports them. They require an argument specifying the length of the rule (line) to be drawn, optionally followed by a single ordinary or special character with which to draw the rule if the default is not desired. If the character is valid in a numerical expression, put **\&** after *l* to disambiguate the input.

¹⁴⁰ Historically, tools named **narchbar** and **changebar** were developed for marking changes with margin characters and could be found in archives of the **comp.sources.unix** Usenet group. Some proprietary Unices also offer(ed) a **diffmk** program.

`\l'I'` [Escape sequence]
`\l'lc'` [Escape sequence]

Draw a horizontal line of length *l* from the drawing position. Rightward motion is positive. Afterward, the drawing position is at the right end of the line. The default scaling unit is ‘m’. The default glyph is the baseline rule special character, `\[ru]`.

```
\l'4i\&-'
```

⇒ -----

Let us see how to draw a box around a word using a macro.

```
.de textbox
\[br]\$*\[br]\l'|0\[rn]'\l'|0\[ul]'
..
```

The foregoing outputs a box rule (a vertical line), the text argument(s), and another box rule. We employ the boundary-relative measurement operator ‘|’. Finally, the line-drawing escape sequences draw a radical extender (a form of overline) and an underline from the drawing position to the position corresponding to beginning of the *input* line. The formatter leaves the drawing position at the right-hand box rule even though the line lengths are negative, as noted above.

`\L'I'` [Escape sequence]
`\L'lc'` [Escape sequence]

Draw a vertical line of length *l* from the drawing position. Downward motion is positive. The default scaling unit is ‘v’. The default glyph is the box rule, `\[br]`. As with vertical motion escape sequences, text processing continues where the line ends.

```
$ nroff <<EOF
This is a \L'3v'test.
EOF
```

⇒ This is a
 ⇒ |
 ⇒ |
 ⇒ |test.

When writing text, the drawing position is at the text baseline; recall Section 5.2 [Page Geometry], page 75.

The `\D` escape sequence provides *drawing commands* that direct the output device to render geometrical objects rather than glyphs. Specific devices may support only a subset, or may feature additional ones; consult the man page for the output driver in use. Terminals in particular implement almost none. See Section 6.2.2.3 [Graphics Commands], page 258.

Rendering starts at the drawing position; when finished, the drawing position is left at the rightmost point of the object, even for closed figures, except where noted. GNU **troff** draws stroked (outlined) objects with the stroke color, and shades filled ones with the fill color. See Section 5.21

[Colors], page 161. Coordinates h and v are horizontal and vertical motions relative to the drawing position or previous point in the command. The default scaling unit for horizontal measurements (and diameters of circles) is ‘m’; for vertical ones, ‘v’.

Circles, ellipses, and polygons can be drawn filled or stroked. These are independent properties; if you want a filled, stroked figure, you must draw the same figure twice using each drawing command. A filled figure is always smaller than an outlined one because the former is drawn only within its defined area, whereas strokes have a line thickness (set with ‘\D't’).

```
\h'1i'\v'1i'\
\# increase line thickness
\Z'\D't 5p''\
\# draw stroked (unfilled) polygon
\Z'\D'p 3 3 -6 0''\
\# draw filled (solid) polygon
\Z'\D'P 3 3 -6 0''
```

`\D'command argument ...'` [Escape sequence]

Drawing command escape sequence parameters begin with an ordinary character, *command*, selecting the type of object to be drawn, followed by *arguments* whose meaning is determined by *command*.

`\D'~ h1 v1 ... hn vn'`

Draw a B-spline to each point in sequence, leaving the drawing position at (hn , vn).

`\D'a hc vc h v'`

Draw a circular arc centered at (hc , vc) counterclockwise from the drawing position to a point (h , v) relative to the center.¹⁴¹

`\D'c d'` Draw a circle of diameter d with its leftmost point at the drawing position.

`\D'C d'` As ‘\D'C ... ’, but the circle is filled.

`\D'e h v'` Draw an ellipse of width h and height v with its leftmost point at the drawing position.

`\D'E x y'` As ‘\D'e ... ’, but the ellipse is filled.

`\D'l dx dy'`

Draw line from the drawing position to (h , v).

The following is a macro for drawing a box around a text argument; for simplicity, the box margin is a fixed at 0.2 m.

¹⁴¹ (hc , vc) is adjusted to the point nearest the perpendicular bisector of the arc’s chord.

```
.de TEXTBOX
.  nr @wd \w'\\$1'
\h'.2m'\
\h'-.2m'\v'(.2m - \\n[rsb]u)'\
\D'1 0 -(\n[rst]u - \\n[rsb]u + .4m)'\
\D'1 (\n[@wd]u + .4m) 0'\
\D'1 0 (\n[rst]u - \\n[rsb]u + .4m)'\
\D'1 -(\n[@wd]u + .4m) 0'\
\h'.2m'\v'-(.2m - \\n[rsb]u)'\
\\$1\
\h'.2m'
..
```

The argument is measured with the `\w` escape sequence. Its width is stored in register `@wd`. `\w` also sets the registers `rst` and `rsb`; these contain its maximum vertical extents of the argument. Then, four lines are drawn to form a box, offset by the box margin.

`\D'p h1 v1 ... hn vn'`

Draw polygon with vertices at the drawing position and each point in sequence. GNU troff closes the polygon by drawing a line from (hn, vn) back to the initial drawing position. Afterward, the drawing position is left at (hn, vn) .

`\D'P dx1 dy1 dx2 dy2 ...'`

As `'\D'P ...'`, but the polygon is filled. `groff` does not specify how the output device must fill concave or self-intersecting polygons.

The following macro is like the `'\D'1'` example, but shades the box. We draw the box before writing the text because colors in GNU troff have no transparency; in the opposite order, the filled polygon would occlude the text.

```
.de TEXTBOX
.  nr @wd \w'\\$1'
\h'.2m'\
\h'-.2m'\v'(.2m - \\n[rsb]u)'\
\M[lightcyan]\
\D'P 0 -(\n[rst]u - \\n[rsb]u + .4m) \
      (\n[@wd]u + .4m) 0 \
      0 (\n[rst]u - \\n[rsb]u + .4m) \
      -(\n[@wd]u + .4m) 0'\
\h'.2m'\v'-(.2m - \\n[rsb]u)'\
\M[]\
\\$1\
\h'.2m'
..
```

`\D't n'` Set the stroke thickness of geometric objects to *n* basic units. A zero *n* selects the minimum supported thickness. A negative *n* selects a thickness proportional to the type size; this is the default.

In a hazy penumbra between text rendering and drawing commands we locate the bracket-building escape sequence, `\b`. It can assemble glyphs that appear large by vertically stacking ordinary ones.

`\b'contents'` [Escape sequence]

Pile and center a sequence of glyphs vertically on the output line. *Piling* stacks glyphs corresponding to each character in *contents*, read from left to right, and placed from top to bottom. GNU **troff** separates the glyphs vertically by 1 m, and the pile itself is centered 0.5 m above the text baseline. The horizontal drawing position is then advanced by the width of the widest glyph in the pile.

This rather inflexible positioning algorithm doesn't work with the **dvi** output device since its bracket pieces vary in height. Instead, use the **eqn** preprocessor.

Section 5.11 [Manipulating Spacing], page 116, describes how to adjust the vertical spacing of the output line with the `\x` escape sequence.

The application of `\b` that lends its name is construction of brackets, braces, and parentheses when typesetting mathematics. We might construct a large opening (left) brace as follows.

```
\b'\[lt]\[bv]\[lk]\[bv]\[lb]'
```

See *groff_char*(7) for a list of special character identifiers.

5.28 Deferring Output

A few **roff** language elements are generally not used in simple documents, but arise as page layouts become more sophisticated and demanding. *Environments* collect formatting parameters like line length and typeface. A *diversion* stores formatted output for later use. A *trap* is a condition on the input or output, tested automatically by the formatter, that is associated with a macro: fulfilling the condition *springs* the trap—calls the macro.

Footnote support often exercises all three of the foregoing features. A simple implementation might work as follows. The author writes a pair of macros: one starts a footnote and the other ends it. They further set a trap a small distance above the page bottom, reserving a footnote area. The author calls the first macro where a footnote mark is desired. The macro establishes a diversion so that the footnote text is collected at the place in the body text where its corresponding mark appears. It further creates an environment for the footnote so that it sets using a smaller typeface. The footnote text is formatted in the diversion using that environment but it does not yet appear in the output. The document author calls the footnote end macro, which returns to the previous environment and ends the diversion. Later, after

body text nearly fills the page, the trap springs. The macro called by the trap draws a line across the page and emits the stored diversion by calling it like a macro. Thus, the footnote renders.

Diversions and traps make the text formatting process non-linear. Let us imagine a set of text lines or paragraphs labelled ‘A’, ‘B’, and so on. If we set up a trap that produces text ‘T’ (as a page footer, say), and we also use a diversion to store the formatted text ‘D’, then a document with input text in the order ‘A B C D E F’ might render as ‘A B C E T F’. The diversion ‘D’ is never output if we do not call it.

Environments of themselves are not a source of non-linearity in document formatting: environment switches have immediate effect. One could always write a macro to change as many formatting parameters as desired with a single convenient call. But because diversions can be nested and macros called by traps that are sprung by other trap-called macros, they may be interpolated in varying contexts. For example, consider a page header that is always to be set in Helvetica. A document that uses Times for most of its body text, but Courier for displayed code examples, poses a challenge if a page break occurs in the middle of a code display; if the header trap assumes that the “previous font” is always Times, the rest of the example will be formatted in the wrong typeface. One could carefully save all formatting parameters upon entering the trap and restore them upon leaving it, but this is verbose, error-prone, and not future-proof as the `groff` language develops. Environments save us considerable effort.

5.29 Traps

Traps are locations in the output, or conditions on the input that, when reached or fulfilled, call a specified macro. These traps can occur at a given location either on the page or in the current diversion (together, these are known as *vertical position traps*), at a blank line, at a line with leading space characters, after a quantity of input lines, or at the end of input. Setting a trap is also called *planting* one. It is said that a trap is *sprung* if its condition is fulfilled. The formatter passes no arguments to macros called by traps.

5.29.1 Vertical Position Traps

A *vertical position trap* calls a macro when the formatter’s vertical drawing position reaches or passes, in the downward direction, a certain location on the output page or in a diversion. Its applications include setting page headers and footers, body text in multiple columns, and footnotes.

<code>.vpt [b]</code>	[Request]
<code>\n[.vpt]</code>	[Register]

Enable or disable vertical position traps per Boolean expression *b*. They are enabled by default, and if *b* is omitted. Vertical position traps are those set by the `wh` request or by `dt` within a diversion. Vertical position

trap enablement is global. Its status is stored in the `.vpt` read-only register.

A page can't be ejected if vertical position traps are disabled.¹⁴²

5.29.1.1 Page Location Traps

A *page location trap* is a vertical position trap that applies to the page; that is, to the top-level diversion. Many can be present; manage them with the `wh` and `ch` requests.

`.wh dist [name]` [Request]

Plant macro *name* as page location trap at *dist*. The default scaling unit is 'v'. Non-negative values for *dist* set the trap relative to the top of the page; negative values set the trap relative to the bottom of the page. It is not possible to plant a trap less than one basic unit from the page bottom: the formatter interprets a *dist* of -0 as 0, the top of the page. `wh` removes any existing *visible* trap (see below) at *dist* is removed; this is its sole function if *name* is missing.

A trap springs only if it is *visible*, meaning that its location is reachable on the page¹⁴³ and it is not hidden by another trap at the same location already planted there.

A macro package might set headers and footers as follows; this example configures vertical margins of one inch to the body text, and one half-inch to the titles. Observe the use of the no-break control character with the `sp` and `bp` requests to position our text baselines and prevent a partially collected line from being written outside the body text, and the page number character '%' used with the `tl` request.

```
.\" hdro.roff
.de hd                \" page header
'  sp .5i
.  tl '\\*(Ti''\\*(Da' \" title and date strings
'  sp |1i
..
.de fo                \" page footer
'  sp .5i-1v
.  tl '%'
'  bp
..
.wh 0   hd           \" trap at top of the page
.wh -1i fo          \" trap 1 inch from bottom
```

Caution: A word about measurements is in order. Recall that the `sp` request vertically spaces such that the next text baseline (of one vee in height by definition) sets with the amount of space given to `sp`'s argument

¹⁴² See Section 5.29.1.2 [The Implicit Page Trap], page 202.

¹⁴³ A trap planted at '20i' or '-30i' cannot spring on a page of length '11i'.

above it. Thus in the example above, when the ‘`hd`’ trap springs at vertical position ‘0’, invoking ‘`sp .5i`’, we get the desired half-inch of top margin. With the ‘`ft`’ trap, we space after the body text by one half-inch *minus one vee* to leave a half-inch bottom margin. The footer title, if taller than a baseline rule, thus “encroaches” into the half-inch margin between the body text and the bottom margin, just as the header title symmetrically intrudes into the half-inch of space between its own cap-height and that of the top of the body text.

To use these traps, copy the above (or load it from a file with the `so` or `mso` requests), then set up the strings it uses.

```
.so hdfo.roff
.ds Ti Final Report\
.ds Da 21 May 2023\
.ti
On 5 August of last year,
this committee tasked me with the investigation of the
CFIT (controlled flight into terrain) incident of
.\ " ...and so on...
```

A trap above the top or at or below the bottom of the page can be made visible by either moving it into the page area or increasing the page length so that the trap is on the page. A negative trap value always uses the *current* page length; the formatter does not convert it to an absolute vertical position. We can use the `pwh` request to dump page location traps to the standard error stream (see Section 5.38 [Debugging], page 231). GNU `troff` reports their positions in basic units, and includes empty slots in the list, where a trap had been planted but subsequently (re)moved, because they can affect the visibility of subsequently planted traps. An `nroff` device example follows.

```
.pl 5i
.wh -1i xx
.pwh
    [error]   xx      -240
.pl 100i
.pwh
    [error]   xx      -240
```

It is possible to have more than one trap at the same location (although only one at a time can be visible); to achieve this, the traps must be defined at different locations, then moved to the same place with the `ch` request. In the following example, the many empty lines caused by the `bp` request are not shown in the output.

```

.de a
.  nop a
..
.de b
.  nop b
..
.de c
.  nop c
..
.
.wh 1i a
.wh 2i b
.wh 3i c
.bp
    ⇒ a b c
.ch b 1i
.ch c 1i
.bp
    ⇒ a
.ch a 0.5i
.bp
    ⇒ a b

```

`\n[.t]` [Register]

The read-only register `.t` holds the distance to the next vertical position trap. If no such traps exist between the drawing position and the bottom of the page, it contains the distance to the page bottom. Within a diversion, in the absence of a diversion trap, this distance is the maximum possible vertical position supported by the output device.

`.ch name [dist]` [Request]

Change the location of a trap by moving macro *name* to new location *dist*, or by unplugging it altogether if *dist* is absent. The default scaling unit is ‘v’. Parameters to `ch` are specified in the opposite order from `wh`. If *name* is the earliest planted macro of multiple traps at the same location, (re)moving it from that location exposes the macro next least recently planted at the same place.¹⁴⁴

Changing a trap’s location is useful for building up footnotes in a diversion to allow more space at the bottom of the page for them.

The same macro can be installed simultaneously at multiple locations; however, only the earliest-planted instance—that has not yet been deleted

¹⁴⁴ It may help to think of each trap location as maintaining a queue; `wh` operates on the head of the queue, and `ch` operates on its tail. Only the trap at the head of the queue is visible.

with `wh`—will be moved by `ch`. The following example (using an `nroff` device) illustrates this behavior. Blank lines have been elided from the output.

```
.de T
Trap sprung at \\n(nlu.
.br
..
.wh 1i T
.wh 2i T
foo
.sp 11i
.bp
.ch T 4i
bar
.sp 11i
.bp
.ch T 5i
baz
.sp 11i
.bp
.wh 5i
.ch T 6i
qux
.sp 11i
⇒ foo
⇒ Trap sprung at 240u.
⇒ Trap sprung at 480u.
⇒ bar
⇒ Trap sprung at 480u.
⇒ Trap sprung at 960u.
⇒ baz
⇒ Trap sprung at 480u.
⇒ Trap sprung at 1200u.
⇒ qux
⇒ Trap sprung at 1440u.
```

`\n[.ne]` [Register]

The read-only register `.ne` contains the amount of space that was needed in the last `ne` request that caused a trap to be sprung; it is useful in conjunction with the `.trunc` register. See Section 5.18 [Page Control], page 131. Since the `.ne` register is set only by traps, it doesn't make sense to interpolate it outside of macros called by traps.

`\n[.trunc]` [Register]

A read-only register containing the amount of vertical space truncated from an `sp` request by the most recently sprung vertical position trap, or, if the trap was sprung by an `ne` request, minus the amount of vertical

motion produced by the `ne` request. In other words, at the point a trap is sprung, it represents the difference of what the vertical position would have been but for the trap, and what the vertical position actually is. Since the `.trunc` register is set only by traps, it doesn't make sense to interpolate it outside of macros called by traps.

`\n[.trap]` [Register]
 This read-only, string-valued register interpolates the name of the next vertical position trap that will be sprung.

`\n[.pe]` [Register]
 This Boolean-valued, read-only register interpolates 1 while a page is being ejected, and 0 otherwise.

In the following example, we plant the same trap at the top and the bottom of the page. We also make the trap report its name and the vertical drawing position.

```
.de T
.tm \\$0: page \\n%, nl=\\n[nl] .pe=\\n[.pe]
..
.ll 46n
.wh 0 T
.wh -1v T
Those who can make you believe absurdities can make you
commit atrocities. \[em] Voltaire
[error] T: page 1, nl=0 .pe=0
[error] T: page 1, nl=2600 .pe=1
⇒ Those who can make you believe absurdities can
⇒ make you commit atrocities. -- Voltaire
```

When designing macros, keep in mind that diversions and traps do not normally interact. For example, if a trap calls a header macro (while outputting a diversion) that tries to change the font on the current page, the effect is not visible before the diversion has completely been printed (except for input protected with `\!` or `\?`) since the data in the diversion is already formatted. In most cases, this is not the expected behaviour.

5.29.1.2 The Implicit Page Trap

If, after starting GNU `troff` without loading a macro package, you use the `pwh` request to dump a list of the active traps to the standard error stream,¹⁴⁵ nothing is reported. Yet the `.t` register will report a steadily decreasing value with every output line your document produces, and once the value of `.t` gets to within `.V` of zero, you will notice that something trap-like happens—the page is ejected, a new one begins, and the value of `.t` becomes large once more.

¹⁴⁵ See Section 5.38 [Debugging], page 231.

This *implicit page trap* always exists in the top-level diversion;¹⁴⁶ its purpose is to eject the current page and start the next one. It works like a trap in some ways but not others. It has no name, so it cannot be moved or deleted with `wh` or `ch` requests. You cannot hide it by placing another trap at its location, and can move it only by redefining the page length with `pl`. Its operation is suppressed when vertical page traps are disabled with GNU `troff`'s `vpt` request.

5.29.1.3 Diversion Traps

A diversion is not formatted in the context of a page, so it lacks page location traps; instead it can have a *diversion trap*. There can exist at most one such vertical position trap per diversion.

`.dt` [*dist name*] [Request]

Set a trap *within* a diversion at location *dist*, which is interpreted relative to diversion rather than page boundaries. If invoked with fewer than two arguments, any diversion trap in the current diversion is removed. The register `.t` works within diversions. It is an error to invoke `dt` in the top-level diversion. See Section 5.30 [Diversions], page 208.

5.29.2 Input Line Traps

`.it` [*n name*] [Request]

`.itc` [*n name*] [Request]

`\n[.it]` [Register]

`\n[.itc]` [Register]

`\n[.itm]` [Register]

Set an input line trap, calling macro *name* after processing the next *n* productive input lines (recall Section 5.9 [Manipulating Filling and Adjustment], page 101). Any existing input line trap in the environment is replaced. Without arguments, `it` and `itc` clear any input line trap that has not yet sprung.

Consider a macro ‘`.ST s n`’ which sets the next *n* input lines in the font style *s*.

¹⁴⁶ See Section 5.30 [Diversions], page 208.

```
.de ST \" Use style $1 for next $2 text lines.
.  it \\$2 ES
.  ft \\$1
..
.de ES \" end ST
.  ft R
..
.ST I 1
oblique
face
.ST I 1
oblique\c
face
```

⇒ *oblique face obliqueface* (second “face” upright)

Unlike the *ce* and *rj* requests, *it* counts lines interrupted with the *\c* escape sequence separately (see Section 5.16 [Line Continuation], page 129); *itc* does not. To see the difference, let’s change the previous example to use *itc* instead.

```
...
.  itc \\$2 ES
...
```

⇒ *oblique face obliqueface* (second “face” oblique)

You can think of the *ce* and *rj* requests as implicitly creating an input line trap with *itc* that schedules a break when the trap is sprung.

```
.de BR
.  br
.  internal: disable centering-without-filling
..
.
.de ce
.  if \\n[.br] .br
.  itc \\$1 BR
.  internal: enable centering-without-filling
..
```

The *.it*, *.itc*, and *.itm* registers report the number of input lines remaining in a pending input trap, a Boolean indication of whether that pending input trap honors output line continuation, and the name of the macro associated with the pending input trap, respectively. All are read-only; *.itm* is string-valued as well.

Let us consider in more detail the sorts of input lines that are or are not “productive”.

```
.de Trap
TRAP SPRUNG
..
.de Mac
.if r a \l'5n'
..
.it 2 Trap
.
foo
.Mac
bar
baz
.it 1 Trap
.sp \" moves, but does not write or draw
qux
.itc 1 Trap
\h'5n'\c \" moves, but does not write or draw
jat
```

When ‘Trap’ gets called depends on whether the ‘a’ register is defined; the control line with the `if` request may or may not produce written output. We also see that the spacing request `sp`, while certainly affecting the output, does not spring the input line trap. Similarly, the horizontal motion escape sequence `\h` also affected the output, but was not “written”. Observe that we had to follow it with `\c` and use `itc` to prevent the newline at the end of the text line from causing a word break, which, like an ordinary space character, counts as written output.

```
$ groff -T ascii input-trap-example.groff
⇒ foo bar TRAP SPRUNG baz
⇒
⇒ qux TRAP SPRUNG          jat TRAP SPRUNG
$ groff -T ascii -r a1 input-trap-example.groff
⇒ foo ----- TRAP SPRUNG bar baz
⇒
⇒ qux TRAP SPRUNG          jat TRAP SPRUNG
```

Input line traps are associated with the environment (see Section 5.32 [Environments], page 216); switching to another environment suspends the current input line trap, and going back resumes it, restoring the count of qualifying lines enumerated in that environment.

5.29.3 Blank Line Traps

.blm [*name*] [Request]

Set a blank line trap, calling the macro *name* when GNU **troff** encounters a blank line in input, instead of the usual behavior (see Section 5.1.4 [Breaking], page 66). A line consisting only of spaces is also treated as blank and subject to this trap. If no argument is supplied, the default blank line behavior is (re-)established.

5.29.4 Leading Space Traps

.lsm [*name*] [Request]

\n[lsn] [Register]

\n[lss] [Register]

Set a leading space trap, calling the macro *name* when GNU **troff** encounters leading spaces on a text line; the implicit line break that normally happens in this case is suppressed. The formatter stores the count of leading spaces on the text line in register **lsn**, and the amount of corresponding horizontal motion in register **lss**, irrespective of whether a leading space trap is set. When it is, GNU **troff** removes the leading spaces from the input line and produces no motion before calling *name*.

If no argument is supplied, GNU **troff** reestablishes the default handling of leading spaces on text lines (breaking the line when filling, and formatting a horizontal motion of ‘**\n[lsn]**’ word spaces).

5.29.5 End-of-input Traps

.em [*name*] [Request]

Set a trap at the end of input, calling macro *name* after the last line of the last input file has been processed. If no argument is given, any existing end-of-input trap is removed.

For example, if the document had to have a section at the bottom of the last page for someone to approve it, the **em** request could be used.

```
.de approval
\c
. ne 3v
. sp (\n[.t]u - 3v)
. in +4i
. lc _
. br
Approved:\t\a
. sp
Date:\t\t\a
..
.
.em approval
```

The `\c` in the above example needs explanation. For historical reasons (compatibility with AT&T **troff**), the end-of-input macro exits as soon as it causes a page break if no partially collected line remains.¹⁴⁷

Let us assume that there is no `\c` in the above **approval** macro, that the page is full, and last output line has been broken with, say, a **br** request. Because there is no more room, a **ne** request at this point causes a page ejection, which in turn makes **troff** exit immediately as just described. In most situations, this is not desired; people generally want to format the input after **ne**.

To force processing of the whole end-of-input macro independently of this behavior, it is thus advisable to (invisibly) ensure the existence of a partially collected line (`\c`) whenever there is a chance that a page break can happen. In the above example, invoking the **ne** request ensures that there is room for the subsequent formatted output on the same page, so we need insert `\c` only once.

The next example shows how to append three lines, then start a new page unconditionally. Since `‘.ne 1’` doesn’t give the desired effect—there is always one line available or we are already at the beginning of the next page—we temporarily increase the page length by one line so that we can use `‘.ne 2’`.

```
.de EM
.pl +1v
\c
.ne 2
line one
.br
\c
.ne 2
line two
.br
\c
.ne 2
line three
.br
.pl -1v
\c
'bp
..
.em EM
```

This specific feature affects only the first potential page break caused by the end-of-input macro; further page breaks emitted by the macro are handled normally.

¹⁴⁷ While processing an end-of-input macro, the formatter assumes that the next page break must be the last; it goes into “sudden death overtime”.

Another possible use of the `em` request is to make GNU `troff` emit a single large page instead of multiple pages. For example, one may want to produce a long plain text file for reading in a terminal or emulator without page footers and headers interrupting the body of the document. One approach is to set the page length at the beginning of the document to a very large value to hold all the text and automatically adjust it to the exact height of the document after the text has been output.

```
.de adjust-page-length
.  br
.  pl \\n[nl]u \" \n[nl]: current vertical position
..
.
.de single-page-mode
.  pl \n[.R]u
.  em adjust-page-length
..
.
.\" Activate the above code if configured.
.if \n[do-continuous-rendering] \
.  single-page-mode
```

Since only one end-of-input trap exists and another macro package may already use it, care must be taken not to break the mechanism. A simple solution would be to append the above macro to the macro package's end-of-input macro using the `am` request.

5.30 Diversions

In `roff` systems it is possible to format text as if for output, but instead of writing it immediately, one can *divert* the formatted text into a named storage area. It is retrieved later by specifying its name after a control character. The formatter uses the same name space for such *diversions* as for strings and macros; recall Section 5.5 [Identifiers], page 82. Such text is sometimes said to be “stored in a macro”, but this coinage obscures the important distinction between macros and strings on one hand and diversions on the other; the former store *unformatted* input text, and the latter capture *formatted* output.¹⁴⁸ Diversions also do not interpret arguments. Applications of diversions include footnotes, tables of contents, indices, and “keeps” (preventing a page break from occurring at an inconvenient place by forcing a set of output lines to be set as a group). For orthogonality it is said that GNU `troff` populates the *top-level diversion* if no diversion is active (that is, formatted output is being “diverted” directly to the output device). The top-level diversion has no name.

¹⁴⁸ See Section 5.37 [GNU `troff` Internals], page 228.

Dereferencing an undefined diversion creates an empty one of that name.¹⁴⁹ A diversion does not exist for the purpose of testing with the **d** conditional expression operator until its initial definition ends; recall Section 5.23.1 [Operators in Conditionals], page 168. The following requests create and alter diversions.

.di [*name*] [Request]
.da [*name*] [Request]

Start collecting formatted output in a diversion called *name*. The **da** request appends to a diversion called *name*, creating it if necessary. If *name* already exists as an alias, the target of the alias is replaced or appended to; recall Section 5.22 [Strings], page 163. The pending output line is diverted as well. Switching to another environment (with the **ev** request) before invoking **di** or **da** avoids including any pending output line in the diversion.¹⁵⁰

Invoking **di** or **da** without an argument stops diverting output to the diversion named by the most recent corresponding request. Invoking **di** or **da** without an argument when no diversion is being populated does nothing.¹⁵¹

```
.ll 56n
Ahoy, me hearties,
I traveled unto a distant isle,
.br
.di HT
and thereupon I lay a vast treasure,
.br
.di
.HT
.br
which none o' ye shall ever see.
⇒ Ahoy, mateys, I traveled unto a distant isle,
⇒ and thereupon I lay a vast treasure,
⇒ which none o' ye shall ever see.
```

GNU **troff** supports *box* requests to exclude a partially collected line from a diversion, as this is often desirable.

