# A TROFF Tutorial

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*ABSTRACT*

**troff** is a text-formatting program for typesetting on the UNIX† operating system. This device is capable of producing high quality text; this paper is an example of **troff** output.

The phototypesetter itself normally runs with four fonts, containing roman, italic and bold letters (as on this page), a full greek alphabet, and a substantial number of special characters and mathematical symbols. Characters can be printed in a range of sizes, and placed anywhere on the page.

**troff** allows the user full control over fonts, sizes, and character positions, as well as the usual features of a formatter — right-margin justification, automatic hyphenation, page titling and numbering, and so on. It also provides macros, arithmetic variables and operations, and conditional testing, for complicated formatting tasks.

This document is an introduction to the most basic use of **troff**. It presents just enough information to enable the user to do simple formatting tasks like making viewgraphs, and to make incremental changes to existing packages of **troff** commands. In most respects, the UNIX formatter **nroff** and a more recent version *(device-independent* **troff)** are identical to the version described here, so this document also serves as a tutorial for them as well.

† UNIX is a trademark of Bell Laboratories.

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## 1. Introduction

**troff** [1] is a text-formatting program, written originally by J. F. Ossanna, for producing high-quality printed output from the phototypesetter on the UNIX operating system. This document is an example of **troff** output.

The single most important rule of using **troff** is not to use it directly, but through some intermediary. In many ways, **troff** resembles an assembly language — a remarkably powerful and flexible one — but nonetheless such that many operations must be specified at a level of detail and in a form that is too hard for most people to use effectively.

For two special applications, there are programs that provide an interface to **troff** for the majority of users. **eqn** [2] provides an easy to learn language for typesetting mathematics; the **eqn** user need know no **troff** whatsoever to typeset mathematics. **tbl** [3] provides the same convenience for producing tables of arbitrary complexity.

For producing straight text (which may well contain mathematics or tables), there are a number of 'macro packages' that define formatting rules and operations for specific styles of documents, and reduce the amount of direct contact with **troff**. In particular, the '−ms' [4], PWB/MM [5], and '−me' [6] packages for internal memoranda and external papers provide most of the facilities needed for a wide range of document preparation.† (This memo was prepared with '−ms'.) There are also packages for viewgraphs, for simulating the older **roff** formatters, and for other special applications. Typically you will find these packages easier to use than **troff** once you get beyond the most trivial operations; you should always consider them first.

In the few cases where existing packages don't do the whole job, the solution is *not* to write an entirely new set of **troff** instructions from scratch, but to make small changes to adapt packages that already exist.

In accordance with this philosophy of letting someone else do the work, the part of **troff** described here is only a small part of the whole, although it tries to concentrate on the more useful parts. In any case, there is no attempt to be complete. Rather, the emphasis is on showing how to do simple things, and how to make incremental changes to what already exists. The contents of the remaining sections are:

2. Point sizes and line spacing
3. Fonts and special characters
4. Indents and line length
5. Tabs
6. Local motions: Drawing lines and characters
7. Strings
8. Introduction to macros
9. Titles, pages and numbering
10. Number registers and arithmetic
11. Macros with arguments
12. Conditionals
13. Environments
14. Diversions

Appendix: Typesetter character set

The **troff** described here is the C-language version supplied with UNIX Version 7 and 32V as documented in [1].

To use **troff** you have to prepare not only the actual text you want printed, but some information that tells *how* you want it printed. (Readers who use **roff** will find the approach familiar.) For **troff** the text and the formatting information are often intertwined quite intimately. Most commands to **troff** are placed on a

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† Most Berkeley Unix sites only have −ms and −me.

line separate from the text itself, beginning with a period (one command per line). For example,

```
Some text.
.ps 14
Some more text.
```

will change the 'point size', that is, the size of the letters being printed, to '14 point' (one point is 1/72 inch) like this:

Some text. Some more text.

Occasionally, though, something special occurs in the middle of a line — to produce

Area = $\pi r^2$

you have to type

```
Area = \(*p\fIr\fR\|\s8\u2\d\s0
```

(which we will explain shortly). The backslash character \ is used to introduce **troff** commands and special characters within a line of text.

### 2. Point Sizes; Line Spacing

As mentioned above, the command .ps sets the point size. One point is 1/72 inch, so 6-point characters are at most 1/12 inch high, and 36-point characters are ½ inch. There are 15 point sizes, listed below.

6 point: Pack my box with five dozen liquor jugs.
7 point: Pack my box with five dozen liquor jugs.
8 point: Pack my box with five dozen liquor jugs.
9 point: Pack my box with five dozen liquor jugs.
10 point: Pack my box with five dozen liquor
11 point: Pack my box with five dozen
12 point: Pack my box with five dozen
14 point: Pack my box with five
16 point 18 point 20 point
22 24 28 36

If the number after .ps is not one of these legal sizes, it is rounded up to the next valid value, with a maximum of 36. If no number follows .ps, **troff** reverts to the previous size, whatever it was. **troff** begins with point size 10, which is usually fine. The original of this document (on 8.5 by 11 inch paper) is in 9 point.

