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Tbl — A Program to Format Tables

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ABSTRACT

Tbl is a document formatting preprocessor for *troff* or *nroff* which makes even fairly complex tables easy to specify and enter. It is available on the PDP-11 UNIX* system and on Honeywell 6000 GCOS. Tables are made up of columns which may be independently centered, right-adjusted, left-adjusted, or aligned by decimal points. Headings may be placed over single columns or groups of columns. A table entry may contain equations, or may consist of several rows of text. Horizontal or vertical lines may be drawn as desired in the table, and any table or element may be enclosed in a box. For example:

1970 Federal Budget Transfers (in billions of dollars)			
State	Taxes collected	Money spent	Net
New York	22.91	21.35	−1.56
New Jersey	8.33	6.96	−1.37
Connecticut	4.12	3.10	−1.02
Maine	0.74	0.67	−0.07
California	22.29	22.42	+0.13
New Mexico	0.70	1.49	+0.79
Georgia	3.30	4.28	+0.98
Mississippi	1.15	2.32	+1.17
Texas	9.33	11.13	+1.80

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Introduction.

Tbl turns a simple description of a table into a *troff* or *nroff* [1] program (list of commands) that prints the table. *Tbl* may be used on the PDP-11 UNIX [2] system and on the Honeywell 6000 GCOS system. It attempts to isolate a portion of a job that it can successfully handle and leave the remainder for other programs. Thus *tbl* may be used with the equation formatting program *eqn* [3] or various layout macro packages [4,5,6], but does not duplicate their functions.

This memorandum is divided into two parts. First we give the rules for preparing *tbl* input; then some examples are shown. The description of rules is precise but technical, and the beginning user may prefer to read the examples first, as they show some common table arrangements. A section explaining how to invoke *tbl* precedes the examples. To avoid repetition, henceforth read *troff* as ''*troff* or *nroff*.''

The input to *tbl* is text for a document, with tables preceded by a ''.TS'' (table start) command and followed by a ''.TE'' (table end) command. *Tbl* processes the tables, generating *troff* formatting commands, and leaves the remainder of the text unchanged. The ''.TS'' and ''.TE'' lines are copied, too, so that *troff* page layout macros (such as the memo formatting macros [4]) can use these lines to delimit and place tables as they see fit. In particular, any arguments on the ''.TS'' or ''.TE'' lines are copied but otherwise ignored, and may be used by document layout macro commands.

The format of the input is as follows:

text
.TS
table
.TE
text
.TS
table
.TE
text
. . .

where the format of each table is as follows:

.TS
options **;**
format **.**
data
.TE

Each table is independent, and must contain formatting information followed by the data to be entered in the table. The formatting information, which describes the individual columns and rows of the table, may be preceded by a few options that affect the entire table. A detailed description of tables is given in the next section.

Input commands.

As indicated above, a table contains, first, global options, then a format section describing the layout of the table entries, and then the data to be printed. The format and data are always required, but not the options. The various parts of the table are entered as follows:

1) OPTIONS. There may be a single line of options affecting the whole table. If present, this line must follow the **.**TS line immediately and must contain a list of option names separated by spaces, tabs, or commas, and must be terminated by a semicolon. The allowable options are:

center	— center the table (default is left-adjust);
expand	— make the table as wide as the current line length;
box	— enclose the table in a box;
allbox	— enclose each item in the table in a box;
doublebox	— enclose the table in two boxes;
tab (*x*)	— use *x* instead of tab to separate data items.
linesize (*n*)	— set lines or rules (e.g. from **box**) in *n* point type;
delim (*xy*)	— recognize *x* and *y* as the *eqn* delimiters.

The *tbl* program tries to keep boxed tables on one page by issuing appropriate ''need'' (**.***ne*) commands. These requests are calculated from the number of lines in the tables, and if there are spacing commands embedded in the input, these requests may be inaccurate; use normal *troff* procedures, such as keep-release macros, in that case. The user who must have a multi-page boxed table should use macros designed for this purpose, as explained below under 'Usage.'

2) FORMAT. The format section of the table specifies the layout of the columns. Each line in this section corresponds to one line of the table (except that the last line corresponds to all following lines up to the next **.**T&, if any — see below), and each line contains a key-letter for each column of the table. It is good practice to separate the key letters for each column by spaces or tabs. Each key-letter is one of the following:

L or **l**	to indicate a left-adjusted column entry;
R or **r**	to indicate a right-adjusted column entry;
C or **c**	to indicate a centered column entry;
N or **n**	to indicate a numerical column entry, to be aligned with other numerical entries so that the units digits of numbers line up;
A or **a**	to indicate an alphabetic subcolumn; all corresponding entries are aligned on the left, and positioned so that the widest is centered within the column (see example on page 12);
S or **s**	to indicate a spanned heading, i.e. to indicate that the entry from the previous column continues across this column (not allowed for the first column, obviously); or
^	to indicate a vertically spanned heading, i.e. to indicate that the entry from the previous row continues down through this row. (Not allowed for the first row of the table, obviously).