.box [*name*] [Request]
.boxa [*name*] [Request]

Divert (or append) output to *name*, similarly to the **di** and **da** requests, respectively. Any pending output line is *not* included in the diversion. Without an argument, stop diverting output; any pending output line inside the diversion is discarded.

¹⁴⁹ GNU **troff** emits a warning in category ‘**mac**’. See Section 5.38.1 [Warnings], page 236.

¹⁵⁰ See Section 5.32 [Environments], page 216.

¹⁵¹ GNU **troff** emits a warning in category ‘**di**’. See Section 5.38.1 [Warnings], page 236.

```
.ll 56n
Ahoy, mateys,
I traveled unto a distant isle,
.br
.box SECRET
and thereupon I lay a vast treasure,
.br
accurst wi' neutron activation,
.box
.SECRET
.br
which none o' ye shall ever see.
    ⇒ Ahoy, mateys, I traveled unto a distant isle,
    ⇒ and thereupon I lay a vast treasure,
    ⇒ which none o' ye shall ever see.
```

Apart from pending output line inclusion and the request names that populate them, boxes are handled exactly as diversions are. All of the following **groff** language elements can be used with them interchangeably.

<code>\n[.z]</code>	[Register]
<code>\n[.d]</code>	[Register]

Diversion requests may be nested. The read-only string-valued register `.z` contains the name of the current diversion. The read-only register `.d` contains the vertical drawing position in the diversion. If the input text is not being diverted, `.d` reports the same location as the register `nl`.

```
.nf
.di A
alpha
.di B
beta
.di
gamma
\*B
.di
delta
\*A
epsilon
    ⇒ delta
    ⇒ alpha
    ⇒ gamma
    ⇒ beta
    ⇒
    ⇒
    ⇒ epsilon
```

`\n[.h]`

[Register]

The read-only register `.h` stores the *high-water mark* on the current page or in the current diversion. It corresponds to the text baseline of the lowest line on the page.¹⁵²

```
.tm .h==\n[.h], nl==\n[nl]
    ⇒ .h==0, nl== -1
This is a test.
.br
.sp 2
.tm .h==\n[.h], nl==\n[nl]
    ⇒ .h==40, nl==120
```

As implied by the example, vertical motion does not produce text baselines and thus does not increase the value interpolated by ‘`\n[.h]`’.

`\n[dn]`

[Register]

`\n[dl]`

[Register]

After output to a (named) diversion stops, the formatter stores its vertical and horizontal sizes, to the writable registers `dn` and `dl`, respectively. Only the lines just processed are counted: for the computation of `dn` and `dl`, the requests `da` and `boxa` are handled as if `di` and `box` had been used, respectively—lines that have been already stored in the diversion (`box`) are not taken into account.

```
.\" Center text both horizontally and vertically.
.\" Macro .(c starts centering mode; .)c terminates it.
.
.\" Disable the escape character with .eo so that we
.\" don't have to double backslashes on the \"\n"s.
.eo
.de (c
.   br
.   ev (c
.   evc 0
.   in 0
.   nf
.   di @c
..
```

¹⁵² Thus, the “water” gets “higher” proceeding *down* the page.

```
.de )c
. br
. ev
. di
. nr @s (((\n[.t]u - \n[dn]u) / 2u) - 1v)
. sp \n[@s]u
. ce 1000
. @c
. ce 0
. sp \n[@s]u
. br
. fi
. rr @s
. rm @c
..
.ec
```

`\!character-sequence` [Escape sequence]
`\?character-sequence\?` [Escape sequence]

Transparently embed *character-sequence* into the current diversion, preventing the formatter from interpreting requests, macro calls, and escape sequences when reading them into a diversion. Doing so prevents them from taking effect until the diverted text is actually output. The `\!` escape sequence transparently embeds input up to and including the end of the line. The `\?` escape sequence transparently embeds input, read in copy mode, up to its own next occurrence on the input line. Use `\!` by itself to embed newlines in a diversion. The two escape sequences differ in that GNU **troff** interprets `\?` even in copy mode; recall Section 5.24.2 [Copy Mode], page 180. Consequently, comparands protected with `\?` need not be valid GNU **troff** syntax.

```
.nr x 1
.nf
.di d
\?\?\?\?\?\?\?\?\?\?\nx\?\?\?\?\?
.di
.nr x 2
.di e
.d
.di
.nr x 3
.di f
.e
.di
.nr x 4
.f
⇒ 4
```

Both escape sequences read the data in copy mode.

If `\!` is used in the top-level diversion, its argument is embedded into GNU **troff**'s device-independent output. One of its applications is control of a postprocessor that transforms the data that are subsequently read by an output driver.

Using the `\?` escape sequence in the top-level diversion produces no output at all; its argument is simply ignored.

.output [*"]character-sequence* [Request]

Emit *character-sequence* directly to GNU **troff**'s output; this usage is similar to that of `\!` when it occurs in the top-level diversion.

GNU **troff** removes a leading neutral double quote `"` from *character-sequence*, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. Recall Section 5.24.2 [Copy Mode], page 180.

Caution: Use of these features can put syntactically invalid content into the formatter's output, which **groff**'s output drivers then fail to process. One application of **output** and of `\!` from the top-level diversion is to pass instructions to a postprocessor that interprets *character-sequence* and filters it out before sending it to the output driver.

.asciify *div* [Request]

Unformat the diversion *div* in a way such that Unicode basic Latin (US-ASCII) characters, characters translated with the **trin** request, space characters, and some escape sequences that were formatted and diverted into *div* are treated like ordinary input characters when *div* is interpolated. Doing so can be useful in conjunction with the **writem** request.

When transforming a glyph node back into an input sequence that demands expression as a special character escape sequence, GNU **troff** uses the default escape character.

asciify can be also used for gross hacks; for example, the following sets register `n` to 1.

```
.tr @.
.di x
@nr n 1
.br
.di
.tr @@
.asciify x
.x
```

asciify cannot return all nodes in a diversion to their source equivalents: those produced by indexed characters (`\N`), for example, remain nodes, so the result cannot be guaranteed to be a character sequence as a macro or string is. Give the diversion name as an argument to the **pm** request

to inspect its contents and node list. Glyph parameters such as the type face and size are not preserved; use `unformat` to achieve that.

`.unformat div` [Request]

Like `asciify`, `unformat` the diversion `div`. However, `unformat` handles only tabs and spaces between words, the latter usually arising from spaces or newlines in the input. Tabs are treated as tokens, and spaces become adjustable again. The vertical sizes of lines are not preserved, but glyph information (font, type size, space width, and so on) is retained.

5.31 Punning Names

Macros, strings, and diversions share a name space; recall Section 5.5 [Identifiers], page 82. Internally, the same mechanism is used to store them. You can thus call a macro with string interpolation syntax and vice versa.

```
.de subject
Typesetting
..
.de predicate
rewards attention to detail
..
\[subject] \[predicate].
Truly.
    ⇒ Typesetting
    ⇒ rewards attention to detail Truly.
```

What went wrong? Strings don't contain newlines, but macros do. String interpolation placed a newline at the end of '`\[subject]`', and the next thing on the input was a space. Then when '`\[predicate]`' was interpolated, it was followed by the empty request '`.`' on a line by itself. If we want to use macros as strings, we must take interpolation behavior into account.

```
.de subject
Typesetting\\
..
.de predicate
rewards attention to detail\\
..
\[subject] \[predicate].
Truly.
    ⇒ Typesetting rewards attention to detail. Truly.
```

By ending each text line of the macros with an escaped RET, we get the desired effect; recall Section 5.16 [Line Continuation], page 129.¹⁵³ What would have happened if we had used only one backslash in each case?

¹⁵³ We must double the backslash. Recall Section 5.24.2 [Copy Mode], page 180.

Interpolating a string does not hide existing macro arguments. We can also place the escaped newline outside the string interpolation instead of within the string definition. Thus, in a macro, a more efficient way of doing

```
.xx \\$@
```

is

```
\\*[xx]\\
```

The latter calling syntax doesn't change the value of `\\$0`, which is then inherited from the calling macro; recall Section 5.24.1 [Parameters], page 178.

It is sometimes convenient to copy a single-line diversion to a string, which can then be interpolated with `\\*`.

```
.di xx
the
.ft I
interpolation system
.ft
.br
.di
.ds yy This is a test of \\*(xx\\c
\\*(yy.
⇒ This is a test of the interpolation system.
```

In the foregoing, we see that formatted output can thus be stored in a string. The `\\c` escape sequence prevents the subsequent newline from being interpreted as a break; again, recall Section 5.16 [Line Continuation], page 129.

Copying multi-output-line diversions produces unexpected results.

```
.di xxx
a funny
.br
test
.br
.di
.ds yyy This is \\*[xxx]\\c
\\*[yyy].
⇒ test This is a funny.
```

Usually, it is not predictable whether a diversion contains one or more output lines, so this mechanism should be avoided. With AT&T **troff**, this was the only solution to strip off a final newline from a diversion. Another disadvantage is that the spaces in the copied string are already formatted, preventing their adjustment. This can cause ugly results.

A clean solution to this problem is available in GNU **troff**, using the requests **chop** to remove the final newline of a diversion, and **unformat** to make the horizontal spaces adjustable again.

```
.box xxx
a funny
.br
test
.br
.box
.chop xxx
.unformat xxx
This is \*[xxx].
    ⇒ This is a funny test.
```

See Section 5.37 [GNU troff Internals], page 228.

5.32 Environments

As discussed in Section 5.28 [Deferring Output], page 196, environments store most of the parameters that determine the appearance of text. A default environment named ‘0’ (zero) exists when the formatter starts up; formatting-related requests and escape sequences modify its properties.

You can create new environments and switch among them. Only one is current at any given time. Active environments are managed using a *stack*, a data structure supporting “push” and “pop” operations. The current environment is at the top of the stack. The same environment name can be pushed onto the stack multiple times, possibly interleaved with others. Popping the environment stack does not destroy the current environment; it remains accessible by name and can be made current again by pushing it at any time. Environments cannot be renamed or deleted, and can only be modified when current. To inspect the environment stack, use the `pev` request.¹⁵⁴

Environments store the following information.

- a partially collected line, if any
- data about the most recently output glyph and line (registers `.cdp`, `.cht`, `.csk`, `.n`, `.w`)
- typeface parameters (size, family, style, height and slant, inter-word and inter-sentence space sizes)
- page parameters (line length, title length, vertical spacing, line spacing, indentation, line numbering, centering, right-alignment, underlining, hyphenation parameters)
- filling enablement; adjustment enablement and mode
- tab stops; tab, leader, escape, control, no-break control, hyphenation, and margin characters
- input line traps
- stroke and fill colors

¹⁵⁴ See Section 5.38 [Debugging], page 231.

<code>.ev [ident]</code>	[Request]
<code>\n[.ev]</code>	[Register]

Enter the environment *ident*, which is created if it does not already exist, using the same parameters as for the default environment used at startup. With no argument, GNU `troff` switches to the previous environment.

Invoking `ev` with an argument puts environment *ident* onto the top of the environment stack. (If it isn't already present in the stack, this is a proper push.) Without an argument, `ev` pops the environment stack, making the previous environment current. It is an error to pop the environment stack with no previous environment available. The read-only string-valued register `.ev` contains the name of the current environment—the one at the top of the stack.

```
.ev footnote-env
.fam N
.ps 6
.vs 8
.ll -.5i
.ev

...

.ev footnote-env
\[dg] Observe the smaller text and vertical spacing.
.ev
```

We can familiarize ourselves with stack behavior by wrapping the `ev` request with a macro that reports the contents of the `.ev` register to the standard error stream.

```
.de EV
.  ev \\$1
.  tm environment is now \\n[.ev]
..
.
.EV foo
.EV bar
.EV
.EV baz
.EV
.EV
.EV
```

<code>error</code>	environment is now foo
<code>error</code>	environment is now bar
<code>error</code>	environment is now foo
<code>error</code>	environment is now baz
<code>error</code>	environment is now foo
<code>error</code>	environment is now 0
<code>error</code>	error: environment stack underflow
<code>error</code>	environment is now 0

`.evc environment` [Request]

Copy the properties of *environment* to the current environment, except for:

- a partially collected line, if present;
- the interruption status of the previous input line (due to use of the `\c` escape sequence);
- the count of remaining lines to center, to right-justify, or to underline (with or without underlined spaces)—these are set to zero;
- the activation status of temporary indentation;
- input line traps and their associated data;
- the activation status of line numbering (which can be reactivated with `.nm +0`); and
- the count of consecutive hyphenated lines (set to zero).

Copying an environment to itself discards the foregoing data.

<code>\n[.w]</code>	[Register]
<code>\n[.cht]</code>	[Register]
<code>\n[.cdp]</code>	[Register]
<code>\n[.csk]</code>	[Register]

The `\n[.w]` register contains the width of the last glyph formatted in the environment.

The `\n[.cht]` register contains the height of the last glyph formatted in the environment.

The `\n[.cdp]` register contains the depth of the last glyph formatted in the environment. It is positive for glyphs extending below the baseline.

The `\n[.csk]` register contains the *skew* (how far to the right of the glyph's center that GNU `troff` should place an accent) of the last glyph formatted in the environment.

`\n[.n]` [Register]

The `\n[.n]` register contains the length of the previous output line emitted in the environment.

5.33 Suppressing Output

\0*[num]* [Escape sequence]

Suppress GNU **troff** output of glyphs and geometric objects. The sequences **\02**, **\03**, **\04**, and **\05** are intended for internal use by **grohtml**.

'\00' Disable the emission of glyphs and geometric objects to the output driver, provided that this sequence occurs at the outermost suppression level (see **\03** and **\04** below). Horizontal motions corresponding to non-overstruck glyph widths still occur.

'\01' Enable the emission of glyphs and geometric objects to the output driver, provided that this sequence occurs at the outermost suppression level.

\00 and **\01** also reset the four registers **opminx**, **opminy**, **opmaxx**, and **opmaxy** to -1 . These four registers mark the top left and bottom right hand corners of a box encompassing all written or drawn output.

'\02' At the outermost suppression level, enable emission of glyphs and geometric objects, and write to the standard error stream the page number and values of the four aforementioned registers encompassing glyphs written since the last interpolation of a **\0** sequence, as well as the page offset, line length, image file name (if any), horizontal and vertical device motion quanta, and input file name. Numeric values are in basic units.

'\03' Begin a nested suppression level. **grohtml** uses this mechanism to create images of output preprocessed with **pic**, **eqn**, and **tbl**. At startup, GNU **troff** is at the outermost suppression level. **pre-grohtml** generates these sequences when processing the document, using GNU **troff** with the **ps** output device, Ghostscript, and the PNM tools to produce images in PNG format. They start a new page if the device is not **html** or **xhtml**, to reduce the number of images crossing a page boundary.

'\04' End a nested suppression level.

'\0[5Pfile]'

At the outermost suppression level, write the name **file** to the standard error stream at position *P*, which must be one of **l**, **r**, **c**, or **i**, corresponding to left, right, centered, and inline alignments within the document, respectively. *file* is a name associated with the production of the next image.

\n*[.0]* [Register]

Output suppression nesting level applied by **\03** and **\04** escape sequences.

5.34 Host System Service Access

Occasionally a document wants to access the system clock, file storage, or other services provided by the operating environment.

`\n[$$]` [Register]
 Process identifier (PID) of the GNU `troff` program in its operating environment.

Date- and time-related registers are set per the local time as determined by `localtime(3)` when the formatter launches. This initialization can be influenced by the environment variable `TZ` or overridden by `SOURCE_DATE_EPOCH`; see Section 2.2 [Environment], page 12.

`\n[seconds]`
 Count of seconds elapsed in the minute (0–60).

`\n[minutes]`
 Count of minutes elapsed in the hour (0–59).

`\n[hours]`
 Count of hours elapsed since midnight (0–23).

`\n[dw]` Day of the week (1–7; 1 is Sunday).

`\n[dy]` Day of the month (1–31).

`\n[mo]` Month of the year (1–12).

`\n[year]` Gregorian year.

`\n[yr]` Gregorian year minus 1900. This register is incorrectly documented in the AT&T `troff` manual as storing the last two digits of the current year. That claim stopped being true in 2000. Old `troff` input that looks like:

```
'\'' The year number is a surprise after 1999.
This document was formatted in 19\n[yr].
```

can be corrected to:

```
This document was formatted in \n[year].
```

or, for portability across many `roff` programs, to the following.

```
.nr y4 1900+\n[yr]
This document was formatted in \n(y4.
```

If you wish to embed the date and/or time of a document's formatting into its output, interpolate these registers into its text. Use the `af` request to format their values for output.

```
.af year 0000
.af mo 00
.af dy 00
.af hours 00
.af minutes 00
.af seconds 00
ISO 8601 date stamp:
\n[year]-\n[mo]-\n[dy]T\n[hours]:\n[minutes]:\n[seconds]
⇒ ISO 8601 date stamp: 2025-12-07T02:17:54
```

`roff` formatters allow files to be read into the input stream. Enabling GNU `troff`'s unsafe mode at the command line permits the writing of files and execution of external commands, with or without inclusion of their output in the document.

Caution: The requests discussed below that accept a file name or system command as an argument treat the remainder of the input line as that argument, including any spaces, up to a newline or comment escape sequence. Suffixing the file name or command with a comment, even an empty one, prevents unwanted space from creeping into it during source document maintenance. GNU `troff` removes a leading neutral double quote `"` from such an argument, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. Recall Section 5.24.2 [Copy Mode], page 180.

```
.so ["]file [Request]
.squiet ["]file [Request]
```

Replace the request's control line with the contents of *file*, "sourcing" it. GNU `troff` searches for *file* in any directories specified by `-I` command-line options, followed by the current working directory. If *file* does not exist, the formatter ignores the request.¹⁵⁵

`so` can be useful for large documents, allowing each chapter of a book, for example, to be maintained in a separate file. However, files interpolated with `so` are not preprocessed; to overcome this limitation, see `soelim(1)`.

Caution: Since the formatter replaces the entire control line with the contents of a file, *file* must end with a newline, or the formatter will continue reading the next input line of the `roff` file as if it were part of the last line of the sourced file. Consider a file `xxx` containing only the word `'foo'` without a trailing newline.

¹⁵⁵ GNU `troff` emits a warning in category `'file'`. See Section 5.38.1 [Warnings], page 236.

```
$ printf 'foo' > xxx
$ groff -T ascii <<EOF
The situation is
.so xxx
bar.
EOF
```

⇒ The situation is foobar.

`soquiet` works the same way, except that GNU `troff` issues no warning diagnostic if *file* does not exist.

.pso [*command*] [Request]

Read the standard output from the specified *command* when passed to `popen(3)` and include it in place of the `pso` request.

It is an error to use this request in safer mode, which is the default. Invoke GNU `troff` or a front end with the `-U` option to enable unsafe mode.

The cautionary note regarding a final newline in the stream read by the `so` request applies to `pso` as well.

.mso [*file*] [Request]

.msoquiet [*file*] [Request]

As the `so` and `soquiet` requests, respectively, except that GNU `troff` searches for the specified *file* in the same directories as macro files; recall `GROFF_TMAC_PATH` in Section 2.2 [Environment], page 12, and `-m` in Section 2.1 [Groff Options], page 7.

.trf [*file*] [Request]

.cf [*file*] [Request]

Break and copy the contents of *file* as “throughput” to GNU `troff`’s output. Each line of *file* is output as if preceded by `\!`, but is not interpreted by the formatter. If *file* does not end with a newline, `trf` appends one. Both requests break the line before reading *file*, unless invoked with the no-break control character. If a diversion is in use, GNU `troff` performs the copy only when the diversion is emitted.

`cf` copies the contents of *file* completely unprocessed; it is therefore an error to use this request in safer mode, which is the default. Invoke GNU `troff` or a front end with the `-U` option to enable unsafe mode.

`trf` discards invalid input characters; recall Section 5.1.9 [Input Format], page 70.

For `cf`, within a diversion, “completely unprocessed” means that each line of a file to be inserted is handled as if it were preceded by `\!\!\!`.

Caution: Use of these requests can put syntactically invalid content into the formatter’s output, which `groff`’s output drivers then fail to process. One application is to pass instructions to a postprocessor that interprets *file*’s contents and filters it out before sending it to the output driver.

To define a macro `x` containing the contents of file `f`, use

```
.ev 1
.di x
.trf f
.di
.ev
```

The calls to `ev` prevent the partially collected output line from becoming part of the diversion; recall Section 5.30 [Diversions], page 208.

In AT&T `troff`, `cf` copies the contents of *file* to the output immediately even if a diversion is active; this behavior is so anomalous that it must be considered a bug.

`.nx` `[["file]` [Request]

Stop processing the input file. If *file* is specified, read it; otherwise, read the next pending input file, if any.

`.rd` `[prompt [arg1 arg2 . . .]]` [Request]

Read from standard input, and include what is read as though it were part of the input file. Text is read until a blank line is encountered.

If standard input is a TTY input device (keyboard), write *prompt* to standard error, followed by a colon (or send BEL for a beep if no argument is given).

Arguments after *prompt* are available for the input. For example, the line

```
.rd data foo bar
```

with the input `'This is \$. '` prints

```
This is bar.
```

Using the `nx` and `rd` requests, it is easy to set up form letters. The form letter template is constructed like this, putting the following lines into a file called `repeat.let`:

```
.ce
\*(td
.sp 2
.nf
.rd
.sp
.rd
.fi
Body of letter.
.bp
.nx repeat.let
```

When this is run, a file containing the following lines should be redirected in. Requests included in this file are executed as though they were part of the form letter. The last block of input is the `ex` request, which tells GNU

`troff` to stop processing. If this were not there, `troff` would not know when to stop.

Trent A. Fisher
708 NW 19th Av., #202
Portland, OR 97209

Dear Trent,

Len Adollar
4315 Sierra Vista
San Diego, CA 92103

Dear Mr. Adollar,

.ex

`.pi` [*command*] [Request]

Use the formatter's device-independent output as the input to the commands specified in *pipe* and emit their output to the standard output stream instead of the formatter's usual output. The formatter reads the remainder of the input line into *command* and passes it to *popen*(3). The formatter does not capture output produced by the command(s).

Multiple `pi` requests construct a multi-stage pipeline in the same order as the formatter encounters the requests.

```
.pi foo
.pi bar
```

is the same as '`.pi foo | bar`'.

`pi` must be invoked before GNU `troff` writes any nodes to its output.¹⁵⁶ The formatter reports an error and ignores the request if `pi` is invoked "too late". Roughly, this means you should set up your `pi` pipeline early in a document, before anything but register, string, and macro definitions (and/or sourcing of files that comprise these exclusively).

Use of this request in safer mode (GNU `troff`'s default) is erroneous. Invoke GNU `troff` or a front end with the `-U` option to enable unsafe mode.

Caution: Use of the `pi` request can put syntactically invalid content into the formatter's output, which `groff`'s output drivers then fail to process. The pipeline you construct is responsible for maintaining the validity of the input to the output driver.

¹⁵⁶ See Section 5.37 [GNU `troff` Internals], page 228.

.sy ["]*command* [Request]
\n[systat] [Register]

Execute the specified shell command(s). The formatter reads the remainder of the input line into a buffer and passes it to *system(3)*. The formatter does not capture the output produced by the command(s).

It is an error to use this request in safer mode; this is the default. Give GNU **troff** or a front end program the **-U** command-line option to enable unsafe mode.

The writable register **systat** contains the return value of the *system(3)* function executed by the most recent **sy** request.

Real-world (and non-malicious) applications of **sy** are esoteric; the request interpolates neither the standard output nor the standard error streams of *command* into the document—worse, AT&T **troff** afforded no means of verifying that *command* operated as expected. We therefore offer a silly example of its use, making a document refuse to format if the system user name running the formatter is ‘**branden**’.¹⁵⁷

```
.ds user branden\  
.sy test "$ {id -un}" = \*[user]  
.if \n[systat]=0 .ab formatting refused for \*[user]  
Hello, world!
```

.open stream ["]*file* [Request]
.opena stream ["]*file* [Request]

Open *file* for writing and associate a stream named *ident* with it, making it available for **write** requests.

The **opena** request is like **open**, but appends to *file* if it already exists instead of overwriting it.

It is an error to use these requests in safer mode; this is the default. Give GNU **troff** or a front end program the **-U** command-line option to enable unsafe mode.

The **pstream** request dumps the list of open streams to the standard error stream.¹⁵⁸

.write stream ["]*contents* [Request]
.writel stream ["]*contents* [Request]

Write *contents* to *stream*, which must previously have been the subject of an **open** (or **opena**) request. GNU **troff** flushes the stream after writing to it.

The **writel** request is like **write**, but only **write** appends a newline to *contents*.

¹⁵⁷ POSIX command environments and **roff** formatters employ different integer-to-Boolean interpretation conventions; a POSIX command exits with a zero status if it succeeds and a positive one if it fails, whereas a **roff** register tests “true” if it has a positive value.

¹⁵⁸ See Section 5.38 [Debugging], page 231.

.writem *stream name* [Request]

Write the contents of the macro or string *name* to *stream*, which must previously have been the subject of an **open** (or **opena**) request. GNU **troff** reads the contents of *name* in copy mode. That is, it ignores already formatted elements (nodes). Consequently, diversions must be unformatted with the **asciify** request before calling **writem**. Usually, this means a loss of information.

.close *stream* [Request]

Close the specified *stream*; the stream is no longer an acceptable argument to the **write** request.

Here a simple macro to write an index entry.

```
.open idx test.idx
.
.de IX
.  write idx \\n[%] \\$*
..
.
.IX test entry
.
.close idx
```

\Ve [Escape sequence]

\V(ev [Escape sequence]

\V[env] [Escape sequence]

Interpolate the contents of the system environment variable *env* (one-character name *e*, two-character name *ev*) as returned by *getenv(3)*. **\V** is interpreted even in copy mode; recall Section 5.24.2 [Copy Mode], page 180.

5.35 Postprocessor Access

Beyond the **cf** and **trf** requests (recall Section 5.34 [Host System Service Access], page 220), two escape sequences and two requests enable documents to pass information directly to a postprocessor. These are useful for exercising device-specific capabilities that the **groff** language does not abstract or generalize; examples include the embedding of hyperlinks and image files. Device-specific functions are documented in each output driver's man page, such as *gropdf(1)*, *grops(1)*, or *grotty(1)*.

.device ["*character-sequence*"] [Request]

\X'contents ...' [Escape sequence]

Embed *character-sequence* into GNU **troff** output as parameters to an '**x X**' device extension command.¹⁵⁹ The output driver or other postprocessor interprets *character-sequence* as it sees fit.

¹⁵⁹ See Section 6.2 [GNU **troff** Output], page 253.

GNU **troff** removes a leading neutral double quote “” from *contents*, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. Recall Section 5.24.2 [Copy Mode], page 180.

The **groff** special character repertoire is unknown to output drivers outside of glyphs named in a device’s fonts, and even then they may not possess complete coverage of the names documented in the *groff_char*(7) man page. Further, escape sequences that produce horizontal or vertical motions, hyphenation breaks, or that are dummy characters may appear in strings or be converted to nodes, particularly in diversions.¹⁶⁰ These are not representable when interpolated directly into device-independent output, as might be done when writing out tag names for PDF book-marks, which can appear in a viewer’s navigation pane.

So that documents or macro packages do not have to laboriously “sanitize” strings destined for interpolation in device extension commands, the `\X` escape sequence performs certain transformations on its argument. For these transformations, character translations and definitions are ignored.

GNU **troff** converts several ordinary characters that typeset as non-basic Latin code points to code points outside that range so that they are used consistently whether they are formatted as glyphs or used in a device extension command argument. These ordinary characters are ‘`’`’, ‘`-`’, ‘`^`’, ‘`~`’, and ‘`~`’; others are written as-is.

Special characters that typeset as Unicode basic Latin characters are translated to basic Latin characters accordingly. So that any Unicode code point can be represented in device extension commands, for example in an author’s name in document metadata or as a usefully named bookmark or hyperlink anchor, GNU **troff** maps other special characters to Unicode special character notation. Recall Section 5.19.4 [Characters and Glyphs], page 140.