The point size can also be changed in the middle of a line or even a word with the in-line command \s. To produce

UNIX runs on a PDP-11/45

type

```
\s8UNIX\s10 runs on a \s8PDP-\s1011/45
```

As above, \s should be followed by a legal point size, except that \s0 causes the size to revert to its previous value. Notice that \s1011 can be understood correctly as 'size 10, followed by an 11', if the size is legal, but not otherwise. Be cautious with similar constructions.

Relative size changes are also legal and useful:

```
\s−2UNIX\s+2
```

temporarily decreases the size, whatever it is, by two points, then restores it. Relative size changes have the advantage that the size difference is independent of the starting size of the document. The amount of the relative change is restricted to a single digit.

The other parameter that determines what the type looks like is the spacing between lines, which is set independently of the point size. Vertical spacing is measured from the bottom of one line to the bottom of the next. The command to control vertical spacing is .vs. For running text, it is usually best to set the vertical spacing about 20% bigger than the character size. For example, so far in this document, we have used ‘‘9 on 11’’, that is,

```
.ps 9
.vs 11p
```

If we changed to

```
.ps 9
.vs 9p
```

the running text would look like this. After a few lines, you will agree it looks a little cramped. The right vertical spacing is partly a matter of taste, depending on how much text you want to squeeze into a given space, and partly a matter of traditional printing style. By default, **troff** uses 10 on 12.

Point size and vertical spacing make a substantial difference in the amount of text per square inch. This is 12 on 14.

Point size and vertical spacing make a substantial difference in the amount of text per square inch. For example, 10 on 12 uses about twice as much space as 7 on 8. This is 6 on 7, which is even smaller. It packs a lot more words per line, but you can go blind trying to read it.

When used without arguments, .ps and .vs revert to the previous size and vertical spacing respectively.

The command .sp is used to get extra vertical space. Unadorned, it gives you one extra blank line (one .vs, whatever that has been set to). Typically, that’s more or less than you want, so .sp can be followed by information about how much space you want —

```
.sp 2i
```

means ‘two inches of vertical space’.

```
.sp 2p
```

means ‘two points of vertical space’; and

```
.sp 2
```

means ‘two vertical spaces’ — two of whatever .vs is set to (this can also be made explicit with .sp 2v); **troff** also understands decimal fractions in most places, so

```
.sp 1.5i
```

is a space of 1.5 inches. These same scale factors can be used after .vs to define line spacing, and in fact after most commands that deal with physical dimensions.

It should be noted that all size numbers are converted internally to ‘machine units’, which are 1/432 inch (1/6 point). For most purposes, this is enough resolution that you don’t have to worry about the accuracy of the representation. The situation is not quite so good vertically, where resolution is 1/144 inch (1/2 point).

## 3. Fonts and Special Characters

**troff** and the typesetter allow four different fonts at any one time. Normally three fonts (Times roman, italic and bold) and one collection of special characters are permanently mounted.

abcdefghijklmnopqrstuvwxyz 0123456789
ABCDEFGHIJKLMNOPQRSTUVWXYZ
*abcdefghijklmnopqrstuvwxyz 0123456789*
*ABCDEFGHIJKLMNOPQRSTUVWXYZ*
**abcdefghijklmnopqrstuvwxyz 0123456789**
**ABCDEFGHIJKLMNOPQRSTUVWXYZ**

The greek, mathematical symbols and miscellany of the special font are listed in Appendix A.

**troff** prints in roman unless told otherwise. To switch into bold, use the .ft command

.ft B

and for italics,

.ft I

To return to roman, use .ft R; to return to the previous font, whatever it was, use either .ft P or just .ft. The 'underline' command

.ul

causes the next input line to print in italics. .ul can be followed by a count to indicate that more than one line is to be italicized.

Fonts can also be changed within a line or word with the in-line command \f:

**bold***face* text

is produced by

\fBbold\fIface\fR text

If you want to do this so the previous font, whatever it was, is left undisturbed, insert extra \fP commands, like this:

\fBbold\fP\fIface\fP\fR text\fP

Because only the immediately previous font is remembered, you have to restore the previous font after each change or you can lose it. The same is true of .ps and .vs when used without an argument.

There are other fonts available besides the standard set, although you can still use only four at any given time. The command .fp tells **troff** what fonts are physically mounted on the typesetter:

.fp 3 H

says that the Helvetica font is mounted on position 3. (The complete list of font sizes and styles depends on your typesetter or laser printer.) Appropriate .fp commands should appear at the beginning of your document if you do not use the standard fonts.

It is possible to make a document relatively independent of the actual fonts used to print it by using font numbers instead of names; for example, \f3 and .ft 3 mean 'whatever font is mounted at position 3', and thus work for any setting. Normal settings are roman font on 1, italic on 2, bold on 3, and special on 4.

There is also a way to get 'synthetic' bold fonts by overstriking letters with a slight offset. Look at the .bd command in [1].