GNU **troff** does not write special characters without a Unicode representation and escape sequences that do not interpolate a sequence of ordinary and/or special characters as arguments to device extension commands.¹⁶¹

GNU **troff** also permits the interpolation of macro or string contents as a device extension command.

<code>.devicem name</code>	[Request]
<code>\Yn</code>	[Escape sequence]
<code>\Y(nm</code>	[Escape sequence]
<code>\Y[name]</code>	[Escape sequence]

The `devicem` request and `\Y` escape sequence correspond to ‘`.device` `\*[name]`’ and ‘`\X'\*[name]`’ (one-character name *n*, two-character name *nm*), respectively. They differ from their counterparts in that GNU

¹⁶⁰ See Section 5.37 [GNU **troff** Internals], page 228.

¹⁶¹ When encountered, these produce warnings in category ‘`char`’. See Section 5.38.1 [Warnings], page 236.

troff does not interpret the contents of the string or macro *name*; further, *name* may be a macro and thus contain newlines. (There is no way to embed a newline in the arguments to **device** or **\X**.) The inclusion of newlines requires an extension to the AT&T **troff** device-independent page description language, and their presence confuses drivers that do not know about it.¹⁶²

Use of device extension commands early in a document (before the first text is formatted) can interfere with processing of page location traps. If you experience problems when placing them early, precede the first with a dummy character escape sequence **\&**; recall Section 5.19.10 [Dummy Characters], page 154.

.tag <i>name</i>	[Request]
.taga <i>name</i>	[Request]
Reserved for internal use.	

5.36 Miscellaneous

We document here GNU **troff** features that fit poorly elsewhere.

.psbb <i>file</i>	[Request]
\n[llx]	[Register]
\n[lly]	[Register]
\n[urx]	[Register]
\n[ury]	[Register]

Retrieve the bounding box of the PostScript image found in *file*, which must conform to Adobe's *Document Structuring Conventions* (DSC), locate a **%%BoundingBox** comment, and store the (upper-, lower-, -left, -right) values into the registers **llx**, **lly**, **urx**, and **ury**. If an error occurs (for example, if no **%%BoundingBox** comment is present), the formatter sets these registers to 0.

Control the search path for *file* with the **-I** command-line option.

5.37 GNU troff Internals

GNU **troff** processes input in three steps. It gathers one or more input characters into a *token*,¹⁶³ the smallest meaningful unit of **troff** input. The process of formatting translates tokens into nodes that populate a pending output line (recall Section 5.9 [Manipulating Filling and Adjustment], page 101). A *node* is a data structure representing any object that may ultimately appear in the output, like a glyph or motion on the page. When the pending output line breaks, the formatter applies any relevant adjustment,

¹⁶² See Section 6.2.2.4 [Device Control Commands], page 261.

¹⁶³ When not in copy mode, the formatter does not tokenize the escape sequences **\f**, **\F**, **\H**, **\m**, **\M**, **\R**, **\s**, and **\S**, but instead updates the environment.

line number, and margin character, and finally appends it to the current diversion. Periodically, the formatter *flushes* accumulated output line(s) to the output device, a process that translates each node into a device-independent output language representation understood by all output drivers. Copy mode tokenizes but does not format; diversions (apart from that at the top level) format but do not write output.

For example, GNU **troff** converts the input ‘**Gi**[:u]\%seppe’ into a character token for ‘**g**’, a character token for ‘**i**’, a special character token for ‘:u’ (representing ‘u’ with an umlaut), a token encoding a hyphenation break point,¹⁶⁴ and further character tokens. You can observe this process by storing the foregoing input into a string—which, because its contents are read in copy mode, is only tokenized, not formatted—and dumping it with the **pm** request.¹⁶⁵ (Using *printf*(1) requires us to double the ‘\’ and ‘%’ characters.)

```
$ printf '.ds str Gi\[:u]\%%seppe\n.pm str\n' \
| groff 2>&1 | jq
```

Similarly, we can observe the details of the formatting process by interpolating the string, or supplying its contents directly as input, and invoking the **pline** request.

```
$ printf 'Gi\[:u]\%%seppe\n.pline\n' | groff -z 2>&1 | jq
```

We now see a list of nodes, including an output line start node, several glyph nodes, a discretionary break node containing a glyph node for the special character ‘:u’ and a glyph node for the special character ‘hy’ (hyphen), and a word space node at the end corresponding to the newline at the end of input.¹⁶⁶

If we change ‘**G**’ to ‘**f**’, we see that the first two glyph nodes, for ‘**f**’ and ‘**i**’, become contained by a ligature node (provided the current font has a glyph for this ligature). All output glyph nodes are “processed”, which means that they are associated with a given font, type size, advance width, and so forth.

Macros, diversions, and strings collect elements in two chained lists: a list of tokens that have been passed unprocessed, and a list of nodes. Consider the following diversion.

¹⁶⁴ GNU **troff** encodes tokens that aren’t Unicode Basic Latin characters as code points in the C0 and C1 control ranges; we plan to move them to the Unicode Private Use Area (PUA) or to code points outside the Unicode encoding space in a future release.

¹⁶⁵ Because GNU **troff**’s internals are subject to revision, we do not show the output of these examples. The names and structures of node types may change over time. The JSON interpreter *jq*(1) is not essential, but can be helpful in understanding the topology of the node trees populating output lines and diversions in particular.

¹⁶⁶ You may wonder why a glyph node for ‘hy’ exists when this example doesn’t produce one on the output. That’s because the break is *discretionary*; at the time a word is formatted into nodes, GNU **troff** doesn’t know where the output line will break. Later, when processing a pending output line, GNU **troff** has that knowledge, and iterates through the output line’s node list, using its discretion to discard these hyphen glyph nodes everywhere except when hyphenating a word at the end of the line.

```
.di xxx
a
\!b
c
.br
.di
```

It contains these elements.

node list	token list	element number
<i>line start node</i>	—	1
<i>glyph node a</i>	—	2
<i>word space node</i>	—	3
—	b	4
—	\n	5
<i>glyph node c</i>	—	6
<i>vertical size node</i>	—	7
<i>vertical size node</i>	—	8
—	\n	9

troff inserts elements 1, 7, and 8; the latter two (which are always present) specify the vertical extent of the last line, possibly modified by **\x**. The **br** request finishes the pending output line, inserting a newline token, which is subsequently converted to a space when the diversion is interpolated. Note that the word space node has a fixed width that isn't adjustable anymore. To convert horizontal space nodes back into tokens, use the **unformat** request.

Macros only contain elements in the token list (and the node list is empty); diversions and strings can contain elements in both lists.

The **chop** request simply reduces the number of elements in a macro, string, or diversion by one. Exceptions are *compatibility save* and *compatibility ignore* tokens, which are ignored. The **substring** request also ignores those tokens.

Some requests like **tr** or **cflags** work on glyph identifiers only; this means that the associated glyph can be changed without destroying this association. This can be very helpful for substituting glyphs. In the following example, we assume that glyph 'foo' isn't available by default, so we provide a substitution using the **fchar** request and map it to input character 'x'.

```
.fchar \[foo] foo
.tr x \[foo]
```

Now let us assume that we install an additional special font 'bar' that has glyph 'foo'.

```
.special bar
.rchar \[foo]
```

Since glyphs defined with **fchar** are searched before glyphs in special fonts, we must call **rchar** to remove the definition of the fallback glyph. Anyway, the translation is still active; 'x' now maps to the real glyph 'foo'.

Macro and request arguments preserve compatibility mode enablement.

```
.cp 1      \" switch to compatibility mode
.de xx
\\$1
..
.cp 0      \" switch compatibility mode off
.xx caf\['e]
⇒ café
```

Since compatibility mode is enabled while **de** is invoked, the macro **xx** enables compatibility mode when it is called. Argument **\$1** can still be handled properly because it inherits the compatibility mode enablement status that was active at the point where **xx** was called.

After interpolation of the parameters, the compatibility save and restore tokens are removed.

5.38 Debugging

Standard troff voodoo, just put a power of two backslashes in front of it until it works and if you still have problems add a \c.

— Ron Natalie

The **roff** language family is not the easiest to debug, in part thanks to its design features of recursive interpolation and the use of multi-stage pipeline processing in the surrounding system. Nevertheless there exist several features useful for troubleshooting.

Preprocessors use the **lf** request to preserve the identity of the line numbers and names of input files. GNU **troff** emits a variety of error diagnostics and supports several categories of warning; the output of each category can be selectively enabled or suppressed. A trace of the formatter's input processing stack can be emitted when errors or warnings occur by means of GNU **troff**'s **-b** option, or produced on demand with the **backtrace** request. The **tm** and related requests can be used to emit customized diagnostic messages or for instrumentation while troubleshooting. The **ex** and **ab** requests cause early termination with successful and error exit codes respectively, to halt further processing when continuing would be fruitless. Examine the state of the formatter with requests that write lists of defined names—macros, strings, and diversions—colors, composite character mappings, environments, occupied font mounting positions, font translations, automatic hyphenation codes and exceptions, registers, open streams, and page location traps. Requests can also disclose to the standard error stream the internal properties and representations of characters and classes, macros (and strings and diversions), and the list of output nodes corresponding to the pending output line. Recall Section 5.37 [GNU **troff** Internals], page 228.

.lf *input-line-number* **[["]*file-identifier*]** [Request]

Set the input line number (and, optionally, the file name) the formatter uses when reporting diagnostics. The argument becomes the input line number of the *next* line the formatter reads. *file-identifier* is a sequence of ordinary characters and/or spaces. GNU **troff** removes a leading neutral double quote “” from *file-identifier*, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. Recall Section 5.24.2 [Copy Mode], page 180.

lf’s primary purpose is to aid the debugging of documents that undergo preprocessing. Programs like **tbl** that transform input in their own languages into **roff** requests use it so that any diagnostic messages emitted by a subsequent preprocessor or by **troff** correspond to the source document.

.tm *terminal-message* [Request]

.tm1 **[“]*message*]** [Request]

.tmc **[“]*message*]** [Request]

Send *terminal-message* to the standard error stream. The formatter reads the argument to the end of the input line in copy mode (recall Section 5.24.2 [Copy Mode], page 180), but does *not* remove a leading double quote; contrast **tm1**.

tm1 removes a leading neutral double quote “” from *message*, permitting initial embedded spaces in it.

tmc works as **tm1**, but does not append a newline.

.ab **[*terminal-message*]** [Request]

Write any *terminal-message* to the standard error stream (like **tm**) and then abort the formatter; that is, stop processing and terminate with a failure status. Aborting does not flush a partially collected line, a potentially significant fact if you’re using **ab** to “bisect” a troublesome document or macro definition; see the **fl** request below.

.ex [Request]

Exit the formatter; that is, stop processing and terminate successfully. To stop processing only the current file, use the **nx** request; recall Section 5.34 [Host System Service Access], page 220.

When doing something complicated, it is useful to leave the debugging statements in the code and have them turned on by a command-line flag.

```
.if \n[DB] .tm debugging output
```

To activate such statements, use the **-r** option to set the register.

```
groff -rDB=1 file
```

If you know in advance that there are many errors and no useful output, or are interested *only* in diagnostic output, you can suppress GNU **troff**’s formatted output with its **-z** option.

- .pchar** *c* ... [Request]
Report, to the standard error stream, information about each character (be it ordinary, special, or indexed) or character class *c*. A character defined by a request (**char**, **fchar**, **fschar**, or **schar**) reports its contents as a JSON-encoded string, but the output is not otherwise in JSON format.
- .pcolor** [*col* ...] [Request]
Report, to the standard error stream, each defined color named *col*, its color space identifier, and channel value assignments, or, without arguments, those of all defined colors. A device's default stroke and/or fill colors, "default", are not listed since they are immutable and their details unknown to the formatter.
- .pcomposite** [Request]
Report, to the standard error stream, the list of configured composite character mappings. Recall the **composite** request description in Section 5.19.4 [Characters and Glyphs], page 140. The "from" code point is listed first, followed by its "to" mapping.
- .pev** [Request]
Report the state of the current environment followed by that of all other environments to the standard error stream.
- .pfp** [Request]
Report, to the standard error stream, the list of occupied font mounting positions. Recall the **fp** request description in Section 5.19.1 [Selecting Fonts], page 135. Occupied mounting positions are listed, one per line, in increasing order, followed by the typeface name; if the name corresponds to an abstract style, the entry ends there. Otherwise, the name of the font description file and the font's "internal name" datum, the meaning of which varies by output device, follow.
- .pfttr** [Request]
Report, to the standard error stream, the list of font translations. Recall the **fttr** request description in Section 5.19.1 [Selecting Fonts], page 135. The "from" font identifier is listed first, followed by its "to" translation.
- .phw** [Request]
Report, to the standard error stream, the list of hyphenation exception words associated with the hyphenation language selected by the **hla** request; recall Section 5.10 [Manipulating Hyphenation], page 108. A '-' marks each hyphenation point. A word prefixed with '-' is not hyphenated at all. The report suffixes words to which automatic hyphenation applies (meaning those defined in a hyphenation pattern file rather than with the **hw** request) with a tab and asterisk (*).
- .pline** [Request]
Report, in JSON syntax to the standard error stream, the list of output nodes corresponding to the pending output line. In JSON, a pair of empty

brackets ‘[]’ represents an empty list. A *pending* output line has not yet undergone adjustment, and lacks a line number and margin character (all as applicable).

.pm [*name* ...] [Request]

Report, to the standard error stream, the JSON-encoded name and contents of each macro, string, or diversion *name*, or, without arguments, the names of all defined macros, strings, and diversions and their lengths in characters or nodes.

.pnr [*reg* ...] [Request]

Report the name and value and, if its type is numeric, the autoincrement amount and assigned format of each register *reg*, or, without arguments, those of all defined registers, to the standard error stream.

.pstream [Request]

Report, in JSON syntax to the standard error stream, the list of open streams, including the name of each open stream, the name of the file backing it, and its mode (writing or appending). In JSON, a pair of empty brackets ‘[]’ represents an empty list.

.pwh [Request]

Report the names and positions of all page location traps to the standard error stream. GNU **troff** reports empty slots in the list, where a trap had been planted but subsequently (re)moved, because they can affect the visibility of subsequently planted traps.

.fl [Request]

Break the line and flush any pending output line immediately. The effect is the same as the **br** request unless the no-break control character is used; ‘**br**’ does nothing, whereas ‘**fl**’ writes the pending output line without further updating the drawing position. However, the *reported* horizontal drawing position is still reckoned from the start of the input line.

```
foo \n(hp
bar \c
'fl
\n(hp baz \n(hp
⇒ foo 96 bar 0 baz 144
```

Flush timing is most easily perceived in device-independent output.

Use of ‘**fl**’ may be desirable immediately prior to an **ab** request when troubleshooting a document or macro definition line by line, because a significant number of formatting operations can accumulate on a partially collected output line, misleading you about “where” the abort “really” took place.

Historically, **fl** was used with **rd** to produce interactive **nroff** documents. GNU **troff** does not easily support that mode of operation, because its output for terminals is first prepared in device-independent format, which **groty** renders a page at a time.

.backtrace [Request]

Write the state of the input stack to the standard error stream.

Consider the following in a file **test**.

```
.de xxx
.  backtrace
..
.de yyy
.  xxx
..
.
.yyy
```

error	troff: backtrace: 'test':2: macro 'xxx'
error	troff: backtrace: 'test':5: macro 'yyy'
error	troff: backtrace: file 'test':8

The **-b** option of GNU **troff** causes a backtrace to be generated on each error or warning. Some warnings have to be enabled; see Section 5.38.1 [Warnings], page 236.

\n[slimit] [Register]

If greater than 0, sets the maximum quantity of objects on GNU **troff**'s internal input stack. If less than or equal to 0, there is no limit: recursion can continue until program memory is exhausted. The default is 1,000.

.warnscale *scaling-unit* [Request]

Set the scaling unit used in certain warnings (one of 'u', 'i', 'c', 'p', and 'P'; default: 'i'). Ignored on **nroff**-mode output devices, for which these diagnostics report the vertical page location in lines, and the horizontal page location in ens.

.spreadwarn [*limit*] [Request]

Emit a **break** warning if the additional space inserted for each space between words in an output line adjusted to both margins with '**.ad b**' is larger than or equal to *limit*. A negative value is treated as zero; an absent argument toggles the warning on and off without changing *limit*. The default scaling unit is 'm'. At startup, **spreadwarn** is inactive and *limit* is 3m.

For example,

```
.spreadwarn 0.2m
```

causes a warning if **break** warnings are not suppressed and GNU **troff** must add 0.2m or more for each inter-word space in a line. See Section 5.38.1 [Warnings], page 236.

.warn [*n*] [Request]**\n[.warn]** [Register]

Select categories of warnings to be reported. *n* is the sum of the numeric codes associated with each warning category that is to be enabled; all

other categories are disabled. The categories and their associated codes are listed in Section 5.38.1 [Warnings], page 236. For example, `‘.warn 0’` disables all warnings, and `‘.warn 1’` disables all warnings except those about missing glyphs. If no argument is given, all warning categories are enabled.

The read-only register `.warn` contains the sum of the numeric codes of enabled warning categories.

GNU `troff` has command-line options for reporting warnings (`-w`), suppressing them (`-W`), and issuing backtraces (`-b`) when a warning or an error occurs.

5.38.1 Warnings

GNU `troff` divides its warning diagnostics into named, numbered categories. The `-w` and `-W` options use the associated names. A power of two characterizes each category; the `warn` request and the `.warn` register respectively set and report the sum of enabled category codes. Warnings of each category are produced under the following circumstances.

`‘char’`

`‘1’` No user-defined character of the requested name or index exists and no mounted font defines a glyph for it, or input could not be encoded for device-independent output. This category is enabled by default.

`‘break’`

`‘4’` A filled output line could not be broken such that its length was less than or equal to, or adjusted such that its length was exactly equal to, the output line length `‘\n[.1]’`. GNU `troff` reports the amount of overset or underset in the scaling unit configured by the `warnscale` request in `troff` mode, and in `ens` (`‘n’`; character cells) in `nroff` mode. See Section 5.14 [`troff` and `nroff` Modes], page 125. This category is enabled by default.

`‘delim’`

`‘8’` The selected delimiter character was ambiguous because it is also meaningful when beginning a numeric expression, or the closing delimiter in an escape sequence was missing or mismatched.

A future `groff` release may reject ambiguous delimiters. In compatibility mode, ambiguous delimiters are accepted without warning.

`‘scale’`

`‘32’` A scaling unit inappropriate to its context was used in a numeric expression.

`‘range’`

`‘64’` A numeric expression was out of range for its context.

<code>'syntax'</code> <code>'128'</code>	A self-contradictory hyphenation mode or character flags were requested; an empty or incomplete numeric expression was encountered; an operand to a numeric operator was missing; an attempt was made to format characters or spaces on an input line after an output line continuation escape sequence; a recognized but inapposite escape sequence or unprintable character code was used in a device extension command; an attempt was made to define a recursive, empty, or nonsensical character class; or a <code>groff</code> extension escape sequence or conditional expression operator was used while in compatibility mode.
<code>'di'</code> <code>'256'</code>	A <code>di</code> , <code>da</code> , <code>box</code> , or <code>boxa</code> request was invoked without an argument when there was no current diversion.
<code>'mac'</code> <code>'512'</code>	An undefined string, macro, or diversion was used. When such an object is dereferenced, an empty one of that name is automatically created. So, unless it is later deleted, GNU <code>troff</code> issues at most one warning for each. GNU <code>troff</code> also uses this category to warn of an attempt to move an unplanted trap macro; recall Section 5.29.1.1 [Page Location Traps], page 198. In such cases, the unplanted macro is <i>not</i> dereferenced, so it is not created if it does not exist.
<code>'reg'</code> <code>'1024'</code>	An undefined register was used. When an undefined register is dereferenced, the formatter automatically defines it with a value of 0. So, unless it is later deleted, GNU <code>troff</code> issues at most one warning for each.
<code>'tab'</code> <code>'2048'</code>	A tab character appeared in a parameterized escape sequence, in an unquoted macro argument, or where a request expected a numeric expression argument.
<code>'missing'</code> <code>'8192'</code>	A request was invoked with a mandatory argument absent.
<code>'input'</code> <code>'16384'</code>	An invalid character occurred on the input stream.
<code>'escape'</code> <code>'32768'</code>	An unsupported escape sequence was encountered.
<code>'space'</code> <code>'65536'</code>	A space was missing between a request or macro and its argument. This warning is produced when an undefined name longer than two characters is encountered and the first two characters

of the name constitute a defined name. No request is invoked, no macro called, and an empty macro is not defined. This category is enabled by default. It never occurs in compatibility mode.

‘font’	
‘131072’	A non-existent font was selected. This category is enabled by default.
‘ig’	
‘262144’	An invalid escape sequence occurred in input ignored using the ig request. This warning category diagnoses a condition that is an error when it occurs in non-ignored input.
‘color’	
‘524288’	An undefined color was selected, an attempt was made to define a color using an unrecognized color space, an invalid channel value in a color definition was encountered, or an attempt was made to redefine a default color.
‘file’	
‘1048576’	An attempt was made to read a file that does not exist, or a stream remained open at formatter exit. This category is enabled by default.

Two warning names group other warning categories for convenience.

‘all’	All warning categories except ‘di’, ‘mac’ and ‘reg’. This shorthand is intended to produce all warnings that are useful with macro packages written for AT&T troff and its descendants, which have less fastidious diagnostics than GNU troff .
‘w’	All warning categories. Authors of documents and macro packages targeting groff are encouraged to use this setting.

5.39 Implementation Differences

GNU **troff** has a number of features that cause incompatibilities with documents written for other versions of **troff**. Some GNU extensions to **troff** have become supported by other implementations.

5.39.1 Safer Mode

GNU **troff** operates in *safer mode* by default; to mitigate risks from untrusted input documents, it disables the **cf**, **pi**, and **sy** requests. GNU **troff**’s **-U** option enables “unsafe mode”, restoring their function and enabling additional extension requests, **open**, **opena**, and **pso**. Recall Section 5.34 [Host System Service Access], page 220.

5.39.2 Compatibility Mode

Some syntactical and behavioral differences between GNU and AT&T **troffs** are thought too important to neglect; GNU **troff** therefore makes available

a *compatibility mode* in an effort to keep documents prepared for AT&T **troff** rendering well.

Identifiers of arbitrary length may be GNU **troff**'s most obvious innovation. AT&T **troff** interprets `‘.dsabcd’` as defining a string `‘ab’` with contents `‘cd’`. Normally, GNU **troff** interprets this input as calling a macro named `dsabcd`. AT&T **troff** also interprets `‘\*[’` and `‘\n[’` as interpolating a string or register, respectively, named `‘[’`. GNU **troff**, however, normally interprets `‘[’` as bracketing a long name (with `‘]’` at the distal end). In compatibility mode, GNU **troff** interprets names in the traditional way; they thus can be two characters long at most.

<code>.cp [b]</code>	[Request]
<code>\n[.C]</code>	[Register]

Enable or disable AT&T **troff** compatibility mode per Boolean expression *b*. It is disabled by default, and enabled if *b* is omitted. In compatibility mode, long names are not recognized, and the incompatibilities they cause do not arise.

The read-only register `.C` interpolates 1 if compatibility mode is enabled, 0 otherwise.

GNU **troff**'s `-C` command-line option causes it to start up in compatibility mode.

<code>.do name [argument ...]</code>	[Request]
<code>\n[.cp]</code>	[Register]

Interpret the string, request, diversion, or macro *name* (along with any further arguments) with compatibility mode disabled. Compatibility mode is restored (only if it was active) when the interpolation of *name* is interpreted; that is, the restored compatibility state applies to the request or contents of the macro, string, or diversion *name*, its arguments, and data read from files or pipes if *name* is the `so`, `soquiet`, `mso`, `msoquiet`, or `pso` request.

The following example illustrates several aspects of `do` behavior.

```

.de mac1
F00
..
.de1 mac2
groff
.mac1
..
.de mac3
compatibility
.mac1
..
.de ma
\\$1
..
.cp 1
.do mac1
.do mac2 \" mac2, defined with .de1, calls "mac1"
.do mac3 \" mac3 calls "ma" with argument "c1"
.do mac3 \[ti] \" groff syntax accepted in .do arguments
    ⇒ F00 groff F00 compatibility c1 ~

```

The read-only register `.cp`, meaningful only when dereferenced from a `do` request, is 1 if compatibility mode was on when the `do` request was encountered, and 0 if it was not. This register is specialized and may require a statement of rationale.

When writing macro packages or documents that use GNU `troff` features and which may be mixed with other packages or documents that do not—common scenarios include serial processing of man pages or use of the `so` or `mso` requests—you may desire correct operation regardless of compatibility mode enablement in the surrounding context. It may occur to you to save the existing value of `\n(.C` into a register, say, `‘_C’`, at the beginning of your file, turn compatibility mode off with `‘.cp 0’`, then restore it from that register at the end with `‘.cp \n(_C’`. At the same time, a modular design of a document or macro package may lead you to multiple layers of inclusion. You cannot use the same register name everywhere lest you “clobber” the value from a preceding or enclosing context. The two-character register name space of AT&T `troff` is confining, but employing GNU `troff`’s more capacious one, as with `‘.nr _my_saved_C \n(.C’`, does not work in compatibility mode; the register name is too long. Employing the `do` request is no help: `‘.do nr _my_saved_C \n(.C’` always saves zero to the register, because `do` turns compatibility mode *off* while it interprets its argument list.

To robustly save compatibility mode before switching it off, use

```

.do nr _my_saved_C \n[.cp]
.cp 0

```

at the beginning of your file, followed by

```
.cp \n[_my_saved_C]
.do rr _my_saved_C
```

at the end. As the C language exposes application programs' symbols to those defined by libraries, **roff** documents share a name space with macro packages; choose a register name that is unlikely to collide with other uses.

Normally, GNU **troff** tracks the nesting depth of interpolations. In compatibility mode, it does not.

```
.ds xx '
\w'abc\*(xxdef'
⇒ 168 (not in compatibility mode on a terminal device)
⇒ 72def' (compatibility mode on a terminal device)
```

The escape sequences **\f**, **\H**, **\m**, **\M**, **\R**, **\s**, and **\S** are transparent to control character recognition at the beginning of a line, or after the conditional expression of an **if** or **ie** request, only in compatibility mode. That is, upon interpreting them, GNU **troff** normally no longer recognizes a control character on the input line; but in compatibility mode, it does, just like AT&T **troff**. Thus the next example produces bold output in both modes, but the text differs.

```
.de xx
Hello!
..
\fB.xx\fP
⇒ .xx (not in compatibility mode)
⇒ Hello! (in compatibility mode)
```

Normally, the syntax form **\sn** accepts only a single character (a digit) for *n*, consistently with other forms that originated in AT&T **troff**, like *****, **\f**, **\g**, **\k**, **\n**, and **\z**. In compatibility mode only, a non-zero *n* must be in the range 4–39. Legacy documents relying upon this quirk of parsing¹⁶⁷ should migrate to another **\s** form.

In compatibility mode, the **de**, **am**, **ds**, and **as** requests behave as **de1**, **am1**, **ds1**, and **as1**, respectively: GNU **troff** inserts a *compatibility save* token at the beginning of the macro, string, or appendment thereto as applicable and a *compatibility restore* token at its end, enabling compatibility mode during its interpolation.¹⁶⁸ Thus they work as expected even if the interpolation context disables compatibility mode.

AT&T **troff** recognized slightly varying sets of delimiters when expecting numerical expressions (as with the **\h** escape sequence), string expressions

¹⁶⁷ The Graphic Systems C/A/T phototypesetter (the original device target for AT&T **troff**) supported only a few discrete type sizes in the range 6–36 points, so Ossanna contrived a special case in the parser to do what the user must have meant. Kernighan warned of this in the 1992 revision of CSTR #54 (§2.3), and more recently, McIlroy referred to it as a “living fossil”.

¹⁶⁸ Recall Section 5.22 [Strings], page 163.

(as with the `\w` escape sequence and `tl` request), and output comparisons (as in `.if #foo#bar# .tm match`). GNU `troff`, when not in compatibility mode, recognizes a single consistent set of delimiters. Compatibility mode emulates AT&T `troff` only up to a point. GNU `troff` accepts leaders and tabs as delimiters, as well as `Control+D` (EOT or EOF), `Control+H` (BS or backspace), and `Control+L` (FF or form feed), all of which, when used as delimiters, cause AT&T `troff` to behave in ways difficult to predict.

5.39.3 Other Differences

GNU `troff` does not emit output if it has nothing to format. For example, it treats an input document consisting solely of `nr` and `tm` requests as empty, and produces nothing on its standard output stream. AT&T `troff` does, creating a blank page.

Use of C0 control characters in identifiers is not portable; Solaris, Plan 9, and Heirloom Doctools `troffs` accept `Control+B`, `Control+C`, `Control+E`, `Control+F`, and `Control+G` (only); DWB 3.3 `troff` does not. GNU `troff` rejects C0 controls in identifiers with an error diagnostic.

Formatters that don't implement GNU `troff` extension request names tend to ignore them, and if they don't support a GNU `troff` extension escape sequence, they are liable to format its function selector character as text. For example, the adjustable, non-breaking space escape sequence `\~` is also supported by Heirloom Doctools `troff` 050915 (September 2005), `mandoc` 1.9.5 (2009-09-21), `neatroff` (commit 1c6ab0f6e, 2016-09-13), and Plan 9 from User Space `troff` (commit 93f8143600, 2022-08-12), but not by Solaris or Documenter's Workbench `troffs`, which both render it as `~`. Recall Section 5.9 [Manipulating Filling and Adjustment], page 101. GNU `troff`'s features sometimes cause incompatibilities with documents written assuming old implementations of `troff`.

AT&T `troff` discards trailing spaces from input lines, like GNU `troff`, but when it does so, AT&T `troff` also cancels end-of-sentence detection. Use of the dummy character escape sequence `\&` is more portable.

When adjusting output lines to both margins, AT&T `troff` at first adjusts spaces starting from the right; GNU `troff` begins from the left. Both implementations adjust spaces from opposite ends on alternating output lines in this adjustment mode to prevent “rivers” in the text.

GNU `troff` does not always hyphenate words as AT&T `troff` does. The AT&T implementation uses a set of hard-coded rules specific to U.S. English, while GNU `troff` uses language-specific hyphenation pattern files derived from `TeX`. Some versions of `troff` reserved meager storage for hyphenation exception words (arguments to the `hw` request); GNU `troff` has no such restriction. When the `hy` request is invoked without an argument, GNU `troff` sets the automatic hyphenation mode to the value of the `.hydefault` register; the AT&T implementation sets it to `'1'`, which is not suitable in GNU `troff` for some languages, including English.

Unlike GNU **troff**, AT&T **troff** does not recognize an occurrence of `\%` at the beginning of a word as suppressing its hyphenation; instead, it (uselessly) marks the start of the word as a potential hyphenation point, permitting output lines to end with hyphens that are not interior to a word.

GNU **troff** handles the dummy character `\&` differently from AT&T **troff** when it is followed by the hyphenation control escape sequence `\%` at the beginning of a word. GNU **troff** does not regard the dummy character as “starting” the word; AT&T **troff** does. Further, Heirloom Doctools **troff** does not honor an explicit hyphenation point marked with `\%` after a word-initial one.¹⁶⁹

GNU **troff** interprets request arguments representing file names and system commands in the same way it does the *contents* argument to the **ds** and **as** requests: it removes a leading neutral double quote `"` from the argument to the **cf**, **nx**, **pi**, **so**, and **sy** requests, and the second argument (if present) to the **lf** request, permitting initial embedded spaces in it, and reads it to the end of the input line in copy mode. Recall Section 5.24.2 [Copy Mode], page 180. This difference permits the formatter to handle files with spaces in their names, but requires more care with trailing comments, and doubling of an initial neutral double quote `"` if the file name has one.

The existence of the `.T` string is a common feature of device-independent **troffs**—DWB 3.3, Solaris, Heirloom Doctools, and Plan 9 **troffs** all support it—but valid values are specific to each implementation.

The (read-only) register `.T` interpolates 1 if GNU **troff** is run with the `-T` option, and 0 otherwise. In contrast, AT&T **troff** interpolated 1 only if **nroff** was the formatter and was run with `-T`.

AT&T **troff** ignored attempts to remove read-only registers; GNU **troff** honors such requests. Recall Section 5.8.5 [Built-in Registers], page 100.

The **lf** request sets the number of the *current* input line in AT&T **troff** and the *next* in GNU **troff**.

AT&T **troff** had only environments named `'0'`, `'1'`, and `'2'`. In GNU **troff**, any number of environments may exist, using any valid identifiers for their names. Recall Section 5.5 [Identifiers], page 82.

As noted in Section 5.20.3 [Using Fractional Type Sizes], page 159, AT&T **troff**'s **ps** request ignores scaling units and thus `' .ps 10u'` sets the type size to 10 points, whereas in GNU **troff** it sets the type size to 10 *scaled* points, possibly a much smaller measurement. AT&T's behavior also means that `' .ps 10p'` and `' .ps 10z'` are portable.

¹⁶⁹ Thus,

```
.ll 10n
\%antidisestablishmen%\tarianism
.br
\&\%antidisestablishmen%\tarianism
.pl \n(nlu
```

produces different results with each of the three formatters.

The **ab** request differs from AT&T **troff**: GNU **troff** writes no message to the standard error stream if no arguments are given, and it exits with a failure status instead of a successful one.

The **bp** request differs from AT&T **troff**: GNU **troff** does not accept a scaling unit on the argument, a page number; the former does (uselessly).

In AT&T **troff**, the **pm** request reports macro, string, and diversion sizes in units of 128-byte blocks, and an argument reduces the report to a sum of the above in the same units. GNU **troff** reports their lengths in characters or nodes if given no arguments, and otherwise dumps the JSON-encoded name, contents, and other properties of each named argument.

AT&T **troff** ignores the **ss** request if the output is a terminal device; GNU **troff** rounds down the values of minimum inter-word and additional inter-sentence space each to the nearest multiple of 12.

GNU **troff** distinguishes characters from glyphs. Characters can be ordinary, special, or indexed, and populate strings and macros. Characters *per se* have not (yet) been formatted. Glyphs represent graphemes (supplied by the output device) and populate diversions (recall Section 5.30 [Diversions], page 208). Formatting converts characters into (sequences of) glyphs. GNU **troff** stores properties of the environment that affect how a glyph is rendered with the glyph node's data. Thus, subsequent formatting operations do not affect it, including **bd**, **cs**, **tkf**, **tr**, and **fp** requests. Normally, a macro or string contains only a list of characters and a diversion contains only a list of nodes. However, applying the **asciify** or **unformat** requests to a diversion converts some of its nodes back into characters. Where the formatter cannot recover the character representation of a node, it stores a null character in the character list corresponding to a single node in the node list.

Consequently, a glyph node does not behave as a character does in macro interpolation: it does not inherit special properties that the character from which it was constructed might have had. For example, the input

```
.di x
\\
.br
.di
.x
```

produces ‘\\’ in GNU **troff**. Each pair of backslashes becomes one backslash *glyph*; the resulting backslashes are thus not interpreted as escape *characters* when they are interpolated as the diversion is output. AT&T **troff** *would* interpret them as escape characters when interpolating them and end up printing one ‘\’.

One correct way to obtain a printable backslash in most documents is to use the **\e** escape sequence; this always prints a single instance of the

current escape character,¹⁷⁰ regardless of whether it is used in a diversion; it also works in both GNU **troff** and AT&T **troff**.

The other correct way, appropriate in contexts independent of the backslash’s common use as a **roff** escape character—perhaps in discussion of character sets or other programming languages—is the special character escape sequence `\(rs` or `\[rs]`, for “reverse solidus”, from its name in the ECMA-6 and ISO 10646 standards.¹⁷¹

To store in a diversion an escape sequence that is interpreted when the diversion is interpolated, either use the traditional `\!` transparent output facility, or, if this is unsuitable, the new `\?` escape sequence. Recall Section 5.30 [Diversions], page 208, and Section 5.37 [GNU **troff** Internals], page 228.

Like AT&T **troff**, GNU **troff** maintains a buffer of device-independent output commands,¹⁷² populating the buffer as formatted output accumulates. GNU **troff** always flushes this buffer when processing a break; AT&T **troff** does so according to no obvious schedule. (Perhaps, if the buffer is of fixed size, the formatter performs the flush when the buffer runs out of room.)

In the somewhat pathological case where a diversion exists containing a partially collected line and a partially collected line at the top-level diversion has never existed, AT&T **troff** outputs a partially collected but otherwise empty line (as if `\c` were in the top-level diversion) at the end of input; GNU **troff** does not.

¹⁷⁰ Naturally, if you’ve changed the escape character, you need to prefix the `e` with whatever it is—and you’ll likely get something other than a backslash in the output.

¹⁷¹ AT&T **troff**’s font description files did not define the `rs` special character, but those of its descendant Heirloom Doctools **troff** do, as of its 060716 release (July 2006).

¹⁷² In GNU **troff**, node objects produce these commands; recall Section 5.37 [GNU **troff** Internals], page 228.

6 File Formats

All files that GNU **troff** reads and writes are text files.¹ The next two sections describe their format.

6.1 Device and Font Description Files

The **groff** font and output device description formats are slight extensions of those used by AT&T device-independent **troff**. In distinction to the AT&T implementation, **groff** lacks a binary format; all files are text files.² The device and font description files for a device *name* are stored in a **devname** directory. The device description file is called **DESC**, and, for each font supported by the device, a font description file is called *f*, where *f* is usually an abbreviation of a font's name and/or style. For example, the **ps** (PostScript) device has **groff** font description files for Times roman (**TR**) and Zapf Chancery Medium italic (**ZCMI**), among many others, while the **utf8** device (for terminals) has font descriptions for the roman, italic, bold, and bold-italic styles (**R**, **I**, **B**, and **BI**, respectively).

Device and font description files are read both by the formatter, GNU **troff**, and by output drivers. The programs delegate these files' processing to an internal library, **libgroff**, ensuring their consistent interpretation.

6.1.1 DESC File Format

The **DESC** file contains a series of directives; each begins a line. Their order is not important, with two exceptions: (1) the **res** directive must precede any **papersize** directive; and (2) the **charset** directive must come last (if at all). If a directive name is repeated, later entries in the file override previous ones (except that the paper dimensions are computed based on the **res** directive last seen when **papersize** is encountered). Spaces and/or tabs separate words and are ignored at line boundaries. Comments start with the '#' character and extend to the end of a line. Empty lines are ignored.

family *fam*

The default font family is *fam*.

fonts *n F1 ... Fn*

Fonts *F1*, ..., *Fn* are mounted at font positions *m*+1, ..., *m*+*n* where *m* is the number of **styles** (see below). This directive may extend over more than one line. A font name of 0 causes no font to be mounted at the corresponding position.

hor *n* The horizontal motion quantum is *n* basic units. Horizontal measurements round to multiples of *n*.

¹ GNU **troff** also reads files that don't satisfy the strict POSIX definition of a text file—for example, those lacking a final newline character—and the **cf** and **trf** requests read arbitrary files. Recall Section 5.34 [Host System Service Access], page 220.

² Plan 9 **troff** has also abandoned the binary format.

image_generator program

Use *program* to generate PNG images from PostScript input. Under GNU/Linux, this is usually **gs**, but under other systems (notably Cygwin) it might be set to another name. The **grohtml** driver uses this directive.

paperlength *n*

The vertical dimension of the output medium is *n* basic units (deprecated: use **papersize** instead).

papersize *format-or-dimension-pair-or-file-name ...*

The dimensions of the output medium are as according to the argument, which is either a standard paper format, a pair of dimensions, or the name of a plain text file containing either of the foregoing.

Recognized paper formats are the ISO and DIN formats A0–A7, B0–B7, C0–C7, D0–D7; the U.S. paper types **letter**, **legal**, **tabloid**, **ledger**, **statement**, and **executive**; and the envelope formats **com10**, **monarch**, and **DL**. Matching is performed without regard for lettercase.

Alternatively, the argument can be a custom paper format in the format **length,width** (with no spaces before or after the comma). Both *length* and *width* must have a unit appended; valid units are ‘i’ for inches, ‘c’ for centimeters, ‘p’ for points, and ‘P’ for picas. Example: ‘12c,235p’. An argument that starts with a digit is always treated as a custom paper format.

Finally, the argument can be a file name (e.g., **/etc/papersize**); if the file can be opened, the first line is read and a match attempted against each of the other forms. No comment syntax is supported.

More than one argument can be specified; each is scanned in turn and the first valid paper specification used.

paperwidth *n*

The horizontal dimension of the output medium is *n* basic units (deprecated: use **papersize** instead).

pass_filenames

Direct GNU **troff** to emit the name of the source file being processed. This is achieved with the intermediate output command ‘x F’, which **grohtml** interprets.

postpro program

Use *program* as the postprocessor.

prepro program

Use *program* as a preprocessor. The **html** and **xhtml** output devices use this directive.

print program

Use *program* as a spooler program for printing. If omitted, the `-l` and `-L` options of `groff` are ignored.

res *n* The device resolution is *n* basic units per inch.

sizes *s1* ... *sn* 0

The device has fonts at *s1*, ..., *sn* scaled points (see below). The list of sizes must be terminated by 0. Each *si* can also be a range of sizes *m*–*n*. The list can extend over more than one line.

sizescale *n*

A typographical point is subdivided into *n* scaled points. The default is 1. See Section 5.20.3 [Using Fractional Type Sizes], page 159.

styles *S1* ... *Sm*

The first *m* mounting positions are associated with styles *S1*, ..., *Sm*.

tcommand The postprocessor can handle the ‘`t`’ and ‘`u`’ intermediate output commands.

unicode The output device supports the complete Unicode repertoire. This directive is useful only for devices that produce character entities instead of glyphs.

If **unicode** is present, no **charset** section is required in the font description files since the Unicode handling built into `groff` is used. However, if there are entries in a font description file’s **charset** section, they either override the default mappings for those particular characters or add new mappings (normally for composite characters).

The `utf8`, `html`, and `xhtml` output devices use this directive.

unitwidth *n*

Arbitrary basis with respect to which font metrics are proportionally scaled when rendering glyphs at a type size of one point.

unscaled_charwidths

Make the font handling module always return unscaled character widths. The `grohtml` driver uses this directive.

use_charnames_in_special

GNU `troff` should encode special characters in arguments to device extension commands; see Section 5.35 [Postprocessor Access], page 226. The `grohtml` driver uses this directive.

vert *n* The vertical motion quantum is *n* basic units. Vertical measurements round to multiples of *n*.

charset This line and everything following it in the file are ignored. It is recognized for compatibility with other `troff` implementations.

In GNU **troff**, character set repertoire is described on a per-font basis.

GNU **troff** recognizes but ignores the directives **spare1**, **spare2**, and **biggestfont**.

The **res**, **unitwidth**, **fonts**, and **sizes** lines are mandatory. Directives not listed above are ignored by GNU **troff** but may be used by postprocessors to obtain further information about the device.

6.1.2 Font Description File Format

On typesetting output devices, each font is typically available at multiple sizes. While paper measurements in the device description file are in absolute units, measurements applicable to fonts must be proportional to the type size. The font's *unit width* establishes a numerical basis that permits all of its metrics to be expressed as integers if rendered at one point. When the formatter configures a type size, it scales the metrics linearly relative to that basis. The unit width has no inherent relationship to the device resolution, and the same division procedure applies to all font metrics. Observe that whatever unit might one select for the unit width, the division operation implied by scaling cancels it out, leaving a dimensionless quantity.

For instance, **groff**'s **lbp** device uses a **unitwidth** directive with an argument of 800. Its Times roman font 'TR' has a **spacewidth** of 833; this is also the width of its comma, period, centered period, and mathematical asterisk, while its 'M' has a width of 2,963. Thus, an 'M' on the **lbp** device is $2,963 \div 800$ times the unit width, or approximately 3.7. At a type size of 10 points, a Times roman 'M' is therefore 37 units wide.

```
$ groff -T lbp
.ps 10
.nr Mw \w'M'
.tm width of 'M' at 10 points=\n(Mw
[error] width of 'M' at 10 points=37
```

A font description file has two sections. The first is a sequence of directives, and is parsed similarly to the **DESC** file described above. Except for the directive names that begin the second section, their ordering is immaterial. Later directives of the same name override earlier ones, spaces and tabs are handled in the same way, and the same comment syntax is supported. Empty lines are ignored throughout.

name f The name of the font is *f*. 'DESC' is an invalid font name. Simple integers are valid, but their use is discouraged.³

³ **groff** requests and escape sequences interpret non-negative integers as mounting positions instead. Further, a font named '0' cannot be automatically mounted by the **fonts** directive of a **DESC** file.

spacewidth *n*

The width of an unadjusted inter-word space is *n*, relative to the device's unit width.

The directives above must appear in the first section; those below are optional.

slant *n* The font's glyphs have a slant of *n* degrees; a positive *n* slants in the direction of text flow.

ligatures *lig1* ... *lign* [0]

Glyphs *lig1*, ..., *lign* are ligatures; possible ligatures are 'ff', 'fi', 'fl', 'ffi' and 'ffl'. For compatibility with other **troff** implementations, the list of ligatures may be terminated with a 0. The list of ligatures must not extend over more than one line.

special The font is *special*: when the document attempts to format a glyph that is not present in the formatter's currently selected font, the glyph is sought in any mounted fonts that bear this property. Often, such fonts are *unstyled*, having no heavy (bold) or slanted (italic or oblique) variants.

Other directives in this section are ignored by GNU **troff**, but may be used by postprocessors to obtain further information about the font.

The second section contains one to three subsections, which can appear in any order, and any of which starts the second section. Each starts with a directive on a line by itself. A **charset** subsection is mandatory unless the associated DESC file contains the **unicode** directive. Another subsection, **kernpairs**, is optional.

The directive **charset** starts the character set subsection.⁴ It precedes a series of glyph descriptions, one per line. Each such glyph description comprises a set of fields separated by spaces or tabs and organized as follows.

name metrics type index [entity-name] [-- comment]

name identifies the glyph: if *name* is a printable character *c*, it corresponds to the **troff** ordinary character *c*. If *name* is a multi-character sequence not beginning with \, it corresponds to the GNU **troff** special character escape sequence '\[*name*]'. A name consisting of three minus signs, '---', is special and indicates that the glyph is unnamed: such glyphs can be accessed only by the \N escape sequence in **troff**. A special character named '---' can still be defined using **char** and similar requests. The *name* '\-' defines the minus sign glyph. Finally, *name* can be the unbreakable one-sixth and one-twelfth space escape sequences, \| and \^ ("thin" and "hair" spaces, respectively), in which case only the width metric described below is interpreted; a font can thus customize the widths of these spaces.

⁴ On typesetters, this directive is misnamed since it starts a list of glyphs, not characters.

The form of the *metrics* field is as follows.

```
width[,height[,depth[,italic-correction
[,left-italic-correction[,subscript-correction]]]]]]]]]
```

Spaces, tabs, and newlines are prohibited between these *subfields*, which are expressed as decimal integers (and have been split here into two lines only for better legibility). The unit of measure is that established by the **unitwidth** directive and scaled to the type size. Unspecified subfields default to 0. Since there is no associated binary format, these values are not required to fit into the C language data type ‘char’ as they are in AT&T device-independent **troff**.

The *width* subfield gives the width of the glyph. The *height* subfield gives the height of the glyph (upward is positive); if a glyph does not extend above the baseline, give it a zero height, not a negative height. The *depth* subfield gives the depth of the glyph—that is, the distance below the baseline to which the glyph extends (downward is positive); if a glyph does not extend below the baseline, give it a zero depth, not a negative depth. Italic corrections apply when upright and slanted (italic or oblique) styles are typeset adjacently. The *italic-correction* is the amount of space to add after a slanted glyph to be followed immediately by an upright glyph. The *left-italic-correction* is the amount of space to add before a slanted glyph to be preceded immediately by an upright glyph. The *subscript-correction* is the amount of space to add after a slanted glyph to be followed by a subscript; it should be less than the italic correction.

For fonts used with typesetters, the *type* field gives a featural description of the glyph: it is a bit mask recording whether the glyph is an ascender, descender, both, or neither. When a `\w` escape sequence is interpolated, these values are bitwise or-ed together for each glyph and stored in the **nr** register. In font descriptions for terminals, all glyphs might have a type of zero, regardless of their appearance.

- | | |
|---|---|
| 0 | means the glyph lies entirely between the baseline and a horizontal line at the “x-height” of the font; typical examples are ‘a’, ‘c’, and ‘x’; |
| 1 | means the glyph descends below the baseline, like ‘p’; |
| 2 | means the glyph ascends above the font’s x-height, like ‘A’ or ‘b’; and |
| 3 | means the glyph is both an ascender and a descender—this is true of parentheses in some fonts. |

The *index* field is an integer that uniquely identifies a glyph within the font; any integer is accepted as input,⁵ but no practical font employs all possible values. An *index* is limited to the range of the system’s C language

⁵ that is, any integer parsable by the C standard library’s `strtol(3)` function

data type **int**. In a **troff** document, use the indexed character escape sequence `\N` to specify a glyph by index.

The *entity-name* field defines an identifier for the glyph that the postprocessor uses to print the GNU **troff** glyph *name*. This field is optional; it was introduced so that the **grohtml** output driver could encode its character set. For example, the glyph ‘`\[Po]`’ is represented by ‘`£`’ in HTML 4.0. For efficiency, these data are now compiled directly into **grohtml**. **grops** uses the field to build sub-encoding arrays for PostScript fonts containing more than 256 glyphs. Anything on the line after the *entity-name* field or ‘`--`’ is ignored.

A line in the **charset** section can also have the form

name "

identifying *name* as another name for the glyph mentioned in the preceding line. Such aliases can be chained.

A **charset-range** subsection works like the **charset** directive except that the glyph descriptions use a *name* of the form `uAAAA..uFFFF`, where *AAAA* and *FFFF* are hexadecimal digit sequences; the specified metrics then apply identically to all glyphs in the designated range.

The directive **kernpairs** starts a list of kerning adjustments to be made to adjacent glyph pairs from this font. It contains a sequence of lines formatted as follows.

g1 g2 n

The foregoing means that when glyph *g1* is typeset immediately before *g2*, the space between them should be increased by *n*. The unit of measure is that established by the **unitwidth** directive and scaled to the type size. Most kerning pairs should have a negative value for *n*.

6.2 GNU troff Output

We now describe the **groff** device-independent page description language produced by GNU **troff**.

As **groff** is a wrapper program around GNU **troff** and automatically runs an output driver, users seldom encounter this format under normal circumstances. **groff** offers the option **-Z** to inhibit postprocessing such that GNU **troff**’s output is sent to the standard output stream just as it is when running GNU **troff** directly.

The purpose of device-independent output is to facilitate the development of postprocessors by providing a common programming interface to all devices. It is a distinct, and much simpler, language from that of the formatter, **troff**. The device-independent output can be thought of as a “page description language”.

In the following discussion, the term *troff output* describes what is output by GNU **troff**, while *page description* denotes the language accepted by the parser that interprets this output for the output drivers. This parser handles

whitespace more flexibly than AT&T **troff**'s implementation, recognizes a GNU extension to the language, and supports a legacy compressed encoding of a subset of commands for compatibility; otherwise, the formats are the same.⁶

When Brian Kernighan designed AT&T **troff**'s device-independent page description language circa 1980, he had to balance readability and maintainability against severe constraints on file size and transmission speed to the output device.⁷ A decade later, when James Clark wrote **groff**, these constraints were no longer as tight.

6.2.1 Language Concepts

The fundamental operation of the GNU **troff** formatter is the translation of the **groff** input language into a series of instructions concerned primarily with placing glyphs or geometric objects at specific positions on a rectangular page. In the following discussion, the term *command* always refers to this device-independent output language, and never to the language intended for direct use by document authors. Device-independent output commands comprise several categories: glyph output; font, color, and text size selection; motion of the drawing position; page advancement; drawing of geometric objects; and device control commands, a catch-all for other operations. The last includes directives to start and stop output, identify the intended output device, and embed URL hyperlinks in supported output formats.

6.2.1.1 Syntax

roff's page description language is a sequence of *tokens*: single-letter commands or their arguments. Some commands accept a subcommand as a first argument, followed by one or more further arguments.

AT&T device-independent **troff** used whitespace minimally when producing output. GNU **troff**, in contrast, attempts to make its output more human-readable. The whitespace characters—tab, space, and newline—are always meaningful. They are never used to represent spacing in the document; that is done with horizontal (**h**, **H**) and vertical (**v**, **V**) positioning commands. Any sequence of space and/or tab characters is equivalent to a single space, separating commands from arguments and arguments from each other. Space is required only where omitting it would cause ambiguity. A line break separates commands. The comment character is a pound/hash sign (**#**), and marks the remainder of the line as a comment. A line comprising only whitespace after comment removal does nothing but separate input tokens.

The positioning commands noted above, and the command to write one glyph (**c**), each take a single argument; the former a signed integer, and the

⁶ The parser for device-independent output can be found in the file *groff-source-dir/src/libs/libdriver/input.cpp*.

⁷ See “A Typesetter-independent TROFF”, Bell Labs CSTR #97, 1982.

latter a printable ISO 646/“ASCII” character. A series of such commands could validly occur without spaces on an input line, but GNU **troff** follows each with a newline.

Some commands have a more complex syntax; the GNU **troff** extension command for writing glyph sequences (**t**) accepts a variable number of arguments. Those that draw geometric objects (**D**) or control the device (**x**) furthermore recognize subcommand arguments. Such commands thus must end with a newline. In GNU **troff**, the device extension (sub)command ‘**x X**’ uniquely supports a line continuation syntax; a single input line contains any other.

6.2.1.2 Argument Units

Some commands take integer arguments that are assumed to represent values in a measurement unit, but the letter for the corresponding scaling unit is not written with the output command arguments. Most commands assume the scaling unit ‘**u**’, the basic unit of the device, some use ‘**z**’, the scaled point unit of the device, while others, such as the color commands, expect plain integers.

Single characters can have the eighth bit set, as can the names of fonts and special characters. The names of characters and fonts can be of arbitrary length. A character that is to be printed is always in the current font.

A string argument is always terminated by the next whitespace character (space, tab, or newline); an embedded ‘**#**’ character is regarded as part of the argument, not as the beginning of a comment command. An integer argument is already terminated by the next non-digit character, which then is regarded as the first character of the next argument or command.

6.2.1.3 Output Structure

Device-independent **troff** output is organized into three parts: a header, a body, and a trailer.

The task of the header is to set general device parameters. GNU **troff** guarantees that its header consists of the following three lines:

```
x T device
x res n h v
x init
```

with the parameters *n*, *h*, and *v* set as outlined in Section 6.2.2.4 [Device Control Commands], page 261. The parser for the device-independent page description language format is able to interpret additional whitespace and comments as well even in the header.

The body contains the document’s visible content. Once an output driver interprets ‘**x init**’, it prepares to handle commands in general. Processing terminates when a ‘**x stop**’ command is encountered; the last line of any GNU **troff** page description output always contains such a command.

Semantically, the body is page-oriented. The **p** command starts a new page. Positioning, writing, and drawing commands are performed within a page, so they cannot occur before the first **p** command. The output driver reckons absolute positioning (by the **H** and **V** commands) with respect to the current page's origin at the top left corner, and all other positioning relative to the drawing position on the page.

The trailer advances the drawing position to the bottom of the page and informs the device that the document (or “job”) has ended.

6.2.2 Command Reference

This subsection describes all page description output commands, both from AT&T **troff** as well as extension commands issued by GNU **troff**.

6.2.2.1 Comment Command

#anything<end of line>

Apply comment annotation. Ignore any characters from the ‘#’ character up to the next newline.

Each comment can be preceded by arbitrary syntactical space, and every command can be terminated by a comment.

6.2.2.2 Simple Commands

The commands in this subsection have a command code consisting of a single character, taking a fixed number of arguments. Most of them are commands for positioning and text writing. These commands are tolerant of whitespace. Optionally, syntactical space can be inserted before, after, and between the command letter and its arguments. All of these commands are stackable; i.e., they can be preceded by other simple commands or followed by arbitrary other commands on the same line. A separating syntactical space is necessary only when two integer arguments would clash or if the preceding argument ends with a string argument.