Special characters have four-character names beginning with \(, and they may be inserted anywhere. For example,

¼ + ½ = ¾

is produced by

\(14 + \(12 = \(34

In particular, greek letters are all of the form \(*−, where − is an upper or lower case roman letter reminiscent of the greek. Thus to get

$\Sigma(\alpha\times\beta) \rightarrow \infty$

in bare **troff** we have to type

\(*S(\(*a\(mu\(*b) \(–> \(if

That line is unscrambled as follows:

| | |
|---|---|
| \(*S | $\Sigma$ |
| ( | ( |
| \(*a | $\alpha$ |
| \(mu | $\times$ |
| \(*b | $\beta$ |
| ) | ) |
| \(–> | $\rightarrow$ |
| \(if | $\infty$ |

A complete list of these special names occurs in Appendix A.

In **eqn** [2] the same effect can be achieved with the input

SIGMA ( alpha times beta ) –> inf

which is less concise, but clearer to the uninitiated.

Notice that each four-character name is a single character as far as **troff** is concerned — the 'translate' command

.tr \(mi\(em

is perfectly clear, meaning

.tr –—

that is, to translate – into —.

Some characters are automatically translated into others: grave ` and acute ´ accents (apostrophes) become open and close single quotes ' '; the combination of ''...'' is generally preferable to the double quotes "...". Similarly a typed minus sign becomes a hyphen -. To print an explicit − sign, use \-. To get a backslash printed, use \e.

## 4. Indents and Line Lengths

**troff** starts with a line length of 6.5 inches, which some people think is too wide for 8½×11 paper. To reset the line length, use the .ll command, as in

.ll 6i

As with .sp, the actual length can be specified in several ways; inches are probably the most intuitive.

The maximum line length provided by the typesetter is 7.5 inches, by the way. To use the full width, you will have to reset the default physical left margin (''page offset''), which is normally slightly less than one inch from the left edge of the paper. This is done by the .po command.

.po 0

sets the offset as far to the left as it will go.

The indent command .in causes the left margin to be indented by some specified amount from the page offset. If we use .in to move the left margin in, and .ll to move the right margin to the left, we can make offset blocks of text:

```
.in 0.3i
.ll −0.3i
text to be set into a block
.ll +0.3i
.in −0.3i
```

will create a block that looks like this:

> Pater noster qui est in caelis sanctificetur nomen tuum; adveniat regnum tuum; fiat voluntas tua, sicut in caelo, et in terra. ... Amen.

Notice the use of '+' and '−' to specify the amount of change. These change the previous setting by the specified amount, rather than just overriding it. The distinction is quite important: .ll +1i makes lines one inch longer; .ll 1i makes them one inch *long.*

With .in, .ll and .po, the previous value is used if no argument is specified.

To indent a single line, use the 'temporary indent' command .ti. For example, all paragraphs in this memo effectively begin with the command

```
.ti 3
```

Three of what? The default unit for .ti, as for most horizontally oriented commands (.ll, .in, .po), is ems; an em is roughly the width of the letter 'm' in the current point size. (Precisely, a em in size *p* is *p* points.) Although inches are usually clearer than ems to people who don't set type for a living, ems have a place: they are a measure of size that is proportional to the current point size. If you want to make text that keeps its proportions regardless of point size, you should use ems for all dimensions. Ems can be specified as scale factors directly, as in .ti 2.5m.

Lines can also be indented negatively if the indent is already positive:

```
.ti −0.3i
```

causes the next line to be moved back three tenths of an inch. Thus to make a decorative initial capital, we indent the whole paragraph, then move the letter 'P' back with a .ti command:

> Pater noster qui est in caelis sanctificetur nomen tuum; adveniat regnum tuum; fiat voluntas tua, sicut in caelo, et in terra. ... Amen.

Of course, there is also some trickery to make the 'P' bigger (just a '\s36P\s0'), and to move it down from its normal position (see the section on local motions).

## 5. Tabs

Tabs (the ASCII 'horizontal tab' character) can be used to produce output in columns, or to set the horizontal position of output. Typically tabs are used only in unfilled text. Tab stops are set by default every half inch from the current indent, but can be changed by the .ta command. To set stops every inch, for example,

```
.ta 1i 2i 3i 4i 5i 6i
```

Unfortunately the stops are left-justified only (as on a typewriter), so lining up columns of right-justified numbers can be painful. If you have many numbers, or if you need more complicated table layout, *don't* use **troff** directly; use the **tbl** program described in [3].

For a handful of numeric columns, you can do it this way: Precede every number by enough blanks to make it line up when typed.

```
.nf
.ta 1i 2i 3i
  1  tab     2  tab     3
 40  tab    50  tab    60
700  tab   800  tab   900
.fi
```

Then change each leading blank into the string \0. This is a character that does not print, but that has the same width as a digit. When printed, this will produce

```
  1            2            3
 40           50           60
700          800          900
```

It is also possible to fill up tabbed-over space with some character other than blanks by setting the 'tab replacement character' with the .tc command:

```
.ta 1.5i 2.5i
.tc \(ru       (\(ru is "_")
Name tab Age tab
```

produces

Name 7777777777777777 Age 7777777777

To reset the tab replacement character to a blank, use .tc with no argument. (Lines can also be drawn with the \l command, described in Section 6.)

**troff** also provides a very general mechanism called 'fields' for setting up complicated columns. (This is used by **tbl**). We will not go into it in this paper.

### 6. Local Motions: Drawing lines and characters

Remember 'Area = $\pi r^2$' and the big 'P' in the Paternoster. How are they done? **troff** provides a host of commands for placing characters of any size at any place. You can use them to draw special characters or to tune your output for a particular appearance. Most of these commands are straightforward, but messy to read and tough to type correctly.

If you won't use **eqn**, subscripts and superscripts are most easily done with the half-line local motions \u and \d. To go back up the page half a point-size, insert a \u at the desired place; to go down, insert a \d. (\u and \d should always be used in pairs, as explained below.) Thus

```
Area = \(*pr\u2\d
```

produces

Area = $\pi r^2$

To make the '2' smaller, bracket it with \s–2...\s0. Since \u and \d refer to the current point size, be sure to put them either both inside or both outside the size changes, or you will get an unbalanced vertical motion.

Sometimes the space given by \u and \d isn't the right amount. The \v command can be used to request an arbitrary amount of vertical motion. The in-line command

```
\v´(amount)´
```

causes motion up or down the page by the amount specified in '(amount)'. For example, to move the 'P' down, we used

```
.in +0.6i        (move paragraph in)
.ll −0.3i        (shorten lines)
.ti −0.3i        (move P back)
\v´2´\s36P\s0\v´−2´ater noster qui est
in caelis ...
```

A minus sign causes upward motion, while no sign or a plus sign means down the page. Thus \v′−2′ causes an upward vertical motion of two line spaces.

There are many other ways to specify the amount of motion —

```
\v´0.1i´
\v´3p´
\v´−0.5m´
```

and so on are all legal. Notice that the scale specifier i or p or m goes inside the quotes. Any character can be used in place of the quotes; this is also true of all other **troff** commands described in this section.

Since **troff** does not take within-the-line vertical motions into account when figuring out where it is on the page, output lines can have unexpected positions if the left and right ends aren't at the same vertical position. Thus \v, like \u and \d, should always balance upward vertical motion in a line with the same amount in the downward direction.

Arbitrary horizontal motions are also available — \h is quite analogous to \v, except that the default scale factor is ems instead of line spaces. As an example,

```
\h´−0.1i´
```

causes a backwards motion of a tenth of an inch. As a practical matter, consider printing the mathematical symbol '>>'. The default spacing is too wide, so **eqn** replaces this by

```
>\h´−0.3m´>
```

to produce ≫.

Frequently \h is used with the 'width function' \w to generate motions equal to the width of some character string. The construction

```
\w´thing´
```

is a number equal to the width of 'thing' in machine units (1/432 inch). All **troff** computations are ultimately done in these units. To move horizontally the width of an 'x', we can say

```
\h´\w´x´u´
```

As we mentioned above, the default scale factor for all horizontal dimensions is m, ems, so here we must have the u for machine units, or the motion produced will be far too large. **troff** is quite happy with the nested quotes, by the way, so long as you don't leave any out.

As a live example of this kind of construction, all of the command names in the text, like .sp, were done by overstriking with a slight offset. The commands for .sp are

```
.sp\h´−\w´.sp´u´\h´1u´.sp
```

That is, put out '.sp', move left by the width of '.sp', move right 1 unit, and print '.sp' again. (Of course there is a way to avoid typing that much input for each command name, which we will discuss in Section 11.)

There are also several special-purpose **troff** commands for local motion. We have already seen \0, which is an unpaddable white space of the same width as a digit. 'Unpaddable' means that it will never be widened or split across a line by line justification and filling. There is also \(blank), which is an unpaddable character the width of a space, \|, which is half that width, \^, which is one quarter of the width of a space, and \&, which has zero width. (This last one is useful, for example, in entering a text line which would otherwise begin with a '.'.)

The command \o, used like

```
\o´set of characters´
```

causes (up to 9) characters to be overstruck, centered on the widest. This is nice for accents, as in

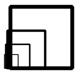
```
syst\o"e\(ga"me t\o"e\(aa"l\o"e\(aa"phonique
```

which makes

système téléphonique

The accents are \(ga and \(aa, or \` and \´; remember that each is just one character to **troff**.

You can make your own overstrikes with another special convention, \z, the zero-motion command. \zx suppresses the normal horizontal motion after printing the single character x, so another character can be laid on top of it. Although sizes can be changed within \o, it centers the characters on the widest, and there can be no horizontal or vertical motions, so \z may be the only way to get what you want:



is produced by

```
.sp 2
\s8\z\(sq\s14\z\(sq\s22\z\(sq\s36\(sq
```

The .sp is needed to leave room for the result.

As another example, an extra-heavy semicolon that looks like

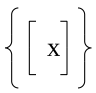
**;** instead of ; or ;

can be constructed with a big comma and a big period above it:

```
\s+6\z,\v´–0.25m´.\v´0.25m´\s0
```

‘0.25m’ is an experimentally-derived constant.

A more ornate overstrike is given by the bracketing function \b, which piles up characters vertically, centered on the current baseline. Thus we can get big brackets, constructing them with piled-up smaller pieces:



by typing in only this:

```
.sp
\b′\(lt\(lk\(lb′ \b′\(lc\(lf′ x \b′\(rc\(rf′ \b′\(rt\(rk\(rb′
```

**troff** also provides a convenient facility for drawing horizontal and vertical lines of arbitrary length with arbitrary characters. \l′1i′ draws a line one inch long, like this: ________________ . The length can be followed by the character to use if the _ isn't appropriate; \l′0.5i.′ draws a half-inch line of dots: ............... The construction \L is entirely analogous, except that it draws a vertical line instead of horizontal.