C *id*<whitespace>

Typeset the glyph of the special character *id*. Trailing syntactical space is necessary to allow special character names of arbitrary length. The drawing position is not advanced.

c *g* Typeset the glyph of the ordinary character *c*. The drawing position is not advanced.

f *n* Select the font mounted at position *n*. *n* cannot be negative.

H *n* Horizontally move the drawing position to *n* basic units from the left edge of the page. *n* cannot be negative.

h *n* Move the drawing position right *n* basic units. AT&T **troff** allowed negative *n*; GNU **troff** does not produce such values, but **groff**'s output driver library handles them.

- m** *color-scheme* [*component* ...]
 Select the stroke color using the *components* in the color space *scheme*. Each *component* is an integer between 0 and 65535. The quantity of components and their meanings vary with each *scheme*. This command is a **groff** extension.
- mc** *cyan magenta yellow*
 Use the CMY color scheme with components cyan, magenta, and yellow.
- md**
 Use the default color (no components; black in most cases).
- mg** *gray*
 Use a grayscale color scheme with a component ranging between 0 (black) and 65535 (white).
- mk** *cyan magenta yellow black*
 Use the CMYK color scheme with components cyan, magenta, yellow, and black.
- mr** *red green blue*
 Use the RGB color scheme with components red, green, and blue.
- N** *n*
 Typeset the glyph with index *n* in the current font. *n* is normally a non-negative integer. The drawing position is not advanced. The **html** and **xhtml** devices use this command with negative *n* to produce unbreakable space; the absolute value of *n* is taken and interpreted in basic units.
- n** *b a*
 Indicate a break. No action is performed; the command is present to make the output more easily parsed. The integers *b* and *a* describe the vertical space amounts before and after the break, respectively. GNU **troff** issues this command but **groff**'s output driver library ignores it. See **v** and **V** below.
- p** *n*
 Begin a new page, setting its number to *n*. Each page is independent, even from those using the same number. The vertical drawing position is set to 0. All positioning, writing, and drawing commands are interpreted in the context of a page, so a **p** command must precede them.
- s** *n*
 Set type size to *n* scaled points (unit **z** in GNU **troff**. AT&T **troff** used unscaled points **p** instead; see Section 6.2.4 [Output Language Compatibility], page 266.
- t** *xyz*<whitespace>
t *xyz dummy-arg*<whitespace>
 Typeset a word *xyz*; that is, set a sequence of ordinary glyphs named *x*, *y*, *z*, ..., terminated by a space character or a line break; an optional second integer argument is ignored (this allows the formatter to generate an even number of arguments).

Each glyph is set at the current drawing position, and the position is then advanced horizontally by the glyph's width. A glyph's width is read from its metrics in the font description file, scaled to the current type size, and rounded to a multiple of the horizontal motion quantum. Use the **C** command to emplace glyphs of special characters. The **t** command is a **groff** extension and is output only for devices whose **DESC** file contains the **tcommand** directive; see Section 6.1.1 [DESC File Format], page 247.

u n xyz<whitespace>

Typeset word *xyz* with track kerning. As **t**, but after placing each glyph, the drawing position is further advanced horizontally by *n* basic units (**u**). The **u** command is a **groff** extension and is output only for devices whose **DESC** file contains the **tcommand** directive; see Section 6.1.1 [DESC File Format], page 247.

V n Vertically move the drawing position to *n* basic units from the top edge of the page. *n* cannot be negative.

v n Move the drawing position down *n* basic units. AT&T **troff** allowed negative *n*; GNU **troff** does not produce such values, but **groff**'s output driver library handles them.

w Indicate an inter-word space. No action is performed; the command is present to make the output more easily parsed. Only inter-word spaces on an output line (be they breakable or not) are thus described; those resulting from horizontal motion escape sequences are not. GNU **troff** issues this command but **groff**'s output driver library ignores it. See **h** and **H** above.

6.2.2.3 Graphics Commands

Each graphics or drawing command in the page description language starts with the letter 'D', followed by one or two characters that specify a subcommand; this is followed by a fixed or variable number of integer arguments that are separated by a single space character. A 'D' command may not be followed by another command on the same line (apart from a comment), so each 'D' command is terminated by a syntactical line break.

GNU **troff** output follows AT&T **troff**'s output conventions (no space between command and subcommand, all arguments are preceded by a single space character), but **groff**'s parser allows optional space between the command letters and makes the space before the first argument optional. As usual, each space can be any sequence of tab and space characters.

Some graphics commands can take a variable number of arguments. In this case, they are integers representing a size measured in basic units 'u'. The arguments called *h1*, *h2*, ..., *hn* stand for horizontal distances where positive means right, negative left. The arguments called *v1*, *v2*, ..., *vn*

stand for vertical distances where positive means down, negative up. All these distances are offsets relative to the current location.

Each graphics command directly corresponds to a **troff** `\D` escape sequence. See Section 5.27 [Drawing Geometric Objects], page 192.

Unknown ‘D’ commands are assumed to be device-specific. Its arguments are parsed as strings; the whole information is then sent to the postprocessor.

In the following command reference, the syntax element `<line break>` means a syntactical line break as defined above.

D~ *h1 v1 h2 v2 ... hn vn*`<line break>`

Draw B-spline from current position to offset (*h1,v1*), then to offset (*h2,v2*), if given, etc., up to (*hn,vn*). This command takes a variable number of argument pairs; the current position is moved to the terminal point of the drawn curve.

Da *h1 v1 h2 v2*`<line break>`

Draw arc from current position to (*h1,v1*)+(*h2,v2*) with center at (*h1,v1*); then move the current position to the final point of the arc.

DC *d*`<line break>`

DC *d dummy-arg*`<line break>`

Draw a solid circle using the current fill color with diameter *d* (integer in basic units ‘u’) with leftmost point at the current position; then move the current position to the rightmost point of the circle. An optional second integer argument is ignored (this allows the formatter to generate an even number of arguments). This command is a GNU extension.

Dc *d*`<line break>`

Draw circle line with diameter *d* (integer in basic units ‘u’) with leftmost point at the current position; then move the current position to the rightmost point of the circle.

DE *h v*`<line break>`

Draw a solid ellipse in the current fill color with a horizontal diameter of *h* and a vertical diameter of *v* (both integers in basic units ‘u’) with the leftmost point at the current position; then move to the rightmost point of the ellipse. This command is a GNU extension.

De *h v*`<line break>`

Draw an outlined ellipse with a horizontal diameter of *h* and a vertical diameter of *v* (both integers in basic units ‘u’) with the leftmost point at current position; then move to the rightmost point of the ellipse.

DF *color-scheme* [*component ...*]`<line break>`

Set fill color for solid drawing objects using different color schemes; the analogous command for setting the color of text,

line graphics, and the outline of graphic objects is ‘m’. The color components are specified as integer arguments between 0 and 65535. The number of color components and their meaning vary for the different color schemes. These commands are generated by GNU **troff**’s escape sequences ‘\D’F ... ’ and \M (with no other corresponding graphics commands). No position changing. This command is a GNU extension.

DFc *cyan magenta yellow*<line break>

Set fill color for solid drawing objects using the CMY color scheme, having the 3 color components *cyan*, *magenta*, and *yellow*.

DFd<line break>

Set fill color for solid drawing objects to the default fill color value (black in most cases). No component arguments.

DFg *gray*<line break>

Set fill color for solid drawing objects to the shade of gray given by the argument, an integer between 0 (black) and 65535 (white).

DFk *cyan magenta yellow black*<line break>

Set fill color for solid drawing objects using the CMYK color scheme, having the 4 color components *cyan*, *magenta*, *yellow*, and *black*.

DFr *red green blue*<line break>

Set fill color for solid drawing objects using the RGB color scheme, having the 3 color components *red*, *green*, and *blue*.

Df *n*<line break>

The argument *n* must be an integer in the range −32767 to 32767.

$0 \leq n \leq 1000$

Set the color for filling solid drawing objects to a shade of gray, where 0 corresponds to solid white, 1000 (the default) to solid black, and values in between to intermediate shades of gray; this command is superseded by ‘DFg’.

$n < 0$ or $n > 1000$

Set the filling color to the color that is currently being used for the text and the outline, see command ‘m’. For example, the command sequence

```
mg 0 0 65535
Df -1
```

sets all colors to blue.

No position changing. This command is a GNU extension.

Dl *h v*<line break>

Draw line from current position to offset (*h*,*v*) (integers in basic units ‘u’); then set current position to the end of the drawn line.

Dp *h1 v1 h2 v2 . . . hn vn*<line break>

Draw a polygon line from current position to offset (*h1*,*v1*), from there to offset (*h2*,*v2*), etc., up to offset (*hn*,*vn*), and from there back to the starting position. For historical reasons, the position is changed by adding the sum of all arguments with odd index to the actual horizontal position and the even ones to the vertical position. Although this doesn’t make sense it is kept for compatibility. This command is a GNU extension.

DP *h1 v1 h2 v2 . . . hn vn*<line break>

Draw a solid polygon in the current fill color rather than an outlined polygon, using the same arguments and positioning as the corresponding ‘Dp’ command. This command is a GNU extension.

Dt *n*<line break>

Set the current line thickness to *n* (an integer in basic units ‘u’) if *n* > 0; if *n* = 0 select the smallest available line thickness; if *n* < 0 set the line thickness proportional to the type size (this is the default before the first ‘Dt’ command was specified). For historical reasons, the horizontal position is changed by adding the argument to the actual horizontal position, while the vertical position is not changed. Although this doesn’t make sense it is kept for compatibility. This command is a GNU extension.

6.2.2.4 Device Control Commands

Each device control command starts with the letter ‘x’, followed by a space character (optional or arbitrary space or tab in GNU **troff**) and a subcommand letter or word; each argument (if any) must be preceded by a syntactical space. All ‘x’ commands are terminated by a syntactical line break; no device control command can be followed by another command on the same line (except a comment).

The subcommand is basically a single letter, but to increase readability, it can be written as a word, i.e., an arbitrary sequence of characters terminated by the next tab, space, or newline character. All characters of the subcommand word but the first are simply ignored. For example, GNU **troff** outputs the initialization command ‘x i’ as ‘x init’ and the resolution command ‘x r’ as ‘x res’.

In the following, the syntax element <line break> means a syntactical line break (see Section 6.2.1.1 [Syntax], page 254).

xF *name*<line break>

The ‘F’ stands for *Filename*.

Use *name* as the intended name for the current file in error reports. This is useful for remembering the original file name when **groff** uses its internal piping mechanism. The input file is not changed by this command. This command is a GNU extension.

xf *n s*<line break>

The ‘f’ stands for *font*.

Mount font position *n* (a non-negative integer) with font named *s* (a text word). See Section 5.19.3 [Font Positions], page 139.

xH *n*<line break>

The ‘H’ stands for *Height*.

Set glyph height to *n* (a positive integer in scaled points ‘z’). AT&T **troff** uses the unit points (‘p’) instead. See Section 6.2.4 [Output Language Compatibility], page 266.

xi<line break>

The ‘i’ stands for *init*.

Initialize device. This is the third command of the header.

xp<line break>

The ‘p’ stands for *pause*.

Parsed but ignored. The AT&T **troff** manual documents this command as

pause device, can be restarted

but GNU **troff** output drivers do nothing with this command.

xr *n h v*<line break>

The ‘r’ stands for *resolution*.

Resolution is *n*, while *h* is the minimum horizontal motion, and *v* the minimum vertical motion possible with this device; all arguments are positive integers in basic units ‘u’ per inch. This is the second command of the header.

xS *n*<line break>

The ‘S’ stands for *Slant*.

Set slant to *n* (an integer in basic units ‘u’).

xs<line break>

The ‘s’ stands for *stop*.

Terminates the processing of the current file; issued as the last command of device-independent **troff** output.

xt<line break>

The ‘t’ stands for *trailer*.

Generate trailer information, if any. In GNU **troff**, this is ignored.

xT *xxx*<line break>

The ‘T’ stands for *Typesetter*.

Set the name of the output driver to *xxx*, a sequence of non-whitespace characters terminated by whitespace. The possible names correspond to those of **groff**’s **-T** option. This is the first command of the header.

xu *n*<line break>

The ‘u’ stands for *underline*.

Configure underlining of spaces. If *n* is 1, start underlining of spaces; if *n* is 0, stop underlining of spaces. This is needed for the **cu** request in **nroff** mode and is ignored otherwise. This command is a GNU extension.

xX *anything*<line break>

The ‘x’ stands for *X-escape*.

Send string *anything* uninterpreted to the device. If the line following this command starts with a ‘+’ character this line is interpreted as a continuation line in the following sense. The ‘+’ is ignored, but a newline character is sent instead to the device, the rest of the line is sent uninterpreted. The same applies to all following lines until the first character of a line is not a ‘+’ character. This command is generated by the escape sequence **\X**. Line continuation is a GNU extension.

6.2.2.5 Legacy Compressed Encoding

AT&T **troff** primarily emitted glyphs by writing two digits (a motion) followed by a single character corresponding to a glyph. This syntax is less a command itself than a compressed encoding of the **c** and **h** commands.

ddg Move right *dd* (exactly two decimal digits) basic units ‘u’, then print glyph *g* (represented as a single character).

In GNU **troff**, arbitrary syntactical space around and within this command is allowed. Only when a preceding command on the same line ends with an argument of variable length is a separating space obligatory. In AT&T **troff**, large clusters of these and other commands are used, mostly without spaces; this made such output almost unreadable.

For modern high-resolution devices, this command is impractical because the widths of the glyphs have a greater magnitude in basic units than two decimal digits can represent. In GNU **troff**, this optimization is used only for the devices **X75**, **X75-12**, **X100**, and **X100-12**. For other devices, the commands ‘t’ and ‘u’ produce more readable output.

6.2.3 GNU troff Output Examples

This section presents the output GNU **troff** generates from the same input formatted for three different devices. The input is the phrase ‘hell world’ piped to GNU **troff** on the command line.

High-resolution device **ps**

We depict the standard output stream of GNU **troff** in its default build configuration and in the absence of an explicit **-T** option.

```
shell> echo "hell world" | groff -Z -T ps

x T ps
x res 72000 1 1
x init
p1
x font 5 TR
f5
s10000
V12000
H72000
thell
wh2500
tw
H96620
torld
n12000 0
x trailer
V792000
x stop
```

This output can be placed onto the standard input stream of **grops** to produce its representation as a PostScript file.

Low-resolution device **latin1**

This is similar to the high-resolution device except that the positioning is done at a minor scale. Some comments (lines starting with ‘#’) were added for clarification; they were not generated by the formatter.

```
shell> echo "hell world" | groff -Z -T latin1

# header
x T latin1
x res 240 24 40
x init
# begin a new page
p1
# font setup
```

```

x font 1 R
f1
s10
# initial positioning on the page
V40
H0
# write text 'hell'
thell
# inform about space, and issue a horizontal jump
wh24
# write text 'world'
tworld
# announce line break, but do nothing because...
n40 0
# ...the end of the document has been reached
x trailer
V2640
x stop

```

This output can be placed onto the standard input stream of `groff` to produce its representation as text file.

AT&T `troff` output

Since a video display has lower resolution than modern printers, GNU `troff`'s output for X11 devices can use the legacy compressed encoding.

```
shell> echo "hell world" | groff -Z -T X100
```

```

x T X100
x res 100 1 1
x init
p1
x font 5 TR
f5
s10
V16
H100
# write text in legacy compressed encoding
ch07e07103lw06w11o07r05l03dh7
n16 0
x trailer
V1100
x stop

```

Place the foregoing into the standard input stream of `xditview` or `gxditview` to display it in an X11 window.

The legacy compressed encoding makes the content of formatted text in AT&T `troff` output almost incomprehensible.

6.2.4 Output Language Compatibility

The page description language of AT&T **troff** was first documented in “A Typesetter-independent TROFF”, by Brian Kernighan, and by 1992 the AT&T **troff** manual was updated to incorporate a description of it.

groff’s page description language is compatible with this specification except in the following aspects.

- AT&T device-independent **troff**’s quasi-device independence is not yet implemented.
- The printing hardware of the early 1980s differed from today’s. **groff**’s output device names also differ from those of AT&T **troff**. For example, the PostScript device in AT&T **troff**, **post** (implemented by the driver command **dpost**), has a resolution of only 720 units per inch, suitable for printers of decades past. **groff**’s **ps** device has a resolution of 72000 units per inch. In principle, by implementing a rescaling mechanism, **groff** could come to emulate AT&T’s **post** device.
- While the B-spline command ‘**D~**’ is reliably interpreted by **groff**’s page description language parser, some output drivers don’t implement drawing routines for it.
- In GNU **troff**, the argument to the commands ‘**s**’ and ‘**x H**’ uses an implicit unit of scaled points ‘**z**’ whereas AT&T **troff** uses spacing points ‘**p**’. This isn’t an incompatibility, but a compatible extension, for both units coincide for any device without a **sizescale** directive in its DESC file, including all postprocessors from AT&T and **groff**’s text (**nroff**-mode) devices. **groff** devices that use **sizescale** either do not exist for AT&T **troff**, have a different name, or seem to have a different resolution. So conflicts are very unlikely.
- The drawing position after the commands ‘**Dp**’, ‘**DP**’, and ‘**Dt**’ are processed is illogical. Since old versions of GNU **troff** had this wart, we’ve retained it for compatibility, but may change it in the future. Wrap these drawing commands with the **\Z** escape sequence to both overcome the illogical positioning and keep your input working consistently regardless of the wart’s presence in the implementation.

Appendix A Copying This Manual

Version 1.3, 3 November 2008

Copyright © 2000-2018 Free Software Foundation, Inc.
<http://fsf.org/>

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document *free* in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondly, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of “copyleft”, which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of

mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The “Cover Texts” are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A “Transparent” copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not “Transparent” is called “Opaque”.

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The “Title Page” means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, “Title Page” means the text near the most prominent appearance of the work’s title, preceding the beginning of the body of the text.

The “publisher” means any person or entity that distributes copies of the Document to the public.

A section “Entitled XYZ” means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve the Title” of such a section when you modify the Document means that it remains a section “Entitled XYZ” according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document’s license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque

copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
- B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.
- C. State on the Title page the name of the publisher of the Modified Version, as the publisher.
- D. Preserve all the copyright notices of the Document.
- E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
- F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
- G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
- H. Include an unaltered copy of this License.
- I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If

there is no section Entitled “History” in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

- J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the “History” section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
- K. For any section Entitled “Acknowledgements” or “Dedications”, Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
- L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.
- M. Delete any section Entitled “Endorsements”. Such a section may not be included in the Modified Version.
- N. Do not retitle any existing section to be Entitled “Endorsements” or to conflict in title with any Invariant Section.
- O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version’s license notice. These titles must be distinct from any other section titles.

You may add a section Entitled “Endorsements”, provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled “History” in the various original documents, forming one section Entitled “History”; likewise combine any sections Entitled “Acknowledgements”, and any sections Entitled “Dedications”. You must delete all sections Entitled “Endorsements.”

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an “aggregate” if the copyright resulting from the compilation is not used to limit the legal rights of the compilation’s users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire

aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in

detail to address new problems or concerns. See <http://www.gnu.org/copyleft/>.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

11. RELICENSING

“Massive Multiauthor Collaboration Site” (or “MMC Site”) means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A “Massive Multiauthor Collaboration” (or “MMC”) contained in the site means any set of copyrightable works thus published on the MMC site.

“CC-BY-SA” means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

“Incorporate” means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is “eligible for relicensing” if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

```
Copyright (C)  year  your name.
Permission is granted to copy, distribute and/or modify this document
under the terms of the GNU Free Documentation License, Version 1.3
or any later version published by the Free Software Foundation;
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover
Texts.  A copy of the license is included in the section entitled ‘‘GNU
Free Documentation License’’.
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with...Texts.” line with this:

```
with the Invariant Sections being  list their titles, with
the Front-Cover Texts being  list, and with the Back-Cover Texts
being  list.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

Appendix B Request Index

Request names appear without a leading control character; the defaults are . for the regular control character and ' for the no-break control character. See Section 5.6.2 [Invoking Requests], page 86.

A

ab.....	232
ad.....	103
af.....	99
aln.....	97
als.....	167
am.....	177
am1.....	177
ami.....	177
ami1.....	177
as.....	165
as1.....	165
asciify.....	213

B

backtrace.....	235
bd.....	152
blm.....	206
box.....	209
boxa.....	209
bp.....	132
br.....	102
break.....	174
brp.....	104

C

c2.....	85
cc.....	85
ce.....	106
cf.....	222
cflags.....	145
ch.....	200
char.....	147
chop.....	166
class.....	149
close.....	226
color.....	161
composite.....	144
continue.....	174
cp.....	239
cs.....	152
cu.....	151

D

da.....	209
de.....	175
de1.....	176
defcolor.....	161
dei.....	177
dei1.....	177
device.....	226
devicem.....	227
di.....	209
do.....	239
ds.....	30, 163
ds1.....	163
dt.....	203

E

ec.....	90
ecr.....	91
ecs.....	91
el.....	171
em.....	206
eo.....	90
ev.....	217
evc.....	218
ex.....	232

F

fam.....	138
fc.....	123
fchar.....	147
fcolor.....	162
fi.....	102
fl.....	234
fp.....	139
fschar.....	147
fspecial.....	150
ft.....	135
ftr.....	137
fzoom.....	137

G

gcolor 162

H

hc 110
 hcode 114
 hla 115
 hlm 115
 hpf 113
 hpfa 113
 hpfcodes 115
 hw 108
 hy 110
 hydefault 113
 hym 115
 hys 116

I

ie 171
 if 170
 ig 94
 in 127
 it 203

K

kern 153

L

lc 122
 length 165
 lf 232
 lg 153
 linetabs 122
 ll 128
 ls 117
 lsm 206
 lt 131

M

mc 191
 mk 184
 mso 222
 msoquiet 222

N

na 104
 ne 132
 nf 102
 nh 112
 nm 189
 nn 190
 nop 171
 nr 30, 95, 96, 98
 nroff 126
 ns 119
 nx 223

O

open 225
 opena 225
 os 133
 output 213

P

pc 131
 pchar 233
 pcolor 233
 pcomposite 233
 pev 233
 pfp 233
 pftr 233
 phw 233
 pi 224
 pl 130
 pline 233
 pm 234
 pn 130
 pnr 234
 po 127
 ps 156
 psbb 228
 pso 222
 pstream 234
 pvs 159
 pwh 234

R

rchar.....	148
rd.....	223
return.....	178
rfschar.....	148
rj.....	107
rm.....	167
rn.....	167
rnn.....	97
rr.....	96
rs.....	119
rt.....	184

S

schar.....	147
shc.....	110
shift.....	179
sizes.....	158
so.....	221
soquiet.....	221
sp.....	116
special.....	150
spreadwarn.....	235
ss.....	107
stringdown.....	166
stringup.....	166
sty.....	138
substring.....	166
sv.....	133
sy.....	225

T

ta.....	119
tag.....	228
taga.....	228
tc.....	121
ti.....	128
tkf.....	153
tl.....	131
tm.....	232
tm1.....	232
tmc.....	232
tr.....	124
trf.....	222
trin.....	124
trnt.....	125
troff.....	126

U

uf.....	152
ul.....	151
unformat.....	214

V

vpt.....	197
vs.....	158

W

warn.....	235
warnscale.....	235
wh.....	198
while.....	173
write.....	225
writec.....	225
writem.....	226

Appendix C Escape Sequence Index

The escape character, `\` by default, is always followed by at least one more input character, making an escape *sequence*. Any token `\X` with `X` not in the list below emits a warning and interpolates character `X`. Note the entries for `\.`, which may be obscured by the leader dots, and for `\RET` and `\SPC`, which are sorted alphabetically, not by code point order. See Section 5.6.4 [Using Escape Sequences], page 89.

<code>\</code>	89, 143	<code>\d</code>	186
<code>\!</code>	212	<code>\D</code>	194
<code>\"</code>	93	<code>\e</code>	90
<code>\#</code>	93	<code>\E</code>	182
<code>\\$</code>	178	<code>\f</code>	135
<code>\\$*</code>	179	<code>\F</code>	138
<code>\\$~</code>	179	<code>\g</code>	99
<code>\\$0</code>	179	<code>\h</code>	186
<code>\\$0</code>	180	<code>\H</code>	150
<code>\%</code>	109	<code>\k</code>	188
<code>\&</code>	154	<code>\l</code>	193
<code>\'</code>	145	<code>\L</code>	193
<code>\(</code>	143	<code>\m</code>	162
<code>\)</code>	156	<code>\M</code>	162
<code>*</code>	163	<code>\n</code>	97, 98
<code>\,</code>	154	<code>\newline</code>	129
<code>\-</code>	145	<code>\N</code>	145
<code>\.</code>	181	<code>\o</code>	189
<code>\/</code>	154	<code>\O</code>	219
<code>\:</code>	109	<code>\p</code>	104
<code>\?</code>	212	<code>\r</code>	186
<code>\[</code>	143	<code>\R</code>	95, 96
<code>\^</code>	187	<code>\RET</code>	129
<code>_</code>	145	<code>\s</code>	157
<code>\`</code>	145	<code>\space</code>	187
<code>\\</code>	181	<code>\S</code>	151
<code>\{</code>	172	<code>\SPC</code>	187
<code>\}</code>	172	<code>\t</code>	119
<code>\ </code>	187	<code>\u</code>	186
<code>\~</code>	102	<code>\v</code>	186
<code>\0</code>	187	<code>\V</code>	226
<code>\a</code>	122	<code>\w</code>	187
<code>\A</code>	83	<code>\x</code>	118
<code>\b</code>	196	<code>\X</code>	226
<code>\B</code>	81	<code>\Y</code>	227
<code>\c</code>	129	<code>\z</code>	189
<code>\C</code>	144	<code>\Z</code>	189

Appendix D Operator Index

See Section 5.4 [Numeric Expressions], page 78.

!	/
! 79	/ 78
%	:
% 78	: 79
&	;
& 79	; 79
(	<
(..... 80	< 79
)	<=
) 80	<= 79
	<?
	<? 79
*	=
* 78	= 79
	==
	== 79
+	>
+ 78	> 79
+ (unary) 80	>= 79
	>? 79
-	
- 78	 80
- (unary) 80	

Appendix E Register Index

Where not used by the formatter itself, a register's associated macro package or program appears in brackets after the register's name.

Interpolate a register name of exactly one character *x* with ‘\nx’; of exactly two characters *xx* with ‘\n(xx)’; or of any length *xxx* with ‘\n[xxx]’. See Section 5.8 [Registers], page 94.

\$		.int	129
\$\$	220	.itm	203
		.j	103
		.k	188
%		.kern	153
%	131, 132	.l	128
		.lg	153
		.linetabs	122
.		.ll	128
.\$	178	.lt	131
.a	118	.L	117
.A	100	.m	162
.b	152	.M	162
.br	85	.n	218
.c	100	.ne	201
.cdp	218	.nm	189
.ce	106	.nn	190
.cht	218	.ns	119
.color	161	.o	127
.cp	239	.O	219
.csk	218	.p	130
.C	239	.pe	202
.d	210	.pn	130
.ev	217	.ps	159
.f	139	.psr	160
.fam	138	.pvs	159
.fn	135	.P	101
.fp	139	.rj	107
.F	101	.R	101
.g	101	.s	156
.h	211	.slant	151
.height	150	.sr	160
.hla	115	.ss	107
.hlc	115	.sss	107
.hlm	115	.sty	138
.hy	110	.t	200
.hydefault	113	.tabs	119
.hym	115	.trap	202
.hys	116	.trunc	201
.H	77	.T	101
.i	127	.u	102
.in	128	.U	101

<code>.v</code>	158
<code>.vpt</code>	197
<code>.V</code>	77
<code>.w</code>	218
<code>.warn</code>	235
<code>.x</code>	101
<code>.y</code>	101
<code>.Y</code>	101
<code>.z</code>	210
<code>.zoom</code>	137

C

<code>c</code>	100
<code>ct</code>	187

D

<code>DD</code> [ms]	35
<code>DI</code> [ms]	35
<code>dl</code>	211
<code>dn</code>	211
<code>dw</code>	220
<code>dy</code>	220

F

<code>FF</code> [ms]	34
<code>FI</code> [ms]	33
<code>FM</code> [ms]	31
<code>FPD</code> [ms]	34
<code>FPS</code> [ms]	34
<code>FVS</code> [ms]	34

G

<code>GROWPS</code> [ms]	33
<code>GS</code> [ms]	59

H

<code>HM</code> [ms]	30
<code>HORPHANS</code> [ms]	33
<code>hours</code>	220
<code>hp</code>	188
<code>HY</code> [ms]	32

L

<code>LL</code> [ms]	30
<code>llx</code>	228
<code>lly</code>	228
<code>ln</code>	189
<code>lsn</code>	206
<code>lss</code>	206
<code>LT</code> [ms]	30

M

<code>MINGW</code> [ms]	35
<code>minutes</code>	220
<code>mo</code>	220

N

<code>nl</code>	133
-----------------------	-----

O

<code>opmaxx</code>	219
<code>opmaxy</code>	219
<code>opminx</code>	219
<code>opminy</code>	219

P

<code>PD</code> [ms]	32
<code>PI</code> [ms]	32
<code>PO</code> [ms]	30
<code>PORPHANS</code> [ms]	32
<code>PS</code> [ms]	31
<code>PSINCR</code> [ms]	33

Q

<code>QI</code> [ms]	32
----------------------------	----

R

<code>rsb</code>	187
<code>rst</code>	187

S

sb..... 187
seconds..... 220
skw..... 187
slimit..... 235
ssc..... 187
st..... 187
systat..... 225

T

TC-MARGIN [ms] 35

U

urx..... 228
ury..... 228

V

VS [ms] 32

Y

year..... 220
yr..... 220

Appendix F Macro Index

The package or program with which a macro is associated appears in brackets after the macro's name. They appear without a leading control character (normally '.'). See Section 5.6.3 [Calling Macros], page 87.