## 7. Strings

Obviously if a paper contains a large number of occurrences of an acute accent over a letter ‘e’, typing \o"e\´" for each é would be a great nuisance.

Fortunately, **troff** provides a way in which you can store an arbitrary collection of text in a ‘string’, and thereafter use the string name as a shorthand for its contents. Strings are one of several **troff** mechanisms whose judicious use lets you type a document with less effort and organize it so that extensive format changes can be made with few editing changes.

A reference to a string is replaced by whatever text the string was defined as. Strings are defined with the command **.ds**. The line

```
.ds e \o"e\´"
```

defines the string **e** to have the value **\o"e\´"**

String names may be either one or two characters long, and are referred to by ***x** for one character names or ***(xy** for two character names. Thus to get téléphone, given the definition of the string **e** as above, we can say t*el*ephone.

If a string must begin with blanks, define it as

```
.ds xx "      text
```

The double quote signals the beginning of the definition. There is no trailing quote; the end of the line terminates the string.

A string may actually be several lines long; if **troff** encounters a \ at the end of *any* line, it is thrown away and the next line added to the current one. So you can make a long string simply by ending each line but the last with a backslash:

```
.ds xx this \
is a very \
long string
```

Strings may be defined in terms of other strings, or even in terms of themselves; we will discuss some of these possibilities later.

## 8. Introduction to Macros

Before we can go much further in **troff**, we need to learn a bit about the macro facility. In its simplest form, a macro is just a shorthand notation quite similar to a string. Suppose we want every paragraph to start in exactly the same way — with a space and a temporary indent of two ems:

```
.sp
.ti +2m
```

Then to save typing, we would like to collapse these into one shorthand line, a **troff** ‘command’ like

```
.PP
```

that would be treated by **troff** exactly as

```
.sp
.ti +2m
```

.PP is called a *macro.* The way we tell **troff** what .PP means is to *define* it with the **.de** command:

```
.de PP
.sp
.ti +2m
..
```

The first line names the macro (we used ‘**.PP**’ for ‘paragraph’, and upper case so it wouldn’t conflict with any name that **troff** might already know about). The last line **..** marks the end of the definition. In between is the text, which is simply inserted whenever **troff** sees the ‘command’ or macro call

```
.PP
```

A macro can contain any mixture of text and formatting commands.

The definition of **.PP** has to precede its first use; undefined macros are simply ignored. Names are restricted to one or two characters.

Using macros for commonly occurring sequences of commands is critically important. Not only does it save typing, but it makes later changes much easier. Suppose we decide that the paragraph indent is too small, the vertical space is much too big, and roman font should be forced. Instead of changing the whole document, we need only change the definition of .PP to something like

```
.de PP     \" paragraph macro
.sp 2p
.ti +3m
.ft R
..
```

and the change takes effect everywhere we used .PP.

\" is a **troff** command that causes the rest of the line to be ignored. We use it here to add comments to the macro definition (a wise idea once definitions get complicated).

As another example of macros, consider these two which start and end a block of offset, unfilled text, like most of the examples in this paper:

```
.de BS     \" start indented block
.sp
.nf
.in +0.3i
..
.de BE     \" end indented block
.sp
.fi
.in –0.3i
..
```

Now we can surround text like

```
Copy to
John Doe
Richard Roberts
Stanley Smith
```

by the commands .BS and .BE, and it will come out as it did above. Notice that we indented by .in +0.3i instead of .in 0.3i. This way we can nest our uses of .BS and BE to get blocks within blocks.

If later on we decide that the indent should be 0.5i, then it is only necessary to change the definitions of .BS and .BE, not the whole paper.

## 9. Titles, Pages and Numbering

This is an area where things get tougher, because nothing is done for you automatically. Of necessity, some of this section is a cookbook, to be copied literally until you get some experience.

Suppose you want a title at the top of each page, saying just

```
left top                  center top                right top
```

In **roff**, one can say

```
.he ´left top´center top´right top´
.fo ´left bottom´center bottom´right bottom´
```

to get headers and footers automatically on every page. Alas, this doesn't work so easily in **troff**, a serious hardship for the novice. Instead you have to do a lot of specification (or use a macro package, which makes it effortless).

You have to say what the actual title is (easy); when to print it (easy enough); and what to do at and around the title line (harder). Taking these in reverse order, first we define a macro .NP (for 'new page') to process titles and the like at the end of one page and the beginning of the next:

```
.de NP
′bp
′sp 0.5i
.tl ´left top´center top´right top´
′sp 0.3i
..
```

To make sure we're at the top of a page, we issue a 'begin page' command ′bp, which causes a skip to top-of-page (we'll explain the ′ shortly). Then we space down half an inch, print the title (the use of .tl should be self explanatory; later we will discuss parameterizing the titles), space another 0.3 inches, and we're done.

To ask for .NP at the bottom of each page, we have to say something like 'when the text is within an inch of the bottom of the page, start the processing for a new page.' This is done with a 'when' command .wh:

```
.wh −1i NP
```

(No '.' is used before NP; this is simply the name of a macro, not a macro call.) The minus sign means 'measure up from the bottom of the page', so '−1i' means 'one inch from the bottom'.

The .wh command appears in the input outside the definition of .NP; typically the input would be

```
.de NP
...
..
.wh −1i NP
```

Now what happens? As text is actually being output, **troff** keeps track of its vertical position on the page, and after a line is printed within one inch from the bottom, the .NP macro is activated. (In the jargon, the .wh command sets a *trap* at the specified place, which is 'sprung' when that point is passed.) .NP causes a skip to the top of the next page (that's what the ′bp was for), then prints the title with the appropriate margins.

Why ′bp and ′sp instead of .bp and .sp? The answer is that .sp and .bp, like several other commands, cause a *break* to take place. That is, all the input text collected but not yet printed is flushed out as soon as possible, and the next input line is guaranteed to start a new line of output. If we had used .sp or .bp in the .NP macro, this would cause a break in the middle of the current output line when a new page is started. The effect would be to print the left-over part of that line at the top of the page, followed by the next input line on a new output line. This is *not* what we want. Using ′ instead of . for a command tells **troff** that no break is to take place — the output line currently being filled should *not* be forced out before the space or new page.

The list of commands that cause a break is short and natural:

```
.bp   .br   .ce   .fi   .nf   .sp   .in   .ti
```

All others cause *no* break, regardless of whether you use a . or a ′. If you really need a break, add a .br command at the appropriate place.

One other thing to beware of — if you're changing fonts or point sizes a lot, you may find that if you cross a page boundary in an unexpected font or size, your titles come out in that size and font instead of what you intended. Furthermore, the length of a title is independent of the current line length, so titles will come out at the default length of 6.5 inches unless you change it, which is done with the .lt command.

There are several ways to fix the problems of point sizes and fonts in titles. For the simplest applications, we can change .NP to set the proper size and font for the title, then restore the previous values, like this:

```
.de NP
'bp
'sp 0.5i
.ft R          \" set title font to roman
.ps 10         \" and size to 10 point
.lt 6i         \" and length to 6 inches
.tl ´left´center´right´
.ps            \" revert to previous size
.ft P          \" and to previous font
'sp 0.3i
..
```

This version of .NP does *not* work if the fields in the .tl command contain size or font changes. To cope with that requires **troff**'s 'environment' mechanism, which we will discuss in Section 13.

To get a footer at the bottom of a page, you can modify .NP so it does some processing before the 'bp command, or split the job into a footer macro invoked at the bottom margin and a header macro invoked at the top of the page. These variations are left as exercises.

Output page numbers are computed automatically as each page is produced (starting at 1), but no numbers are printed unless you ask for them explicitly. To get page numbers printed, include the character % in the .tl line at the position where you want the number to appear. For example

```
.tl ´´- % -´´
```

centers the page number inside hyphens, as on this page. You can set the page number at any time with either .bp n, which immediately starts a new page numbered n, or with .pn n, which sets the page number for the next page but doesn't cause a skip to the new page. Again, .bp +n sets the page number to n more than its current value; .bp means .bp +1.

## 1. Macros with arguments

The next step is to define macros that can change from one use to the next according to parameters supplied as arguments. To make this work, we need two things: first, when we define the macro, we have to indicate that some parts of it will be provided as arguments when the macro is called. Then when the macro is called we have to provide actual arguments to be plugged into the definition.

Let us illustrate by defining a macro .SM that will print its argument two points smaller than the surrounding text. That is, the macro call

```
ˆSM TROFF
```

will produce TROFF.

The definition of .SM is

```
ˆde SM
\s−2\\$1\s+2
ˆˆ
```

Within a macro definition, the symbol \\$n refers to the nth argument that the macro was called with. Thus \\$1 is the string to be placed in a smaller point size when .SM is called.

As a slightly more complicated version, the following definition of .SM permits optional second and third arguments that will be printed in the normal size:

```
ˆde SM
\\$3\s−2\\$1\s+2\\$2
ˆˆ
```

Arguments not provided when the macro is called are treated as empty, so

```
ˆSM  TROFF  ),
```

produces TROFF), while

```
ˆSM  TROFF  ).  (
```

produces (TROFF). It is convenient to reverse the order of arguments because trailing punctuation is much more common than leading.

By the way, the number of arguments that a macro was called with is available in number register .$.

The following macro ˆBD is the one used to make the 'bold roman' we have been using for **troff** command names in text. It combines horizontal motions, width computations, and argument rearrangement.

```
.de BD
\&\\$3\f1\\$1\h´−\w´\\$1´u+1u´\\$1\fP\\$2
..
```

The \h and \w commands need no extra backslash, as we discussed above. The \& is there in case the argument begins with a period.

Two backslashes are needed with the \\$n commands, though, to protect one of them when the macro is being defined. Perhaps a second example will make this clearer. Consider a macro called .SH which produces section headings rather like those in this paper, with the sections numbered automatically, and the title in bold in a smaller size. The use is

```
ˆSH  "Section title ..."
```

(If the argument to a macro is to contain blanks, then it must be *surrounded* by double quotes, unlike a string, where only one leading quote is permitted.)