[	
[[ms]	50
]	
] [ms]	50
1	
1C [ms]	54
2	
2C [ms]	54
A	
AB [ms]	36
AE [ms]	36
AI [ms]	36
AM [ms]	60
AU [ms]	36
B	
B [ms]	42
B1 [ms]	48
B2 [ms]	48
BD [ms]	48
BI [ms]	42
BT [man]	23
BX [ms]	42
C	
CD [ms]	49
CT [man]	24
CW [man]	24
CW [ms]	42
D	
DA [ms]	36
De [man]	24
DE [ms]	49
Ds [man]	24
DS [ms]	48, 49
E	
EE [man]	24
EF [ms]	53
EH [ms]	53
EN [ms]	50
EQ [ms]	50
EX [man]	24
F	
FE [ms]	51
FS [ms]	51
G	
G [man]	24
GL [man]	24
H	
HB [man]	24
I	
I [ms]	42
ID [ms]	48
IP [ms]	38
K	
KE [ms]	47
KF [ms]	47
KS [ms]	47

L

LD [ms]	48
LG [ms]	43
LP [ms]	38

M

MC [ms]	54
MS [man]	24

N

ND [ms]	36
NE [man]	25
NH [ms]	40
NL [ms]	43
NT [man]	24

O

OF [ms]	53
OH [ms]	53

P

P1 [ms]	53
PE [ms]	50
PF [ms]	50
Pn [man]	25
PN [man]	25
PP [ms]	38
PS [ms]	50
PT [man]	23
PX [ms]	55

Q

QE [ms]	39
QP [ms]	38
QS [ms]	39

R

R [man]	25
R [ms]	42
RD [ms]	49
RE [ms]	46
RN [man]	25
RP [ms]	35
RS [ms]	46

S

SH [ms]	41
SM [ms]	43

T

TA [ms]	54
TB [man]	24
TC [ms]	55
TE [ms]	49
TL [ms]	36
TS [ms]	49

U

UL [ms]	43
---------	----

V

VE [man]	25
VS [man]	25

X

XA [ms]	55
XE [ms]	55
XH [ms]	56
XH-REPLACEMENT [ms]	56
XH-UPDATE-TOC [ms]	56
XN [ms]	56
XN-INIT [ms]	56
XN-REPLACEMENT [ms]	56
XP [ms]	39
XS [ms]	55

Appendix G String Index

The macro package or program with which a string is associated appears in brackets after the string's name. The formatter itself defines only one string, .T.

Interpolate a string name of exactly one character **x** with ‘***x**’; of exactly two characters **xx** with ‘*(**xx**’; or of any length **xxx** with ‘*[**xxx**]’ . See Section 5.22 [Strings], page 163.

!	?
! [ms] 61	? [ms] 61
,	^
' [ms] 59, 60	^ [ms] 60
*	-
* [ms] 51	- [ms] 61
,	‘
, [ms] 60	~ [ms] 60
—	{
- [ms] 38	{ [ms] 43
.	}
. [ms] 61	} [ms] 43
.T 163	
/	~
/ [ms] 60	~ [ms] 60
:	3
: [ms] 60	3 [ms] 61
<	8
< [ms] 43	8 [ms] 61
>	
> [ms] 43	

A

ABSTRACT [ms]	52
Ae [ms]	61
ae [ms]	61

C

C [ms]	60
CF [ms]	31
CH [ms]	31

D

d- [ms]	61
D- [ms]	61

F

FAM [ms]	32
FR [ms]	34

L

LF [ms]	31
LH [ms]	31

M

MONTH1 [ms]	53
MONTH10 [ms]	53
MONTH11 [ms]	53
MONTH12 [ms]	53
MONTH2 [ms]	53
MONTH3 [ms]	53
MONTH4 [ms]	53
MONTH5 [ms]	53
MONTH6 [ms]	53
MONTH7 [ms]	53
MONTH8 [ms]	53

MONTH9 [ms]	53
-------------	----

O

o [ms]	61
oe [ms]	61
OE [ms]	61

Q

q [ms]	61
Q [ms]	38

R

REFERENCES [ms]	52
RF [ms]	31
RH [ms]	31

S

SN [ms]	41
SN-DOT [ms]	40
SN-NO-DOT [ms]	41
SN-STYLE [ms]	33, 40

T

Th [ms]	61
th [ms]	61
TOC [ms]	52

U

U [ms]	38
--------	----

V

v [ms]	60
--------	----

Appendix H File Keyword Index

See Section 6.1 [Device and Font Description Files], page 247.

#

..... 247, 250

—

--- 251

B

biggestfont 250

C

charset 249, 251

charset-range 253

F

family 135, 247

fonts 140, 150, 247

H

hor 247

I

image_generator 248

K

kernpairs 253

L

ligatures 251

N

name 250

P

paperlength 248

papersize 248

paperwidth 248

pass_filenames 248

postpro 248

prepro 248

print 249

R

res 249

S

sizes 249

sizescale 249

slant 251

spacewidth 251

spare1 250

spare2 250

special 152, 251

styles 135, 139, 249

T

tcommand 249

U

unicode 249

unitwidth 249

unscaled_charwidths 249

use_charnames_in_special 249

V

vert 249

Appendix I Program and File Index

A

an.tmac 23

C

changebar 192
chem 7
composite.tmac 144
cs.tmac 113

D

de.tmac 113
DESC 135, 139, 140, 145, 150
diffmk 192

E

ec.tmac 72
en.tmac 113
eqn 7, 49
es.tmac 113

F

fr.tmac 113
freeeuro.pfa 72

G

gdifmk 192
grn 7
groff 7

H

hyphen.cs 111
hyphen.den 111
hyphen.det 111
hyphen.en 111
hyphen.es 111
hyphen.fr 111
hyphen.it 111
hyphen.pl 111
hyphen.ru 111
hyphen.sv 111
hyphenex.cs 111
hyphenex.en 111
hyphenex.pl 111

I

it.tmac 113

J

ja.tmac 113

K

koi8-r.tmac 71

L

latin1.tmac 71
latin2.tmac 72
latin5.tmac 72
latin9.tmac 72

M

makeindex 21
man.local 23
man.tmac 23
man.ultrix 24

N

nrchbar 192

P

pic..... 7, 49
pl.tmac..... 113
post-grohtml 11
pre-grohtml 11
preconv..... 7

R

rap..... 7
refer..... 7, 49
ru.tmac..... 113

S

soelim..... 7, 232
sv.tmac..... 113

T

tbl..... 7, 49
trace.tmac 178
troff..... 7
troffrc..... 10, 113, 115, 126
troffrc-end..... 10, 115, 126
tty.tmac..... 126, 127

V

vtroff..... 168

Z

zh.tmac..... 113

Appendix J Concept Index

"

", as delimiter 91
 ", at end of sentence 65, 146
 ", at the start of a request argument .. 221
 ", embedding in a macro argument 87

%

%, as delimiter 92

&

&, as delimiter 92

,

', as a comment 93
 ', as delimiter 91
 ', at end of sentence 65, 146

(

(, as delimiter 92

)

), as delimiter 92
), at end of sentence 65, 146

*

*, as delimiter 92
 *, at end of sentence 65, 146

+

+, and page motion 80
 +, as delimiter 92

—

—, and page motion 80
 —, as delimiter 92

.

., as delimiter 92
 .h register, difference from **nl** 211
 .ps register, compared to **.psr** 160
 .s register, compared to **.sr** 160
 .S register, Plan 9 name for **.tabs** 121
 .t register, and diversions 203
 .tabs register, Plan 9 name for (.S) .. 121
 .V register, and **vs** 158

/

/, as delimiter 92

:

:, as delimiter 92

<

<, as delimiter 92

=

=, as delimiter 92

>

>, as delimiter 92

[

[, macro names starting with, and
refer 83

]

], as part of an identifier 83
], at end of sentence 65, 146
], macro names starting with, and
refer 83

<code>\</code>	
<code>\!</code> , and copy mode	212
<code>\!</code> , and output request	213
<code>\!</code> , and trnt	125
<code>\!</code> , as delimiter	91, 92
<code>\!</code> , in top-level diversion	213
<code>\!</code> , incompatibilities with AT&T troff	244
<code>\"</code> , interpretation in copy mode	93
<code>\#</code> , interpretation in copy mode	93
<code>\\$</code> , interpretation in copy mode	178
<code>\%</code> , and translations	124
<code>\%</code> , as delimiter	91, 92
<code>\%</code> , following <code>\X</code> or <code>\Y</code>	109
<code>\%</code> , in device extension commands	227
<code>\&</code> , and glyph definitions	147
<code>\&</code> , and translations	124
<code>\&</code> , as delimiter	91
<code>\&</code> , at end of sentence	64
<code>\&</code> , in device extension commands	227
<code>\'</code> , and translations	124
<code>\'</code> , as delimiter	91, 92
<code>\(</code> , and translations	124
<code>\)</code> , as delimiter	91
<code>\)</code> , in device extension commands	227
<code>*</code> , and warnings	237
<code>*</code> , incompatibilities with AT&T troff	239
<code>*</code> , interpretation in copy mode	163
<code>\</code> , disabling (eo)	90
<code>\</code> , embedding in a macro argument	87
<code>\</code> , as delimiter	91
<code>\-</code> glyph, and cflags	146
<code>\-</code> , and translations	124
<code>\-</code> , as delimiter	91, 92
<code>\-</code> , interpretation in copy mode	181
<code>\</code> , as delimiter	91, 92
<code>\:</code> , as delimiter	91, 92
<code>\:</code> , in device extension commands	227
<code>\?</code> , and copy mode	169, 212
<code>\?</code> , as delimiter	91
<code>\?</code> , in top-level diversion	213
<code>\?</code> , incompatibilities with AT&T troff	244
<code>\?</code> , interpretation in copy mode	212
<code>\[</code> , and translations	124
<code>\^</code> , as delimiter	91
<code>_</code> , and translations	124
<code>_</code> , as delimiter	91, 92
<code>\`</code> , and translations	124
<code>\`</code> , as delimiter	91, 92
<code>\</code> , as quotation character	181
<code>\</code> , interpretation in copy mode	181
<code>\{</code> , as delimiter	91, 92
<code>\}</code> , as delimiter	91, 92
<code>\ </code> , as delimiter	91
<code>\~</code> , and translations	124
<code>\~</code> , as delimiter	91
<code>\~</code> , difference from <code>\SPC</code>	87
<code>\~</code> , incompatibilities with AT&T troff	242
<code>\0</code> , as delimiter	91
<code>\a</code> , and copy mode	122
<code>\a</code> , and translations	124
<code>\a</code> , as delimiter	91
<code>\b</code> , limitations of	196
<code>\c</code> , as delimiter	91, 92
<code>\c</code> , when filling disabled	130
<code>\c</code> , when filling enabled	129
<code>\C</code> , and translations	124
<code>\d</code> , as delimiter	91
<code>\D</code> , delimiters allowed by	91
<code>\e</code> , and glyph definitions	147
<code>\e</code> , and translations	124
<code>\e</code> , as delimiter	91, 92
<code>\e</code> , incompatibilities with AT&T troff	244
<code>\e</code> , interpretation in copy mode	90
<code>\E</code> , as delimiter	91
<code>\f</code> escape sequence, untokenized on input	136
<code>\f</code> , and font translations	137
<code>\f</code> , incompatibilities with AT&T troff	241
<code>\F</code> escape sequence, untokenized on input	138
<code>\F</code> , and changing fonts	135
<code>\g</code> , interpretation in copy mode	100
<code>\h</code> , delimiters allowed by	91
<code>\H</code> escape sequence, untokenized on input	150
<code>\H</code> , delimiters allowed by	91
<code>\H</code> , incompatibilities with AT&T troff	241
<code>\H</code> , using <code>+</code> and <code>-</code> with	80
<code>\H</code> , with fractional type sizes	159
<code>\l</code> , and glyph definitions	147
<code>\l</code> , delimiters allowed by	91
<code>\L</code> , and glyph definitions	147
<code>\L</code> , delimiters allowed by	91
<code>\m</code> escape sequence, untokenized on input	162
<code>\M</code> escape sequence, untokenized on input	162
<code>\n</code> , and warnings	237
<code>\n</code> , incompatibilities with AT&T troff	239
<code>\n</code> , interpretation in copy mode	97
<code>\N</code> , and translations	124
<code>\N</code> , delimiters allowed by	91
<code>\p</code> , as delimiter	91, 92
<code>\r</code> , as delimiter	91

- \R escape sequence, untokenized on
 - input 95
 - \R, and warnings 237
 - \R, delimiters allowed by 91
 - \R, difference from **nr** 98
 - \R, using + and - with 80
 - \RET, interpretation in copy mode 129
 - \S escape sequence, untokenized on
 - input 157
 - \s, delimiters allowed by 91
 - \s, incompatibilities with AT&T **troff** 241
 - \s, using + and - with 80
 - \s, with fractional type sizes 159
 - \S escape sequence, untokenized on
 - input 151
 - \S, delimiters allowed by 91
 - \S, incompatibilities with AT&T **troff** 241
 - \SPC, as delimiter 91
 - \SPC, difference from ~ 87
 - \t, and copy mode 119
 - \t, and translations 124
 - \t, and warnings 237
 - \t, as delimiter 91
 - \u, as delimiter 91
 - \v, delimiters allowed by 91
 - \v, internal representation 230
 - \V, and copy mode 226
 - \V, interpretation in copy mode 226
 - \x, delimiters allowed by 91
 - \X, followed by % 109
 - \Y, followed by % 109
-
- |
 - |) operator, use with **sp** request 117
 - |, and page motion 80
 - |, as delimiter 92
-
- ## A
- ab** request, incompatibilities with AT&T
 - troff** 243
 - abort (**ab**) 232
 - absolute (*sic*) position operator (**l**) 80
 - abstract font style 135
 - abstract font style, setting up (**sty**)... 138
 - accent marks [**ms**] 59
 - access to postprocessor 226
 - accessing unnamed glyphs with \N 251
 - activating kerning (**kern**) 153
 - activating ligatures (**lg**) 153
 - activating track kerning (**tkf**) 153
 - ad** request, and hyphenation margin .. 115
 - ad** request, and hyphenation space 116
 - addition 78
 - additional inter-sentence space 107
 - adjustment (introduction) 17
 - adjustment and filling, manipulating .. 101
 - adjustment mode register (**.j**) 103
 - adjustment to both margins, difference
 - from AT&T **troff** 242
 - adjustment, and **break** warnings 236
 - Adobe Glyph List (AGL) 142
 - alias, diversion, creating (**als**) 167
 - alias, diversion, removing (**rm**) 167
 - alias, macro, creating (**als**) 167
 - alias, macro, removing (**rm**) 167
 - alias, register, creating (**aln**) 97
 - alias, register, removing (**rr**) 97
 - alias, string, creating (**als**) 167
 - alias, string, removing (**rm**) 167
 - aliasing fonts with third argument to **fp**
 - request 139
 - als** request, and \$0 180
 - am**, **am1**, **ami** requests, and warnings... 237
 - annotation, output line 189
 - appending to a diversion (**da**, **boxa**)... 209
 - appending to a file (**opena**) 225
 - appending to a macro (**am**) 177
 - appending to a string (**as**) 165
 - approximation output register (**.A**) ... 100
 - arc, drawing ('**D'a ...'**) 194
 - argument 68
 - arguments to macros 87
 - arguments to macros, and tabs 86
 - arguments to requests 86
 - arguments to requests, and tabs 86
 - arguments, and compatibility mode... 231
 - arguments, file name, to requests, in other
 - implementations 243
 - arguments, to escape sequences,
 - delimiting 91
 - arguments, to strings 163
 - arithmetic operators 78
 - artificial fonts 150
 - as** and **as1** requests, arguments starting
 - with double quote ", and comments. 165
 - as** request, and comments 164
 - as**, **as1** requests, and warnings 237
 - as1** request, and comments 164
 - ASCII output encoding 11
 - asciify** request, and **writem** 226
 - assertion (arithmetic operator) 78
 - assign input line number request (**lf**) . 232

assign number format to register (af) ..	98
assignments, indirect	97
assignments, nested	97
AT&T ms , macro package differences ...	57
AT&T troff bug, in cf request	223
AT&T troff bugs	223
attributes, character cell	135
auto-incrementation of a register	97
automatic font mounting	136
automatic hyphenation	108
automatic hyphenation parameters ...	110
auxiliary macro package	23
available glyphs, list of (<i>groff_char</i> (7) man page)	142
available registers, number of, register (.R)	101

B

background	1
background color name register (.M) ..	163
backslash glyph, formatting (\[rs]) ...	90
backslash, embedding in a macro argument	87
backslash, printing (\ , \e , \E , \[rs]) ..	244
backspace character	187
backspace character, and translations ..	124
backtrace of input stack (backtrace) ..	235
baseline rule special character (\[ru]) ..	193
baseline, text	75, 156
basic scaling unit (u)	76
basic units	75
basic units, conversion to	76
basics of macro package usage	17
bd request, and font styles	138
bd request, and font translations	137
bd request, incompatibilities with AT&T troff	244
beginning diversion (di , box)	209
beginning of conditional block (\{) ...	172
blank line	66
blank line macro (blm)	66, 86, 206
blank line trap (blm)	86
blank line traps	206
blank lines, disabling	119
block paragraphs	19
block, conditional, beginning (\{)	172
block, conditional, end (\})	172
blocks, conditional	171
body, of a while request	173
boldface, imitating (bd)	152
bottom margin	198

boundary-relative measurement operator (l)	80
boundary-relative measurement operator (l), use with sp request	117
bounding box	228
box (diversion operation)	209
box request, and warnings	237
box rule special character (\[br]) ...	193
box , boxa requests, and warnings ...	237
boxa request, and dn (dl)	211
boxa request, and warnings	237
boxes [ms]	48
bp request, and top-level diversion ...	132
bp request, and traps (.pe)	202
bp request, causing implicit break	101
bp request, incompatibilities with AT&T troff	244
bp request, using + and - with	80
br glyph, and cflags	146
br request, nilpotence with no-break control character	101
brace escape sequences (\{ , \})	172
break	66, 101
break (introduction)	17
break request, in a while loop	174
break, page	75, 131, 202
break, page (introduction)	19
break, page, final	207
break, page, prevented by vpt	198
breaking file names (\:)	109
breaking URLs (\:)	109
breaking without hyphens (\:)	109
brp request, nilpotence with no-break control character	101
bug, in AT&T troff cf request	223
built-in register, removing	100
built-in registers	100
bulleted list, example markup [ms]	44

C

c scaling unit	76
calling macros	87
calling macros (introduction)	68
capabilities of GNU troff	2
case-transforming a string (stringdown , stringup)	166
categories, warning	236
ce request, causing implicit break	101
ce request, difference from ' .ad c ' ...	106
cell, character, attributes	135
centered text (filled)	103

- centered text (unfilled) 106
- centering lines (**ce**) 106
- centering lines (introduction) 19
- centimeter scaling unit (**c**) 76
- cf** request, and copy mode 222
- cf** request, arguments starting with
 - double quote **"**, and comments 221
- cf** request, causing implicit break 101
- cf** request, incompatibilities with AT&T
 - troff** 243
- changing control characters 85
- changing font family (**fam**, **\F**) 138
- changing fonts (**ft**, **\f**) 135
- changing format, and read-only
 - registers 99
- changing the font height (**\H**) 150
- changing the font slant (**\S**) 151
- changing the page number character
 - (**pc**) 131
- changing trap location (**ch**) 200
- changing type sizes (**ps**, **\s**) 156, 160
- changing vertical line spacing (**vs**) 158
- char** request, and comments 147
- char** request, and soft hyphen
 - character 110
- char** request, and translations 124
- char** request, used with **\N** 145
- character 140
- character cell attributes 135
- character class (**class**) 149
- character class name space, shared with
 - special characters 84
- character classes 148
- character mappings, composite, dumping
 - (**pcomposite**) 233
- character properties (**cflags**) 145
- character translations 124
- character, backspace 187
- character, backspace, and translations 124
- character, control (**.**) 67
- character, control, changing (**cc**) 85
- character, defining (**char**) 147
- character, defining fallback (**fchar**,
 - fschar**, **schar**) 147
- character, distinguished from glyph 140
- character, dummy (**\&**) 154
- character, dummy (**\&**), as control
 - character suppressor 67
- character, dummy (**\&**), effect on **\l**
 - escape sequence 192
- character, dummy (**\&**), effect on
 - kerning 153
- character, escape, changing (**ec**) 90
- character, escape, while defining glyph 147
- character, field delimiting (**fc**) 123
- character, field padding (**fc**) 123
- character, horizontal tab 67
- character, hyphenation (**\%**) 109
- character, indexed, formatting (**\N**) 145
- character, leader 67
- character, leader repetition (**lc**) 122
- character, leader, and translations 124
- character, leader, non-interpreted (**\a**) 122
- character, margins (**mc**) 191
- character, named (**\C**) 144
- character, newline, and translations 124
- character, no-break control (**'**) 67
- character, no-break control, changing
 - (**c2**) 85
- character, ordinary 82
- character, removing definition (**rchar**,
 - rfschar**) 148
- character, soft hyphen, setting (**shc**) 110
- character, special 124
- character, tab repetition (**tc**) 121
- character, tab, and translations 124
- character, tab, non-interpreted (**\t**) 119
- character, transparent 146
- character, transparent dummy (**\)**) 156
- characters, end-of-sentence 146
- characters, end-of-sentence transparent 65
- characters, hyphenation 146
- characters, input, and output glyphs,
 - compatibility with AT&T **troff** 244
- characters, invalid for **trf** request 222
- characters, invalid input 70
- characters, overlapping 146
- characters, special 65
- characters, special, list of (*groff.char(7)*
 - man page) 142
- characters, unnamed, accessing with
 - \N** 251
- circle, filled, drawing (**'\D'C ...'**) 194
- circle, outlined, drawing (**'\D'c ...'**) 194
- circle, solid, drawing (**'\D'C ...'**) 194
- circle, stroked, drawing (**'\D'c ...'**) 194
- class of characters (**class**) 149
- classes, character 148
- clearing input line trap (**it**, **itc**) 203
- closing brace escape sequence (**\}**) 172
- closing file (**close**) 226
- code, hyphenation (**hcode**) 114
- color name, background, register (**.M**) 163
- color name, fill, register (**.M**) 163

- color name, stroke, register (**.m**) 162
- color, default 162
- color, fill 161
- color, stroke 161
- colors 161
- colors, defined, dumping (**pcolor**) 233
- command prefix 12
- command-line options 7
- comments 93
- comments in device description files 247
- comments in font description files 250
- comments, after character definitions 147
- comments, after file name arguments 113
- comments, after file name or system
 - command arguments 221
- comments, lining up with tabs 93
- comments, with string definitions and
 - appendments 164
- comments, with string length
 - measurements 165
- common features 19
- common name space of macros, diversions,
 - and strings 84
- common name space of special characters
 - and character classes 84
- comparison of strings 169
- comparison operators 79
- compatibility mode 237, 238
- compatibility mode, and parameters 231
- complementation, logical 79
- composite characters mappings, dumping
 - (**pcomposite**) 233
- composite glyph names 142
- conditional block, beginning (**\f**) 172
- conditional block, end (**\}**) 172
- conditional blocks 171
- conditional expressions 168
- conditional output for terminal (TTY) 168
- conditional page break (**ne**) 132
- conditionals and loops 168
- configuring control characters 85
- configuring the page length (**p1**) 130
- consecutive hyphenated lines (**h1m**) 115
- constant glyph spacing mode (**cs**) 152
- contents, table of 21, 123
- continuation, input line (**\RET**) 129
- continuation, output line (**\c**) 129
- continue** request, in a **while** loop 174
- continued output line register (**.int**) 130
- continuous underlining (**cu**) 151
- control character (**.**) 67
- control character, changing (**cc**) 85
- control character, no-break (**'**) 67
- control character, no-break, changing
 - (**c2**) 85
- control characters 85
- control line 67
- control, line 129
- control, page 131
- conventions for input 72
- conversion to basic units 76
- copy mode 180
- copy mode, and **\!** 212
- copy mode, and **\?** 169, 212
- copy mode, and **\a** 122
- copy mode, and **\t** 119
- copy mode, and **\V** 226
- copy mode, and **cf** request 222
- copy mode, and **device** request 226
- copy mode, and **length** request 165
- copy mode, and macro parameters 179
- copy mode, and **output** request 213
- copy mode, and **trf** request 222
- copy mode, and **write** request 225
- copy mode, and **writec** request 225
- copy mode, and **writem** request 226
- copying environment (**evc**) 218
- correction between upright and slanted
 - glyph (**\/, \,**) 154
- correction, italic (**\/**) 154
- correction, left italic (**\,**) 154
- corrections between slanted and upright
 - glyphs (**\/, \,**) 154
- cover page in [**ms**], example markup 36
- cp** request, and glyph definitions 147
- cq** glyph, at end of sentence 65, 146
- creating alias of register (**aln**) 97
- creating alias, for diversion (**als**) 167
- creating alias, for macro (**als**) 167
- creating alias, for string (**als**) 167
- creating new characters (**char**) 147
- credits 5
- cs** request, and font styles 138
- cs** request, and font translations 137
- cs** request, incompatibilities with AT&T
 - troff** 244
- cs** request, with fractional type sizes 159
- CSTR #54 errata 96, 107, 127, 132, 151, 157, 167, 188, 220
- CSTR #54 erratum, **\s** escape
 - sequence 157
- CSTR #54 erratum, **\S** escape 151
- CSTR #54 erratum, **bp** request 132
- CSTR #54 erratum, **po** request 127

CSTR #54 erratum, **ps** request 157
 CSTR #54 erratum, **rm** request 167
 CSTR #54 erratum, **rr** request 96
 CSTR #54 erratum, **sb** register 188
 CSTR #54 erratum, **ss** request 107
 CSTR #54 erratum, **st** register 188
 CSTR #54 erratum, **yr** register 220
 current directory 14
 current input file name register (**.F**) . . 101
 current page number (%) 132
 current time, hours (**hours**) 220
 current time, minutes (**minutes**) 220
 current time, seconds (**seconds**) 220
 customizing **man** package 23
 customizing **mdoc** package 25