Here is the definition of the .SH macro:

```
ˆnr SH 0        \" initialize section number
ˆde SH
ˆsp 0.3i
ˆft B
ˆnr SH \\n(SH+1      \" increment number
ˆps \\n(PS−1  \" decrease PS
\\n(SH.  \\$1  \" number. title
ˆps \\n(PS              \" restore PS
ˆsp 0.3i
ˆft R
ˆˆ
```

The section number is kept in number register SH, which is incremented each time just before it is used. (A number register may have the same name as a macro without conflict but a string may not.)

We used \\n(SH instead of \n(SH and \\n(PS instead of \n(PS. If we had used \n(SH, we would get the value of the register at the time the macro was *defined,* not at the time it was *used.* If that's what you want, fine, but not here. Similarly, by using \\n(PS, we get the point size at the time the macro is called.

As an example that does not involve numbers, recall our .NP macro which had a

```
ˆtl ´left´center´right´
```

We could make these into parameters by using instead

```
ˆtl ´\\∗(LT´\\∗(CT´\\∗(RT´
```

so the title comes from three strings called LT, CT and RT. If these are empty, then the title will be a blank line. Normally CT would be set with something like

```
ˆds  CT  - % -
```

to give just the page number between hyphens (as on the top of this page), but a user could supply private definitions for any of the strings.

**2. Conditionals**

Suppose we want the .SH macro to leave two extra inches of space just before section 1, but nowhere else. The cleanest way to do that is to test inside the .SH macro whether the section number is 1, and add some space if it is. The .if command provides the conditional test that we can add just before the heading line is output:

```
ˆif \\n(SH=1 ˆsp 2i           \" first section only
```

The condition after the .if can be any arithmetic or logical expression. If the condition is logically true, or arithmetically greater than zero, the rest of the line is treated as if it were text — here a command. If the condition is false, or zero or negative, the rest of the line is skipped.

It is possible to do more than one command if a condition is true. Suppose several operations are to be done before section 1. One possibility is to define a macro .S1 and invoke it if we are about to do section 1 (as determined by an .if).

```
ˆde S1
---  processing for section 1 ---
ˆˆ
ˆde SH
ˆˆˆ
ˆif \\n(SH=1 ˆS1
ˆˆˆ
ˆˆ
```

An alternate way is to use the extended form of the .if, like this:

```
ˆif \\n(SH=1 \{--- processing
for section 1 ----\}
```

The braces \{ and \} must occur in the positions shown or you will get unexpected extra lines in your output. **troff** also provides an ‘if-else’ construction, which we will not go into here.

A condition can be negated by preceding it with !; we get the same effect as above (but less clearly) by using

```
ˆif !\\n(SH>1 ˆS1
```

There are a handful of other conditions that can be tested with .if. For example, is the current page even or odd?

```
ˆif o ˆtl ´odd page title´´- % -´
ˆif e ˆtl ´- % -´´even page title´
```

gives facing pages different titles and page numbers on the outside edge when used inside an appropriate new page macro.

Two other conditions are t and n, which tell you whether the formatter is **troff** or **nroff**.

```
ˆif t troff stuff ...
ˆif n nroff stuff ...
```

Finally, string comparisons may be made in an .if:

```
ˆif  ´string1´string2´  stuff
```

does ‘stuff’ if *string1* is the same as *string2*. The character separating the strings can be anything reasonable that is not contained in either string. The strings themselves can reference strings with *, arguments with \$, and so on.

**3. Environments**

As we mentioned, there is a potential problem when going across a page boundary: parameters like size and font for a page title may well be different from those in effect in the text when the page boundary occurs. **troff** provides a very general way to deal with this and similar situations. There are three ‘environments’, each of which has independently settable versions of many of the parameters associated with processing, including size, font, line and title lengths, fill/nofill mode, tab stops, and even partially collected lines. Thus the titling problem may be readily solved by processing the main text in one environment and titles in a separate one with its own suitable parameters.

The command .ev n shifts to environment n; n must be 0, 1 or 2. The command .ev with no argument returns to the previous environment. Environment names are maintained in a stack, so calls for different environments may be nested and unwound consistently.

Suppose we say that the main text is processed in environment 0, which is where **troff** begins by default. Then we can modify the new page macro .NP to process titles in environment 1 like this:

```
ˆde NP
ˆev 1        \" shift to new environment
ˆlt 6i       \" set parameters here
ˆft R
ˆps 10
... any other processing ...
ˆev          \" return to previous environment
ˆˆ
```

It is also possible to initialize the parameters for an environment outside the .NP macro, but the version shown keeps all the processing in one place and is thus easier to understand and change.

## 4. Diversions

There are numerous occasions in page layout when it is necessary to store some text for a period of time without actually printing it. Footnotes are the most obvious example: the text of the footnote usually appears in the input well before the place on the page where it is to be printed is reached. In fact, the place where it is output normally depends on how big it is, which implies that there must be a way to process the footnote at least enough to decide its size without printing it.

**troff** provides a mechanism called a diversion for doing this processing. Any part of the output may be diverted into a macro instead of being printed, and then at some convenient time the macro may be put back into the input.