D

da request, and **dn** (**dl**) 211
da request, and warnings 237
 date, day of the month register (**dy**) . . 220
 date, day of the week register (**dw**) . . . 220
 date, month of the year register (**mo**) . . 220
 date, year register (**year**, **yr**) 220
 day of the month register (**dy**) 220
 day of the week register (**dw**) 220
dd glyph, at end of sentence 65, 146
de request, and **while** 173
de, **de1**, **dei** requests, and warnings . . 237
 debugging 231
 debugging page location traps 199
 decimal point, as delimiter 92
 decrementation, automatic, of a register . 97
 default color 162
 default tab stops 120
 default units 77
 deferred output 196
 defined colors, dumping (**pcolor**) 233
 defining character (**char**) 147
 defining character class (**class**) 149
 defining fallback character (**fchar**, **fschar**,
 schar) 147
 defining glyph (**char**) 147
 defining symbol (**char**) 147
 delimiters, for escape sequence
 arguments 91
 delimiting character, for fields (**fc**) . . . 123
 delimiting escape sequence arguments . . 91
 depth, interpolation 89, 92, 241
 depth, nesting, of escape sequences in
 macro definitions 182
 depth, nesting, of interpolations . 89, 92, 241

depth, nesting, of macro definitions . . 175
 depth, of last glyph (**.cdp**) 218
DESC file format 247
DESC file, and font mounting 140
 description file, device, introduced 14
 description file, font 135
 description file, font, introduced 14
 device description file, introduced 14
 device description files, comments 247
device request, and copy mode 226
device request, arguments starting with
 double quote "**",** and comments 226
 device resolution 75, 249
 device resolution, obtaining in the
 formatter 76
 devices for output 3
dg glyph, at end of sentence 65, 146
di request, and warnings 237
 differences in implementation 238
 digit-width space (**\0**) 187
 digits, as delimiters 92
 dimensions, line 126
 directories for macro packages 14
 directory, current 14
 directory, device and font description . . 14
 directory, for **tmac** files 14
 directory, home 14
 directory, platform-specific 14
 directory, site-local 14, 15
 disabling **\ (eo)** 90
 disabling hyphenation (**\%**) 109
 discardable horizontal space 108
 displays 21
 displays [**ms**] 48
 displays, and footnotes [**ms**] 51
 distance to next vertical position trap
 register (**.t**) 200
 diversion 196
 diversion name register (**.z**) 210
 diversion name space, shared with macros
 and strings 84
 diversion trap, setting (**dt**) 203
 diversion traps 203
 diversion, appending to (**da**, **boxa**) . . . 209
 diversion, beginning (**di**, **box**) 209
 diversion, creating alias of (**als**) 167
 diversion, dumping (**pm**) 234
 diversion, ending (**di**, **box**) 209
 diversion, nested 210
 diversion, removing (**rm**) 167
 diversion, removing alias of (**rm**) 167
 diversion, renaming (**rn**) 167

diversion, stripping final newline 215

diversion, top-level 208

diversion, top-level, and \! 213

diversion, top-level, and \? 213

diversion, top-level, and bp 132

diversion, unformatting (**asciify**) 213

diversion, vertical position in, register
 (**.d**) 210

diversions 208, 214

diversions, and traps 202

division by zero 78

division, truncating 78

dl register, and **da** (**boxa**) 211

dn register, and **da** (**boxa**) 211

document description macros, [**ms**] 35

document formats 22

documents, multi-file 232

documents, structuring the source of 86

dot, as delimiter 92

double quote, at the start of a request
 argument 221

double quote, embedding in a macro
 argument 87

double-spacing (**ls**) 117

double-spacing (**vs**, **pvs**) 158

down-casing a string (**stringdown**) 166

drawing a filled circle (**\D'C** . . . ') . . . 194

drawing a filled ellipse (**\D'E** . . . ') . . . 194

drawing a filled polygon (**\D'P** . . . ') . . . 195

drawing a line (**\D'L** . . . ') 194

drawing a solid circle (**\D'C** . . . ') . . . 194

drawing a solid ellipse (**\D'E** . . . ') . . . 194

drawing a solid polygon (**\D'P** . . . ') . . . 195

drawing a spline (**\D'~** . . . ') 194

drawing a stroked circle (**\D'c** . . . ') . . . 194

drawing a stroked ellipse (**\D'e** . . . ') . . . 194

drawing a stroked polygon (**\D'p**
 . . . ') 195

drawing an arc (**\D'a** . . . ') 194

drawing an outlined circle (**\D'c**
 . . . ') 194

drawing an outlined ellipse (**\D'e**
 . . . ') 194

drawing an outlined polygon (**\D'p**
 . . . ') 195

drawing horizontal lines (**\l**) 193

drawing position 75

drawing position, initial 75

drawing position, vertical (**nl**) 133

drawing requests 192

drawing vertical lines (**\L**) 193

ds and **ds1** request, and leading spaces . 164

ds and **ds1** requests, arguments starting
 with double quote ", and comments . 164

ds request, and comments 164

ds, **ds1** requests, and warnings 237

ds1 request, and comments 164

dummy character (**\&**) 154

dummy character (**\&**), as control
 character suppressor 67

dummy character (**\&**), effect on **\l** escape
 sequence 192

dummy character (**\&**), effect on
 kerning 153

dummy character, transparent (**\)** . . . 156

dummy environment, used by **\w** escape
 sequence 187

dumping composite character mappings
 (**pcomposite**) 233

dumping defined colors (**pcolor**) 233

dumping environments (**pev**) 233

dumping font translations (**pfttr**) 233

dumping hyphenation exception words
 (**phw**) 233

dumping macros, strings, or diversions
 (**pm**) 234

dumping occupied font mounting positions
 (**pfp**) 233

dumping open streams (**pstream**) 234

dumping page location traps (**pwh**) 234

dumping pending output line node list
 (**pline**) 233

dumping registers (**pnr**) 234

dumping symbol table (**pm**) 234

E

ejection, page 75, 131, 202

ejection, page, of final page 207

ejection, page, prevented by **vpt** 198

ellipse, filled, drawing (**\D'E** . . . ') . . . 194

ellipse, outlined, drawing (**\D'e** . . . ') . . . 194

ellipse, solid, drawing (**\D'E** . . . ') . . . 194

ellipse, stroked, drawing (**\D'e** . . . ') . . . 194

em glyph, and **cflags** 146

em scaling unit (**m**) 77

embolding of special fonts 152

empty line 66

en scaling unit (**n**) 77

enabling vertical position traps (**vpt**) . . . 197

encoding, input, ISO Latin-1 (8859-1) . . . 71

encoding, input, ISO Latin-2 (8859-2) . . . 72

encoding, input, ISO Latin-5 (8859-9) . . . 72

encoding, input, ISO Latin-9 (8859-15) . . . 72

encoding, input, KOI8-R..... 71
 encoding, output, ASCII..... 11
 encoding, output, ISO Latin-1 (8859-1)..... 11
 encoding, output, ISO 646..... 11
 encoding, output, UTF-8..... 11
 end of conditional block (`\}`)..... 172
 end-of-input macro (`em`)..... 206
 end-of-input trap, setting (`em`)..... 206
 end-of-input traps..... 206
 end-of-sentence characters..... 64, 146
 end-of-sentence detection, cancellation, on
 AT&T `troff`..... 242
 end-of-sentence transparent characters..... 65
 ending diversion (`di`, `box`)..... 209
 endnotes..... 21
 environment..... 196
 environment availability and naming,
 incompatibilities with..... 243
 environment number/name register
 (`.ev`)..... 217
 environment variables..... 12
 environment, copying (`evc`)..... 218
 environment, dimensions of last glyph (`.w`,
 `.cht`, `.cdp`, `.csk`)..... 218
 environment, dummy, used by `\w` escape
 sequence..... 187
 environment, previous line length (`.n`)..... 218
 environment, switching (`ev`)..... 217
 environments..... 216
 environments, dumping (`pev`)..... 233
 equality operator..... 79
 equation example [`ms`]..... 50
 equations [`ms`]..... 49
 escape character, changing (`ec`)..... 90
 escape character, formatting (`\e`)..... 90
 escape character, while defining glyph..... 147
 escape sequence..... 84
 escape sequence argument delimiters..... 91
 escape sequences..... 89
 escape sequences, brace (`\{`, `\}`)..... 172
 escaping newline characters, in strings..... 164
`ex` request, use in debugging..... 232
`ex` request, used with `nx` and `rd`..... 223
 example markup, bulleted list [`ms`]..... 44
 example markup, cover page in [`ms`]..... 36
 example markup, glossary-style list [`ms`]..... 45
 example markup, numbered list [`ms`]..... 44
 examples of invocation..... 15
 exception words, hyphenation, dumping
 (`phw`)..... 233
 exiting (`ex`)..... 232
 expansion of strings (`\*`)..... 163

explicit hyphen (`\%`)..... 115
 explicit hyphenation..... 108
 expression, limitation of logical not in..... 79
 expression, order of evaluation..... 80
 expressions, and register format..... 100
 expressions, and space characters..... 82
 expressions, conditional..... 168
 expressions, numeric..... 78
 extra post-vertical line space (`\x`)..... 158
 extra post-vertical line space register
 (`.a`)..... 118
 extra pre-vertical line space (`\x`)..... 158
 extra spaces between words..... 67
 extreme values representable with Roman
 numerals..... 99
 extremum operators (`>?`, `<?`)..... 79

F

`f` scaling unit..... 161
 factor, zoom, of a font (`fzoom`)..... 137
 fallback character, defining (`fchar`,
 `fschar`, `schar`)..... 147
 fallback character, removing definition of
 (`rchar`, `rfschar`)..... 148
`fam` request, and changing fonts..... 135
 families, font..... 137
 family, font..... 134
`fchar` request, and comments..... 147
 features, common..... 19
`fi` request, causing implicit break..... 101
 field delimiting character (`fc`)..... 123
 field padding character (`fc`)..... 123
 fields..... 123
 fields, and tabs..... 119
 figure space (`\0`)..... 187
 figures [`ms`]..... 49
 file formats..... 247
 file name arguments to requests, in other
 implementations..... 243
 file names, breaking (`\:`)..... 109
 file stream, writing to (`write`, `writec`)..... 225
 file, appending to (`opena`)..... 225
 file, closing (`close`)..... 226
 file, device description, introduced..... 14
 file, font description..... 135
 file, font description, introduced..... 14
 file, inclusion (`so`)..... 221
 file, macro, search path..... 14
 file, next, read (`nx`)..... 223
 file, opening (`open`)..... 225
 files, font..... 247

- fill color 161
- fill color name register (**.M**) 163
- fill mode, and **\c** 129
- fill mode, disabling, request (**nf**) 102
- fill mode, enabling, request (**fi**) 102
- filled circle, drawing (**'\D'C ...'**) 194
- filled ellipse, drawing (**'\D'E ...'**) 194
- filled polygon, drawing (**'\D'P ...'**) 195
- filling 63
- filling (introduction) 17
- filling and adjustment, manipulating .. 101
- filling of output, disabling request (**nf**) 102
- filling of output, enabling request (**fi**) 102
- filling, and **break** warnings 236
- filling, and inter-sentence space 107
- final newline, stripping in diversions .. 215
- fl** request, causing implicit break 101
- floating keep 21
- flush pending output line (**fl**) 234
- flushing of output, timing of,
 - incompatibilities with AT&T **troff** 245
- flushing, of an output line 228
- font 134
- font aliasing with third argument to **fp**
 - request 139
- font description file 135
- font description file format 247
- font description file, format 250
- font description file, introduced 14
- font description files, comments 250
- font directory 14
- font families 137
- font family 134
- font family, changing (**fam**, **\F**) 138
- font file, format 250
- font files 247
- font for underlining (**uf**) 152
- font height, changing (**\H**) 150
- font magnification request (**fzoom**) 137
- font metrics 135
- font mounting positions, occupied,
 - dumping (**pf**) 233
- font mounting, automatic 136
- font path 14
- font position register (**.f**) 140
- font positions 139
- font slant, changing (**\S**) 151
- font style 134
- font style, abstract 135
- font style, abstract, setting up (**sty**) .. 138
- font styles 137
- font translation (**ftr**) 137
- font translations, dumping (**pftr**) 233
- font, mounting (**fp**) 139
- font, optical size, setting (**fzoom**) 137
- font, previous, selecting (**\f**[], **\fP**)... 136
- font, previous, selecting (**ft**) 135
- font, selection 135
- font, special 134
- font, text 134
- font, unstyled 134
- font, zoom factor (**fzoom**) 137
- fonts, artificial 150
- fonts, changing (**ft**, **\f**) 135
- fonts, searching for 14
- fonts, special 149
- footers 130, 198
- footers [**ms**] 53
- footnote mark [**ms**] 51
- footnotes 21
- footnotes [**ms**] 51
- footnotes, and displays [**ms**] 51
- footnotes, and keeps [**ms**] 51
- form letters 223
- format of font description file 247
- format of font description files 250
- format of font files 250
- format of register (**\g**) 100
- format, paper 15
- format, register 94
- format, **troff** output 253
- formats, file 247
- formatter instructions 84
- formatting a backslash glyph (**\[rs]**) .. 90
- formatting a title line (**tl**) 131
- formatting the escape character (**\e**)... 90
- fp** request, and font translations 137
- fp** request, incompatibilities with AT&T
 - troff** 244
- fractional point sizes 159, 243
- fractional type sizes 159, 243
- fractional type sizes in **ms** macros 58
- French spacing 64
- fschar** request, and comments 147
- fspecial** request, and font styles 138
- fspecial** request, and font
 - translations 137
- fspecial** request, and glyph search
 - order 140
- fspecial** request, and imitating bold .. 152
- ft** request, and font translations 137
- full-service macro package 23

G

geometry, page 75
 GGL (**groff** glyph list) 142, 149
 glossary-style list, example markup [**ms**] . 45
 glyph 140
 glyph mode, constant spacing (**cs**) 152
 glyph names, composite 142
 glyph pile (**\b**) 196
 glyph properties (**cflags**) 145
 glyph, defining (**char**) 147
 glyph, distinguished from character ... 140
 glyph, last, dimensions (**.w**, **.cht**, **.cdp**,
 .csk) 218
 glyph, leader repetition (**lc**) 122
 glyph, numbered (**\N**) 124
 glyph, numbered, accessing (**\N**) 145
 glyph, removing definition (**rchar**,
 rfschar) 148
 glyph, soft hyphen (**hy**) 110
 glyph, tab repetition (**tc**) 121
 glyphs, available, list of (*groff.char(7)* man
 page) 142
 glyphs, output, and input characters,
 compatibility with AT&T **troff** ... 244
 glyphs, overstriking (**\o**) 189
 glyphs, unnamed 145
 glyphs, unnamed, accessing with **\N** ... 251
 GNU **troff** capabilities 2
 GNU **troff**, identification register
 (**.g**) 101
 GNU **troff**, PID register (**\$\$**) 220
 GNU **troff**, process ID register (**\$\$**) . 220
 GNU-specific register (**.g**) 101
 graphic renditions 135
 greater than (or equal to) operator 79
groff glyph list (GGL) 142, 149
groff invocation 7
groff—what is it? 1
GROFF_BIN_PATH, environment variable. 12
GROFF_COMMAND_PREFIX, environment
 variable 12
GROFF_ENCODING, environment variable. 13
GROFF_FONT_PATH, environment
 variable 13, 15
GROFF_TMAC_PATH, environment
 variable 13, 14
GROFF_TMPDIR, environment variable ... 13
GROFF_TYPESETTER, environment
 variable 13
grohtml, the program 11

H

hair space (**\^**) 187
hcode request, and glyph definitions . 147
 headers 130, 198
 headers [**ms**] 53
 headings, run-in 20
 heavy (font stroke weight) 134
 height, font, changing (**\H**) 150
 height, of last glyph (**.cht**) 218
 high-water mark register (**.h**) 211
 home directory 14
 horizontal discardable space 108
 horizontal input line position register
 (**hp**) 188
 horizontal input line position, saving
 (**\k**) 188
 horizontal line, drawing (**\l**) 193
 horizontal motion (**\h**) 186
 horizontal motion quantum 247
 horizontal motion quantum register
 (**.H**) 77
 horizontal output line position register
 (**.k**) 188
 horizontal resolution 247
 horizontal resolution register (**.H**) 77
 horizontal space (**\h**) 186
 horizontal space, unformatting 215
 horizontal tab character 67
 Host System Service Access 220
 hours, current time (**hours**) 220
hpf request, and comments 113
hpf request, and hyphenation language. 115
hpfa request, and comments 113
hw request, and **hy** restrictions 109
hw request, and hyphenation language. 115
hy glyph, and **cflags** 146
 hyphen, explicit (**\%**) 115
 hyphenated lines, consecutive (**hlm**) ... 115
 hyphenating characters 146
 hyphenation 65
 hyphenation character (**\%**) 109
 hyphenation code (**hcode**) 114
 hyphenation consecutive line count
 register (**.hlc**) 115
 hyphenation consecutive line limit register
 (**.hlm**) 115
 hyphenation exception words 108
 hyphenation exception words, dumping
 (**phw**) 233
 hyphenation language register (**.hla**) . 115
 hyphenation margin (**hym**) 115
 hyphenation margin register (**.hym**) ... 116

hyphenation mode default register (.hydefault)	113	input characters and output glyphs, compatibility with AT&T troff	244
hyphenation mode register (.hy)	110	input characters, invalid	70
hyphenation parameters, automatic	110	input conventions	72
hyphenation pattern files	111	input encoding, ISO Latin-1 (8859-1) ..	71
hyphenation patterns (hpf)	113	input encoding, ISO Latin-2 (8859-2) ..	72
hyphenation space (hys)	116	input encoding, ISO Latin-5 (8859-9) ..	72
hyphenation space adjustment threshold	116	input encoding, ISO Latin-9 (8859-15) ..	72
hyphenation space adjustment threshold register (.hys)	116	input encoding, KOI8-R	71
hyphenation, automatic	108	input file name, current, register (.F) ..	101
hyphenation, disabling (\%)	109	input level	89, 92, 241
hyphenation, explicit	108	input line continuation (RET)	129
hyphenation, incompatibilities with AT&T troff	242	input line number register (.c, c.)	100
hyphenation, manipulating	108	input line number, assignment, request (lf)	232
hyphenation, manual	108	input line position, horizontal, saving (k)	188
		input line trap, clearing (it , itc)	203
		input line trap, setting (it , itc)	203
		input line traps	203
		input line traps and interrupted lines (itc)	204
		input line, horizontal position, register (hp)	188
		input line, productive	105
		input stack, backtrace (backtrace)	235
		input stack, setting limit	235
		input stream, standard, interpolate from (rd)	223
		input token	228
		inserting horizontal space (\h)	186
		installation	3
		instructing the formatter	84
		inter-sentence space	64
		inter-sentence space size register (.sss)	107
		inter-sentence space, additional	107
		inter-word spacing, minimum	107
		interactive use of GNU troff	234
		intercepting requests	85
		intermediate output	253
		interpolating registers (\n)	97
		interpolation	68
		interpolation depth	89, 92, 241
		interpolation of strings (*)	163
		interpretation mode	180
		interrupted line	129
		interrupted line register (.int)	130
		interrupted lines and input line traps (itc)	204
		introduction	1
		invalid characters for trf request	222

I

i scaling unit	76
identifiers	82
identifiers, undefined	84
ie request, and font translations	137
ie request, operators to use with	168
if request, and font translations	137
if request, and the '!' operator	78
if request, operators to use with	168
if-else	171
if-then	170
imitating boldface (bd)	152
implementation differences	238
implicit line break	66
implicit trap	202
in request, causing implicit break	101
in request, using + and - with	80
inch scaling unit (i)	76
including a file (so)	221
incompatibilities with AT&T troff	238
increment value without changing the register	98
incrementation, automatic, of a register ..	97
indentation (in)	126
indentation, of roff source code	86
indented paragraphs	19
index, in macro package	21
indexed character, formatting (\N)	145
indicator, scaling	76
indirect assignments	97
initial drawing position	75
input and output requests	220

invalid input characters 70
 invocation examples 15
 invoking **groff** 7
 invoking requests 86
 ISO Latin-1 (8859-1) input encoding ... 71
 ISO Latin-1 (8859-1) output encoding.. 11
 ISO Latin-2 (8859-2) input encoding ... 72
 ISO Latin-5 (8859-9) input encoding ... 72
 ISO Latin-9 (8859-15) input encoding.. 72
 ISO 646 output encoding 11
 italic correction (**\/**) 154

J

justifying text 101

K

keep, floating 21
 keeps (introduction) 21
 keeps [**ms**] 47
 keeps, and footnotes [**ms**] 51
 kerning and ligatures 152
 kerning enabled register (**.kern**) 153
 kerning, activating (**kern**) 153
 kerning, track 153
 KOI8-R, input encoding 71

L

landscape page orientation 15
 language [**ms**] 52
 language, **troff** page description 253
 last glyph, dimensions (**.w**, **.cht**, **.cdp**,
 .csk) 218
 last-requested point size registers (**.psr**,
 .sr) 160
 last-requested type size registers (**.psr**,
 .sr) 160
 Latin-1 (ISO 8859-1) input encoding ... 71
 Latin-1 (ISO 8859-1) output encoding.. 11
 Latin-2 (ISO 8859-2) input encoding ... 72
 Latin-5 (ISO 8859-9) input encoding ... 72
 Latin-9 (ISO 8859-15) input encoding.. 72
 layout, line 126
 layout, page 130
lc request, and glyph definitions 147
 leader 21
 leader character 67, 122
 leader character, and translations 124
 leader character, non-interpreted (**\a**) . 122
 leader repetition character (**lc**) 122

leaders 122
 leading 156
 leading space macro (**lsm**) 66
 leading space traps 206
 leading spaces 66
 leading spaces in **ds** and **ds1** argument . 164
 leading spaces macro (**lsm**) 206
 left italic correction (**\,**) 154
 left margin (**po**) 126
 length of a string (**length**) 165
 length of line (**ll**) 126
 length of previous line (**.n**) 218
 length of the page, configuring (**pl**) ... 130
 length of title line, configuring (**lt**) ... 131
length request, and comments 165
length request, and copy mode 165
length request, arguments starting with
 double quote "**",** and comments 165
 less than (or equal to) operator 79
 letters, form 223
 level, input 89, 92, 241
 level, suppression nesting, register (**.0**) . 219
lf request, arguments starting with
 double quote "**",** and comments 232
lf request, incompatibilities with AT&T
 troff 243
 ligature 140
 ligatures and kerning 152
 ligatures enabled register (**.lg**) 153
 ligatures, activating (**lg**) 153
 limitations of **\b** escape sequence 196
 line annotation, output 189
 line break 101
 line break (introduction) 17
 line break, output 66
 line break, output (introduction) 17
 line control 129
 line dimensions 126
 line indentation (**in**) 126
 line layout 126
 line length (**ll**) 126
 line length register (**.l**) 128
 line length, previous (**.n**) 218
 line number, input, register (**.c**, **c.**) .. 100
 line number, output, register (**ln**) 190
 line numbers, printing (**nm**) 189
 line space, extra post-vertical (**\x**) 158
 line space, extra pre-vertical (**\x**) 158
 line spacing register (**.L**) 117
 line spacing, post-vertical (**pvs**) 158
 line thickness (**\D't ...'**) 196
 line, blank 66

line, drawing (<code>\D'1 ...'</code>)	194
line, horizontal, drawing (<code>\l</code>)	193
line, input, continuation (<code>\RET</code>)	129
line, input, horizontal position, register (<code>hp</code>)	188
line, input, horizontal position, saving (<code>\k</code>)	188
line, interrupted	129
line, output, continuation (<code>\c</code>)	129
line, output, horizontal position, register (<code>.k</code>)	188
line, productive input	105
line, vertical, drawing (<code>\L</code>)	193
line-tabs mode	122
lines, blank, disabling	119
lines, centering (<code>ce</code>)	106
lines, centering (introduction)	19
lines, consecutive hyphenated (<code>hlm</code>)	115
lines, interrupted, and input line traps (<code>itc</code>)	204
lines, right-aligning (introduction)	19
list of special characters (<code>groff_char(7)</code> man page)	142
listing page location traps (<code>pwh</code>)	234
lists	19
ll request, using <code>+</code> and <code>-</code> with	80
localization	113
localization [<code>ms</code>]	52
locating macro files	14
locating macro packages	14
location, vertical, page, marking (<code>mk</code>)	184
location, vertical, page, returning to marked (<code>rt</code>)	184
logical “and” operator	79
logical “or” operator	79
logical complementation operator	79
logical conjunction operator	79
logical disjunction operator	79
logical not, limitation in expression	79
logical operators	79
long names	239
loops and conditionals	168
lowercasing a string (<code>stringdown</code>)	166
ls request, alternative to (<code>pvs</code>)	159
lt request, using <code>+</code> and <code>-</code> with	80

M

m scaling unit	77
M scaling unit	77
machine units	75
macro	68
macro arguments	87
macro arguments, and compatibility mode	231
macro arguments, and tabs	86
macro file search path	14
macro name register (<code>\\$0</code>)	180
macro name space, shared with strings and diversions	84
macro names, starting with <code>[or]</code> , and refer	83
macro package	70
macro package directories	14
macro package search path	14
macro package usage, basics of	17
macro package, auxiliary	23
macro package, full-service	23
macro package, introduction	2
macro package, major	23
macro package, minor	23
macro package, structuring the source of	86
macro packages, search procedure for	14
macro, appending to (<code>am</code>)	177
macro, creating alias of (<code>als</code>)	167
macro, dumping (<code>pm</code>)	234
macro, end-of-input (<code>em</code>)	206
macro, parameters (<code>\\$</code>)	179
macro, removing (<code>rm</code>)	167
macro, removing alias of (<code>rm</code>)	167
macro, renaming (<code>rn</code>)	167
macros packages, tutorial for users of	17
macros, recursive	174
macros, writing	175
magnification, font, request (<code>fzoom</code>)	137
major macro package	23
major version number register (<code>.x</code>)	101
man macro package	23
man macros, customizing headers and footers of	23
man macros, Ultrix-specific	24
man pages	5
manipulating filling and adjustment	101
manipulating hyphenation	108
manipulating spacing	116
manipulating type size and vertical spacing	156
manual hyphenation	108
manual pages (“man pages”)	5

- margin character (**mc**) 191
- margin, bottom 198
- margin, hyphenation (**hym**) 115
- margin, left (**po**) 126
- margin, right 126
- margin, top 198
- mark, footnote [**ms**] 51
- mark, high-water, register (**.h**) 211
- marking vertical page location (**mk**) ... 184
- maximum operator 79
- maximum value representable with Roman numerals 99
- mdoc** macro package 25
- me** macro package 26
- measurements 76
- measurements, specifying safely 78
- metrics, font 135
- minimum inter-word spacing 107
- minimum operator 79
- minimum value representable with Roman numerals 99
- minor macro package 23
- minor version number register (**.y**) ... 101
- minutes, current time (**minutes**) 220
- mm** macro package 26
- mode, compatibility 238
- mode, compatibility, and parameters .. 231
- mode, constant glyph spacing (**cs**) 152
- mode, copy 180
- mode, copy, and **\!** 212
- mode, copy, and **\?** 169, 212
- mode, copy, and **\a** 122
- mode, copy, and **\t** 119
- mode, copy, and **\V** 226
- mode, copy, and **cf** request 222
- mode, copy, and **device** request 226
- mode, copy, and **length** request 165
- mode, copy, and macro parameters ... 179
- mode, copy, and **output** request 213
- mode, copy, and **trf** request 222
- mode, copy, and **write** request 225
- mode, copy, and **writec** request 225
- mode, copy, and **writem** request 226
- mode, fill, and **\c** 129
- mode, fill, and **break** warnings 236
- mode, fill, and inter-sentence space ... 107
- mode, fill, disabling, request (**nf**) 102
- mode, fill, enabling, request (**fi**) 102
- mode, interpretation 180
- mode, line-tabs 122
- mode, no-fill request (**nf**) 102
- mode, no-fill, and **\c** 130
- mode, no-space, enabling, request (**ns**) . 119
- mode, **nroff** 125
- mode, safer . 10, 14, 101, 222, 224, 225, 238
- mode, **troff** 125
- mode, unsafe ... 11, 14, 101, 222, 224, 225
- modifying requests 85
- modulus by zero 78
- modulus operator 78
- mom** macro package 26
- month of the year register (**mo**) 220
- motion operators 80
- motion quanta 77
- motion quantum, horizontal 247
- motion quantum, horizontal, register (**.H**) 77
- motion quantum, vertical 249
- motion quantum, vertical, register (**.V**) . 77
- motion, horizontal (**\h**) 186
- motion, vertical (**\v**) 186
- motions, page 184
- mounting a font (**fp**) 139
- mounting position 135
- mounting positions, occupied by fonts,
 - dumping (**pfp**) 233
- mounting, font, automatic 136
- ms** document structure 29
- ms** macro package 26
- ms** macros, accent marks 59
- ms** macros, body text 37
- ms** macros, creating table of contents ... 55
- ms** macros, displays 47
- ms** macros, document control settings .. 30
- ms** macros, document description 35
- ms** macros, equations 49
- ms** macros, figures 49
- ms** macros, footers 53
- ms** macros, footnotes 51
- ms** macros, fractional type sizes in 58
- ms** macros, **groff** differences from
 - AT&T 57
- ms** macros, headers 53
- ms** macros, headings 39
- ms** macros, keeps 47
- ms** macros, language 52
- ms** macros, lists 44
- ms** macros, localization 52
- ms** macros, margins 54
- ms** macros, multiple columns 54
- ms** macros, naming conventions 62
- ms** macros, nested lists 46
- ms** macros, obtaining typographical
 - symbols 38

ms macros, page layout 53
ms macros, paragraph handling 38
ms macros, references 49
ms macros, special characters 59
ms macros, strings 59
ms macros, tables 49
ms macros, text settings 37
mso request, arguments starting with
 double quote `"`, and comments 221
msoquiet request, arguments starting with
 double quote `"`, and comments 221
multi-file documents 232
multi-line strings 164
multi-page table example [**ms**] 50
multiple columns [**ms**] 54
multiplication 78