The command .di xy begins a diversion — all subsequent output is collected into the macro xy until the command .di with no arguments is encountered. This terminates the diversion. The processed text is available at any time thereafter, simply by giving the command

```
ˆxy
```

The vertical size of the last finished diversion is contained in the built-in number register dn.

As a simple example, suppose we want to implement a ‘keep-release’ operation, so that text between the commands .KS and .KE will not be split across a page boundary (as for a figure or table). Clearly, when a .KS is encountered, we have to begin diverting the output so we can find out how big it is. Then when a .KE is seen, we decide whether the diverted text will fit on the current page, and print it either there if it fits, or at the top of the next page if it doesn’t. So:

```
ˆde KS     \" start keep
ˆbr        \" start fresh line
ˆev 1      \" collect in new environment
ˆfi        \" make it filled text
ˆdi XX     \" collect in XX
ˆˆ

ˆde KE     \" end keep
ˆbr        \" get last partial line
ˆdi        \" end diversion
ˆif \\n(dn>=\\n(.t .bp   \" bp if doesn´t fit
ˆnf        \" bring it back in no-fill
ˆXX        \" text
ˆev        \" return to normal environment
ˆˆ
```

Recall that number register nl is the current position on the output page. Since output was being diverted, this remains at its value when the diversion started. dn is the amount of text in the diversion; .t (another built-in register) is the distance to the next trap, which we assume is at the bottom margin of the page. If the diversion is large enough to go past the trap, the .if is satisfied, and a .bp is issued. In either case, the diverted output is then brought back with .XX. It is essential to bring it back in no-fill mode so **troff** will do no further processing on it.

This is not the most general keep-release, nor is it robust in the face of all conceivable inputs, but it would require more space than we have here to write it in full generality. This section is not intended to teach everything about diversions, but to sketch out enough that you can read existing macro packages with some comprehension.

**Acknowledgements**

I am deeply indebted to J. F. Ossanna, the author of **troff**, for his repeated patient explanations of fine points, and for his continuing willingness to adapt **troff** to make other uses easier. I am also grateful to Jim Blinn, Ted Dolotta, Doug McIlroy, Mike Lesk and Joel Sturman for helpful comments on this paper.

**References**

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[6] Eric P. Allman, *Writing Papers with NROFF using -me,* University of California, Berkeley.

**Appendix A: Phototypesetter Character Set (APS-5)**

These characters exist in roman, italic, and bold. To get the one on the left, type the four-character name on the right.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | \(ff | ﬁ | \(fi | ﬂ | \(fl | | \(Fi | | \(Fl |
| _ | \(ru | — | \(em | ¼ | \(14 | ½ | \(12 | ¾ | \(34 |
| © | \(co | ° | \(de | † | \(dg | ′ | \(fm | ¢ | \(ct |
| ® | \(rg | • | \(bu | □ | \(sq | - | \(hy | | |

(In bold, \(sq is □.)

The following are special-font characters:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| + | \(pl | − | \(mi | × | \(mu | ÷ | \(di |
| = | \(eq | ≡ | \(== | ≥ | \(>= | ≤ | \(<= |
| ≠ | \(!= | ± | \(+- | ¬ | \(no | / | \(sl |
| ~ | \(ap | ≈ | \(~= | ∝ | \(pt | ∇ | \(gr |
| → | \(-> | ← | \(<- | ↑ | \(ua | ↓ | \(da |
| ∫ | \(is | ∂ | \(pd | ∞ | \(if | √ | \(sr |
| ⊂ | \(sb | ⊃ | \(sp | ∪ | \(cu | ∩ | \(ca |
| ⊆ | \(ib | ⊇ | \(ip | ∈ | \(mo | ∅ | \(es |
| ´ | \(aa | ` | \(ga | ○ | \(ci | ♥ | \(bs |
| § | \(sc | ‡ | \(dd | ⇐ | \(lh | ⇒ | \(rh |
| ⎧ | \(lt | ⎫ | \(rt | ⌈ | \(lc | ⌉ | \(rc |
| ⎩ | \(lb | ⎭ | \(rb | ⌊ | \(lf | ⌋ | \(rf |
| ⎨ | \(lk | ⎬ | \(rk | \| | \(bv | ς | \(ts |
| \| | \(br | \| | \(or | _ | \(ul | ‾ | \(rn |
| * | \(** | | | | | | |

These four characters also have two-character names. The ´ is the apostrophe on terminals; the ` is the other quote mark.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ´ | \´ | ` | \` | – | \– | _ | _ |

These characters exist only on the special font, but they do not have four-character names:

" { } < > ˜ ˆ \ # @

For greek, precede the roman letter by \(* to get the corresponding greek; for example, \(*a is α.

a b g d e z y h i k l m n c o p r s t u f x q w
α β γ δ ε ζ η θ ι κ λ μ ν ξ ο π ρ σ τ υ φ χ ψ ω

A B G D E Z Y H I K L M N C O P R S T U F X Q W
Α Β Γ Δ Ε Ζ Η Θ Ι Κ Λ Μ Ν Ξ Ο Π Ρ Σ Τ Υ Φ Χ Ψ Ω

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## Index