N

n scaling unit 77
name space, common, of macros,
 diversions, and strings 84
name space, common, of special characters
 and character classes 84
name, background color, register (**.M**) 163
name, fill color, register (**.M**) 163
name, stroke color, register (**.m**) 162
named character (**\C**) 144
names, long 239
naming conventions, **ms** macros 62
ne request, and the **.trunc** register ... 201
ne request, comparison with **sv** 133
need vertical space request (**ne**) 132
negating register values 96
negation 78
nested assignments 97
nested diversions 210
nested lists [**ms**] 46
nesting depth, of escape sequences in
 macro definitions 182
nesting depth, of interpolations . 89, 92, 241
nesting depth, of macro definitions 175
nesting level, suppression, register (**.O**) . 219
new page request (**bp**) 132
newline character, and translations ... 124
newline character, in strings, escaping . 164
newline, final, stripping in diversions .. 215
next file, read (**nx**) 223
next free font position register (**.fp**) .. 140
next page number register (**.pn**) 130
next page number, assignment request
 (**pn**) 130

next trap name register (**.trap**) 202
nf request, causing implicit break 101
nl register, and **.d** 210
nl register, difference from **.h** 211
nm request, using **+** and **-** with 80
no-break control character (**'**) 67
no-break control character, changing
 (**c2**) 85
no-fill mode request (**nf**) 102
no-fill mode, and **\c** 130
no-space mode, enabling, request (**ns**) . 119
node 228
node list, of pending output line, dumping
 (**pline**) 233
nodes, in device extension commands . 227
non-printing break point (**\:**) 109
normal (font stroke weight) 134
nr request, and warnings 237
nr request, using **+** and **-** with 80
nroff mode 125
number format, assigning to register
 (**af**) 98
number of available registers register
 (**.R**) 101
number, input line, assignment request
 (**lf**) 232
number, next page assignment request
 (**pn**) 130
number, next page, register (**.pn**) 130
numbered glyph (**\N**) 124
numbered glyph, accessing (**\N**) 145
numbered list, example markup [**ms**] ... 44
numbers, line, printing (**nm**) 189
numeral-width space (**\O**) 187
numerals, as delimiters 92
numerals, Roman 99
numeric expression, valid 81
numeric expressions 78
nx request, arguments starting with
 double quote `"`, and comments 221
nx request, incompatibilities with AT&T
 troff 243

O

object creation 178
 oblique (font shape) 134
 occupied font mounting positions,
 dumping (**pfp**) 233
 offset, page 75
 offset, page (**po**) 126
open request, and safer mode 10
open request, arguments starting with
 double quote ", and comments 221
 open streams, dumping (**pstream**) 234
opena request, and safer mode 10
opena request, arguments starting with
 double quote ", and comments 221
 opening brace escape sequence (**\}**) ... 172
 opening file (**open**) 225
 operator, scaling 79
 operators, arithmetic 78
 operators, as delimiters 92
 operators, comparison 79
 operators, extremum (**>?**, **<?**) 79
 operators, logical 79
 operators, motion 80
 operators, unary arithmetic 78
 optical size of a font, setting the
 (**fzoom**) 137
 options 7
 order of evaluation in expressions 80
 ordinary character 82
 orientation, landscape 15
 origin 75
 orphan 133
 orphan lines, preventing with **ne** 132
os request, and no-space mode 133
 outlined circle, drawing (**'\D'c ... '**) . 194
 outlined ellipse, drawing (**'\D'e ... '**) . 194
 outlined polygon, drawing (**'\D'p ... '**) 195
 output and input requests 220
 output comparison operator 168
 output device name string (**.T**) 11, 163
 output device name string (**.T**), in other
 implementations 243
 output device usage register (**.T**) 11
 output device usage register (**.T**),
 incompatibility with AT&T **troff** .. 243
 output devices 3
 output encoding, ASCII 11
 output encoding, ISO Latin-1 (8859-1) . 11
 output encoding, ISO 646 11
 output encoding, UTF-8 11

output flushes, timing of, incompatibilities
 with AT&T **troff** 245
 output format, **troff** 253
 output glyphs, and input characters,
 compatibility with AT&T **troff** 244
 output line annotation 189
 output line break 66
 output line break (introduction) 17
 output line number register (**ln**) 190
 output line properties 101
 output line, continuation (**\c**) 129
 output line, flush pending (**f1**) 234
 output line, horizontal position, register
 (**.k**) 188
 output line, node list of pending, dumping
 (**pline**) 233
 output node 228
output request, and **\!** 213
output request, and copy mode 213
 output, filling, disabling request (**nf**) .. 102
 output, filling, enabling request (**fi**) .. 102
 output, intermediate 253
 output, suppressing (**\0**) 219
 output, transparent (**\!**, **\?**) 212
 output, transparent (**cf**, **trf**) 222
 output, transparent, incompatibilities with
 AT&T **troff** 244
 output, **troff** 253
 overlapping characters 146
 overstriking glyphs (**\o**) 189

P

p scaling unit 76
P scaling unit 76
 package, macro 70
 package, macro, auxiliary 23
 package, macro, full-service 23
 package, macro, introduction 2
 package, macro, major 23
 package, macro, minor 23
 package, macro, search path 14
 package, package, structuring the source
 of 86
 packages, macro, tutorial for users of ... 17
 padding character, for fields (**fc**) 123
 page 75
 page break 75, 131, 202
 page break (introduction) 19
 page break, conditional (**ne**) 132
 page break, final 207
 page break, prevented by **vpt** 198

- page control 131
- page description language, **troff** 253
- page ejection 75, 131, 202
- page ejection status register (**.pe**) 202
- page ejection, of final page 207
- page ejection, prevented by **vpt** 198
- page footers 198
- page headers 198
- page layout 130
- page layout [**ms**] 53
- page length register (**.p**) 130
- page length, configuring (**pl**) 130
- page location traps 198
- page location traps, debugging 199
- page location, vertical, marking (**mk**) .. 184
- page location, vertical, returning to
 - marked (**rt**) 184
- page motions 184
- page number character (%) 131
- page number character, changing (**pc**) . 131
- page number register (%) 132
- page number, next, assignment request
 - (**pn**) 130
- page number, next, register (**.pn**) 130
- page offset 75
- page offset (**po**) 126
- page orientation, landscape 15
- page, geometry of 75
- page, new request (**bp**) 132
- paper format 15
- paper size 15
- paragraphs 19
- parameter count register (**.\$**) 178
- parameters 178
- parameters, and compatibility mode .. 231
- parameters, macro (**\\$**) 179
- parentheses 80
- partially collected line 101
- path, for font files 14
- path, for tmac files 14
- pattern files, for hyphenation 111
- patterns for hyphenation (**hpf**) 113
- pending node list of output line, dumping
 - (**pline**) 233
- pending output line 101
- pending output line, flush (**fl**) 234
- pi** request, and safer mode 10
- pi** request, arguments starting with
 - double quote ", and comments 221
- pi** request, disabled by default 238
- pi** request, incompatibilities with AT&T
 - troff** 243
- pica scaling unit (**P**) 76
- PID of GNU **troff** register (**\$\$**) 220
- pile, glyph (**\b**) 196
- pl** request, using + and - with 80
- plain text approximation output register
 - (**.A**) 8, 100
- planting a trap 197
- platform-specific directory 14
- pm** request, incompatibilities with AT&T
 - troff** 244
- pn** request, using + and - with 80
- PNG image generation from
 - PostScript 248
- po** request, using + and - with 80
- point scaling unit (**p**) 76
- point size registers (**.s**, **.ps**) 157
- point size registers, last-requested (**.psr**,
 - .sr**) 160
- point sizes, changing (**ps**, **\s**) 156, 160
- point sizes, fractional 159, 243
- point, scaled, scaling unit (**s**) 76, 159
- point, typographical, scaling unit
 - (**z**) 76, 159
- polygon, filled, drawing (**\D'P ...'**) . 195
- polygon, outlined, drawing (**\D'p**
 - ...'**) 195
- polygon, solid, drawing (**\D'P ...'**) . 195
- polygon, stroked, drawing (**\D'p**
 - ...'**) 195
- position of lowest text line (**.h**) 211
- position, absolute (*sic*) operator (**l**) 80
- position, drawing 75
- position, horizontal input line, saving
 - (**\k**) 188
- position, horizontal, in input line, register
 - (**hp**) 188
- position, horizontal, in output line,
 - register (**.k**) 188
- position, mounting 135
- position, vertical, in diversion, register
 - (**.d**) 210
- positions, font 139
- positions, font mounting, occupied,
 - dumping (**pfp**) 233
- post-vertical line spacing 158
- post-vertical line spacing register
 - (**.pvs**) 159
- post-vertical line spacing, changing
 - (**pvs**) 159
- postprocessor access 226
- postprocessors 3
- PostScript, bounding box 228

- PostScript, PNG image generation 248
 - prefix, for commands 12
 - preprocessors 3
 - previous font, selecting (**\f[]**, **\fP**) . . . 136
 - previous font, selecting (**\ft**) 135
 - previous line length (**\n**) 218
 - print current page register (**\P**) 10
 - print to the standard error stream (**\tm**,
 - \tm1**, **\tmc**) 232
 - printing backslash (****, **\e**, **\E**, **\[rs]**) . 244
 - printing line numbers (**\nm**) 189
 - printing, zero-width (**\z**, **\Z**) 189
 - process ID of GNU **\troff** register (**\\$**) . 220
 - productive input line 105
 - properties of characters (**\cflags**) 145
 - properties of glyphs (**\cflags**) 145
 - properties of output lines 101
 - \ps** request, and constant glyph spacing
 - mode 152
 - \ps** request, incompatibilities with AT&T
 - \troff** 243
 - \ps** request, using + and - with 80
 - \ps** request, with fractional type sizes . 159
 - \pso** request, and safer mode 10
 - \pvs** request, using + and - with 80
- Q**
- quanta, motion 77
 - quantum, horizontal motion 247
 - quantum, vertical motion 249
 - quoting the control character with **** . 181
 - quoting the escape character with **** . 181
- R**
- \radical** glyph, and **\cflags** 146
 - ragged-left text 103
 - ragged-right text 103
 - \rc** request, and glyph definitions 147
 - read (interpolate) from standard input
 - stream (**\rd**) 223
 - read next file (**\nx**) 223
 - read-only register removal, incompatibility
 - with AT&T **\troff** 243
 - read-only register, changing format . . . 99
 - recursive macros 174
 - \refer**, and macro names starting with [
 - or] 83
 - reference, **\troff** 63
 - references [**\ms**] 49
 - register format 94
 - register format, in expressions 100
 - register, assigning number format to
 - (**\af**) 98
 - register, built-in, removing 100
 - register, creating alias of (**\aln**) 97
 - register, format (**\g**) 100
 - register, read-only, removal,
 - incompatibility with AT&T **\troff** . 243
 - register, removing (**\rr**) 96
 - register, removing alias of (**\rr**) 97
 - register, renaming (**\rnn**) 97
 - registers 94
 - registers, available number of, register
 - (**\R**) 101
 - registers, built-in 100
 - registers, dumping (**\pnr**) 234
 - registers, interpolating (**\n**) 97
 - registers, setting (**\nr**, **\R**) 95
 - removal of read-only registers,
 - incompatibility with AT&T **\troff** . 243
 - removing a built-in register 100
 - removing a register (**\rr**) 96
 - removing alias of register (**\rr**) 97
 - removing alias, for diversion (**\rm**) 167
 - removing alias, for macro (**\rm**) 167
 - removing alias, for string (**\rm**) 167
 - removing character definition (**\rchar**,
 - \rfschar**) 148
 - removing diversion (**\rm**) 167
 - removing macro (**\rm**) 167
 - removing request (**\rm**) 167
 - removing string (**\rm**) 167
 - renaming a register (**\rnn**) 97
 - renaming diversion (**\rn**) 167
 - renaming macro (**\rn**) 167
 - renaming request (**\rn**) 167
 - renaming string (**\rn**) 167
 - renditions, graphic 135
 - request 67, 84
 - request arguments 86
 - request arguments, and compatibility
 - mode 231
 - request arguments, and tabs 86
 - request, removing (**\rm**) 167
 - request, renaming (**\rn**) 167
 - request, undefined 93
 - requests for drawing 192
 - requests for input and output 220
 - requests handling file name arguments, in
 - other implementations 243
 - requests, intercepting 85
 - requests, invoking 86

requests, modifying 85
 resolution, device 75, 249
 resolution, device, obtaining in the
 formatter 76
 resolution, horizontal 247
 resolution, horizontal, register (.H) 77
 resolution, vertical 249
 resolution, vertical, register (.V) 77
 RET (keycap notation) 4
 returning to marked vertical page location
 (rt) 184
 revision number register (.Y) 101
 right margin 126
 right-aligning lines (introduction) 19
 right-aligning text (rj) 107
 rivers 242
 rj request, causing implicit break 101
 rn glyph, and cflags 146
 roman glyph, correction after slanted
 glyph (V) 154
 roman glyph, correction before slanted
 glyph (\,) 154
 Roman numerals 99
 Roman numerals, extrema (maximum and
 minimum) 99
 rq glyph, at end of sentence 65, 146
 rt request, using + and - with 80
 ru glyph, and cflags 146
 run-in headings 20
 running system commands 225

S

s scaling unit 76, 159
 safer mode . 10, 14, 101, 222, 224, 225, 238
 saturating arithmetic 78
 saving horizontal input line position
 (\k) 188
 scaled point scaling unit (s) 76, 159
 scaling indicator 76
 scaling operator 79
 scaling unit c 76
 scaling unit f 161
 scaling unit i 76
 scaling unit m 77
 scaling unit M 77
 scaling unit n 77
 scaling unit p 76
 scaling unit P 76
 scaling unit s 76, 159
 scaling unit u 76
 scaling unit v 77
 scaling unit z 76, 159
 schar request, and comments 147
 search path, font 14
 search procedure for macro packages ... 14
 seconds, current time (seconds) 220
 selecting the previous font (ft) 135
 sentence space size register (.sss) 107
 sentence, cancelling detection of end of, on
 AT&T troff 242
 sentence-ending punctuation 64
 sentences 64
 sequence, escape 84
 setting diversion trap (dt) 203
 setting end-of-input trap (em) 206
 setting input line trap (it, itc) 203
 setting registers (nr, \R) 95
 setting the page length (pl) 130
 setting up an abstract font style (sty) . 138
 shc request, and translations 124
 site-local directory 14, 15
 size of sentence space register (.sss) .. 107
 size of word space register (.ss) 107
 size, optical, of a font, setting (fzoom) . 137
 size, paper 15
 size, size 156
 sizes, fractional 243
 sizes, fractional type 159
 skew, of last glyph (.csk) 218
 slant, font, changing (\S) 151
 slanted (font shape) 134
 so request, arguments starting with
 double quote ", and comments 221
 so request, incompatibilities with AT&T
 troff 243
 soft hyphen character, setting (shc) ... 110
 soft hyphen glyph (hy) 110
 solid circle, drawing ('D'C ...') 194
 solid ellipse, drawing ('D'E ...') 194
 solid polygon, drawing ('D'P ...') .. 195
 soquiet request, arguments starting with
 double quote ", and comments 221
 SOURCE_DATE_EPOCH, environment
 variable 13
 sp request, and no-space mode 119
 sp request, causing implicit break 101
 space between sentences 64
 space between sentences register
 (.sss) 107
 space between words register (.ss) ... 107
 space character, as delimiter 92
 space characters, in expressions 82
 space, between sentences 107

- space, between words 107
- space, discardable, horizontal 108
- space, hair ($\backslash^$) 187
- space, horizontal ($\backslash h$) 186
- space, horizontal, unformatting 215
- space, thin ($\backslash l$) 187
- space, trailing, on input lines, difference
 - from AT&T **troff** 242
- space, unbreakable ($\backslash^$) 102
- space, unbreakable and unadjustable
 - ($\backslash SPC$) 187
- space, vertical, unit (**v**) 77
- space, width of a digit (numeral) ($\backslash 0$) 187
- space, word 107
- spaces in character definitions 147
- spaces in **ds** and **ds1** argument, leading 164
- spaces in file name arguments 113
- spaces in file name or system command
 - arguments 221
- spaces in string definitions and
 - appendments 164
- spaces in string length measurement .. 165
- spaces, in a macro argument 87
- spaces, leading and trailing 66
- spacing (introduction) 18
- spacing, manipulating 116
- spacing, vertical 75, 156
- spacing, vertical (introduction) 18
- SPC** (keycap notation) 4
- special character name space, shared with
 - character classes 84
- special characters 65, 124
- special characters [**ms**] 59
- special characters, in device extension
 - commands 227
- special characters, list of (*groff_char(7)*
 - man page) 142
- special font 134
- special fonts 140, 149, 251
- special fonts, emboldening 152
- special** request, and font translations 137
- special** request, and glyph search
 - order 140
- spline, drawing ($\backslash D' \sim \dots'$) 194
- springing a trap 197
- sqr tex** glyph, and **cflags** 146
- ss** request, incompatibilities with AT&T
 - troff** 244
- stack 216
- stacking glyphs ($\backslash b$) 196
- standard error stream, write to (**tm**, **tm1**,
 - tmc**) 232
- standard input stream, interpolate from
 - (**rd**) 223
- stops, tab 67
- stream, standard error, write to (**tm**, **tm1**,
 - tmc**) 232
- streams, open, dumping (**pstream**) 234
- string arguments 163
- string comparison 169
- string expansion ($\backslash *$) 163
- string interpolation ($\backslash *$) 163
- string name space, shared with macros
 - and diversions 84
- string, appending (**as**) 165
- string, creating alias of (**als**) 167
- string, dumping (**pm**) 234
- string, length of (**length**) 165
- string, removing (**rm**) 167
- string, removing alias of (**rm**) 167
- string, renaming (**rn**) 167
- strings 163
- strings [**ms**] 59
- strings, multi-line 164
- stripping final newline in diversions ... 215
- stroke color 161
- stroke color name register (**.m**) 162
- stroked circle, drawing ($\backslash D' c \dots'$) 194
- stroked ellipse, drawing ($\backslash D' e \dots'$) 194
- stroked polygon, drawing ($\backslash D' p$
 - $\dots'$) 195
- structuring source code of documents or
 - macro packages 86
- sty** request, and changing fonts 135
- sty** request, and font translations 137
- style, font 134
- style, font, abstract 135
- style, font, abstract, setting up (**sty**) . 138
- styles, font 137
- substring (**substring**) 166
- subtraction 78
- supplemental inter-sentence space 107
- suppressing output ($\backslash 0$) 219
- suppression nesting level register (**.0**) 219
- sv** request, and no-space mode 133
- switching environments (**ev**) 217
- sy** request, and safer mode 10
- sy** request, arguments starting with
 - double quote **"**, and comments 221
- sy** request, disabled by default 238
- sy** request, incompatibilities with AT&T
 - troff** 243
- symbol 140
- symbol table, dumping (**pm**) 234

symbol, defining (**char**)..... 147
 symbols (characters and glyphs), using. 140
 system commands, running..... 225
system() return value register
 (**systat**)..... 225

T

tab character..... 67
 tab character encoding..... 119
 tab character, and translations..... 124
 tab character, as delimiter..... 92
 tab character, non-interpreted (**\t**)... 119
 tab repetition character (**tc**)..... 121
 tab stop settings register (**.tabs**).... 121
 tab stops..... 67
 tab stops, default..... 120
 tab, line-tabs mode..... 122
 table of contents..... 21, 123
 table of contents, creating [**ms**]..... 55
 table, multi-page, example [**ms**]..... 50
 tables [**ms**]..... 49
 tabs, and fields..... 119
 tabs, and macro arguments..... 86
 tabs, and request arguments..... 86
 tabs, before comments..... 93
 tagged paragraphs..... 19
 tags, paragraph..... 19
 terminal, conditional output for..... 168
 text baseline..... 75, 156
 text font..... 134
 text line..... 68
 text line, position of lowest (**.h**)..... 211
 text, GNU **troff** processing of..... 63
 text, justifying..... 101
 text, right-aligning (**rj**)..... 107
 thickness of lines ('**\D't ...'**)..... 196
 thin space (**\l**)..... 187
 three-part title (**tl**)..... 131
ti request, causing implicit break..... 101
ti request, using + and - with..... 80
 time, current, hours (**hours**)..... 220
 time, current, minutes (**minutes**)..... 220
 time, current, seconds (**seconds**)..... 220
 timing of output flushes, incompatibilities
 with AT&T **troff**..... 245
 title length, configuring (**lt**)..... 131
 title line length register (**.lt**)..... 131
 title line, formatting (**tl**)..... 131
 titles..... 130
tkf request, and font styles..... 138
tkf request, and font translations..... 137

tkf request, with fractional type sizes. 159
tl request, and **mc**..... 191
 tmac, directory..... 14
 tmac, path..... 14
 TMPDIR, environment variable..... 13
 token..... 228
 top margin..... 198
 top-level diversion..... 208
 top-level diversion, and **\!**..... 213
 top-level diversion, and **\?**..... 213
 top-level diversion, and **bp**..... 132
tr request, and glyph definitions..... 147
tr request, and soft hyphen character. 110
tr request, incompatibilities with AT&T
 troff..... 244
 track kerning..... 153
 track kerning, activating (**tkf**)..... 153
 trailing space, on input lines, difference
 from AT&T **troff**..... 242
 trailing spaces on text lines..... 66
 translations of characters..... 124
 translations, font, dumping (**pftr**).... 233
 transparent characters..... 146
 transparent dummy character (**\)**).... 156
 transparent output (**\!**, **\?**)..... 212
 transparent output (**cf**, **trf**)..... 222
 transparent output, incompatibilities with
 AT&T **troff**..... 244
 trap..... 196
 trap name, next, register (**.trap**)..... 202
 trap, changing location (**ch**)..... 200
 trap, distance to next vertical position,
 register (**.t**)..... 200
 trap, diversion, setting (**dt**)..... 203
 trap, end-of-input, setting (**em**)..... 206
 trap, implicit..... 202
 trap, input line, clearing (**it**, **itc**).... 203
 trap, input line, setting (**it**, **itc**).... 203
 trap, planting..... 197
 trap, springing..... 197
 traps..... 197
 traps, and diversions..... 202
 traps, blank line..... 206
 traps, diversion..... 203
 traps, end-of-input..... 206
 traps, input line..... 203
 traps, input line, and interrupted lines
 (**itc**)..... 204
 traps, leading space..... 206
 traps, page location..... 198
 traps, page location, dumping (**pwh**).. 234
 traps, page location, listing (**pwh**).... 234

traps, sprung by **bp** request (**.pe**) 202
traps, vertical position 197
trf request, and copy mode 222
trf request, and invalid characters 222
trf request, arguments starting with
 double quote **"**, and comments 221
trf request, causing implicit break 101
trin request, and **asciify** 213
troff mode 125
troff output format 253
troff page description language 253
troff, GNU, interactive use of 234
troff, GNU, reference 63
troff, interactive use of 234
troff, output 253
troff, reference 63
truncated vertical space register
 (**.trunc**) 201
truncating division 78
TTY, conditional output for 168
tutorial for macro package users 17
type size 156
type size registers (**.s**, **.ps**) 157
type size registers, last-requested (**.psr**,
 .sr) 160
type sizes, changing (**ps**, **\s**) 156, 160
type sizes, fractional 159, 243
typeface 134
typographical point scaling unit (**z**) . 76, 159
TZ, environment variable 13

U

u scaling unit 76
uf request, and font styles 138
ul glyph, and **cflags** 146
ul request, and font translations 137
Ultrix-specific **man** macros 24
unadjustable and unbreakable space
 (**\SPC**) 187
unary arithmetic operators 78
unbreakable and unadjustable space
 (**\SPC**) 187
unbreakable space (**\~**) 102
undefined identifiers 84
undefined request 93
underline font (**uf**) 152
underlining (**ul**) 151
underlining, continuous (**cu**) 151
unformatting diversions (**asciify**) 213
unformatting horizontal space 215
Unicode 70, 145
unit, scaling, **c** 76
unit, scaling, **f** 161
unit, scaling, **i** 76
unit, scaling, **m** 77
unit, scaling, **M** 77
unit, scaling, **n** 77
unit, scaling, **p** 76
unit, scaling, **P** 76
unit, scaling, **s** 76, 159
unit, scaling, **u** 76
unit, scaling, **v** 77
unit, scaling, **z** 76, 159
units of measurement 76
units, basic 75
units, basic, conversion to 76
units, default 77
units, machine 75
unnamed glyphs 145
unnamed glyphs, accessing with **\N** 251
unsafe mode 11, 14, 101, 222, 224, 225
unstyled font 134
untokenized escape sequence, **\f** 136
untokenized escape sequence, **\F** 138
untokenized escape sequence, **\H** 150
untokenized escape sequence, **\m** 162
untokenized escape sequence, **\M** 162
untokenized escape sequence, **\R** 95
untokenized escape sequence, **\s** 157
untokenized escape sequence, **\S** 151
uppercasing a string (**stringup**) 166
upright (font shape) 134
upright glyph, correction after slanted
 glyph (**\V**) 154
upright glyph, correction before slanted
 glyph (**\,**) 154
URLs, breaking (**\:**) 109
user's tutorial 17
using escape sequences 89
using symbols (characters and glyphs) . 140
UTF-8 output encoding 11

V

v scaling unit 77
 valid numeric expression 81
 value, incrementing without changing the
 register 98
 variables in environment 12
 vee 75
 vee scaling unit (**v**) 77
 version number, major, register (**.x**) .. 101
 version number, minor, register (**.y**) .. 101
 vertical drawing position (**nl**) 133
 vertical line drawing (**\L**) 193
 vertical line spacing register (**.v**) 158
 vertical line spacing, changing (**vs**) ... 158
 vertical line spacing, effective value ... 158
 vertical motion (**\v**) 186
 vertical motion quantum 249
 vertical motion quantum register (**.V**) .. 77
 vertical page location, marking (**mk**)... 184
 vertical page location, returning to marked
 (**rt**) 184
 vertical position in diversion register
 (**.d**) 210
 vertical position trap enable register
 (**.vpt**) 197
 vertical position traps 197
 vertical position traps, enabling (**vpt**) . 197
 vertical position, drawing (**nl**) 133
 vertical resolution 249
 vertical resolution register (**.V**) 77
 vertical space unit (**v**) 77
 vertical spacing 75, 156
 vertical spacing (introduction) 18

W

warning categories 236
 warning level (**warn**) 235
 warnings 236
 what is **groff**? 1
while request 173
while request, and font translations .. 137
while request, and the ‘!’ operator ... 78
while request, confusing with **br** 174
while request, operators to use with .. 168
 widow 133
 width computation escape sequence
 (**\w**) 187
 width, of last glyph (**.w**) 218
 word space 107
 word space size register (**.ss**) 107
 word, definition of 63
write request, and copy mode 225
writec request, and copy mode 225
writem request, and copy mode 226
 writing macros 175

Y

year, current, register (**year**, **yr**) 220

Z

z scaling unit 76, 159
 zero, division and modulus by 78
 zero-width printing (**\z**, **\Z**) 189
 zoom factor of a font (**fzoom**) 137