When numerical alignment is specified, a location for the decimal point is sought. The rightmost dot (**.**) adjacent to a digit is used as a decimal point; if there is no dot adjoining a digit, the rightmost digit is used as a units digit; if no alignment is indicated, the item is centered in the column. However, the special non-printing character string \& may be used to override unconditionally dots and digits, or to align alphabetic data; this string lines up where a dot normally would, and then disappears from the final output. In the example below, the items shown at the left will be aligned (in a numerical column) as shown on the right:

13	13
4.2	4.2
26.4.12	26.4.12
abc	abc
abc\&	abc
43\&3.22	433.22
749.12	749.12

Note: If numerical data are used in the same column with wider **L** or **r** type table entries, the widest *number* is centered relative to the wider **L** or **r** items (**L** is used instead of **l** for readability; they have the same meaning as key-letters). Alignment within the numerical items is preserved. This is similar to the behavior of **a** type data, as explained above. However, alphabetic subcolumns (requested by the **a** key-letter) are always slightly indented relative to **L** items; if necessary, the column width is increased to force this. This is not true for **n** type entries.

Warning: the **n** and **a** items should not be used in the same column.

For readability, the key-letters describing each column should be separated by spaces. The end of the format section is indicated by a period. The layout of the key-letters in the format section resembles the layout of the actual data in the table. Thus a simple format might appear as:

```
c s s
l n n .
```

which specifies a table of three columns. The first line of the table contains a heading centered across all three columns; each remaining line contains a left-adjusted item in the first column followed by two columns of numerical data. A sample table in this format might be:

Overall title		
Item-a	34.22	9.1
Item-b	12.65	.02
Items: c,d,e	23	5.8
Total	69.87	14.92

There are some additional features of the key-letter system:

Horizontal lines — A key-letter may be replaced by '_' (underscore) to indicate a horizontal line in place of the corresponding column entry, or by '=' to indicate a double horizontal line. If an adjacent column contains a horizontal line, or if there are vertical lines adjoining this column, this horizontal line is extended to meet the nearby lines. If any data entry is provided for this column, it is ignored and a warning message is printed.

Vertical lines — A vertical bar may be placed between column key-letters. This will cause a vertical line between the corresponding columns of the table. A vertical bar to the left of the first key-letter or to the right of the last one produces a line at the edge of the table. If two vertical bars appear between key-letters, a double vertical line is drawn.

Space between columns — A number may follow the key-letter. This indicates the amount of separation between this column and the next column. The number normally specifies the separation in *ens* (one en is about the width of the letter 'n').* If the ''expand'' option is used, then these numbers are multiplied by a constant such that the table is as wide as the current line length. The default column separation number is 3. If the separation is changed the worst case (largest space requested) governs.

Vertical spanning — Normally, vertically spanned items extending over several rows of the table are centered in their vertical range. If a key-letter is followed by **t** or **T**, any corresponding vertically spanned item will begin at the top line of its range.

* More precisely, an en is a number of points (1 point = 1/72 inch) equal to half the current type size.

Font changes — A key-letter may be followed by a string containing a font name or number preceded by the letter **f** or **F**. This indicates that the corresponding column should be in a different font from the default font (usually Roman). All font names are one or two letters; a one-letter font name should be separated from whatever follows by a space or tab. The single letters **B**, **b**, **I**, and **i** are shorter synonyms for **fB** and **fI**. Font change commands given with the table entries override these specifications.

Point size changes — A key-letter may be followed by the letter **p** or **P** and a number to indicate the point size of the corresponding table entries. The number may be a signed digit, in which case it is taken as an increment or decrement from the current point size. If both a point size and a column separation value are given, one or more blanks must separate them.

Vertical spacing changes — A key-letter may be followed by the letter **v** or **V** and a number to indicate the vertical line spacing to be used within a multi-line corresponding table entry. The number may be a signed digit, in which case it is taken as an increment or decrement from the current vertical spacing. A column separation value must be separated by blanks or some other specification from a vertical spacing request. This request has no effect unless the corresponding table entry is a text block (see below).

Column width indication — A key-letter may be followed by the letter **w** or **W** and a width value in parentheses. This width is used as a minimum column width. If the largest element in the column is not as wide as the width value given after the **w**, the largest element is assumed to be that wide. If the largest element in the column is wider than the specified value, its width is used. The width is also used as a default line length for included text blocks. Normal *troff* units can be used to scale the width value; if none are used, the default is ens. If the width specification is a unitless integer the parentheses may be omitted. If the width value is changed in a column, the *last* one given controls.

Equal width columns — A key-letter may be followed by the letter **e** or **E** to indicate equal width columns. All columns whose key-letters are followed by **e** or **E** are made the same width. This permits the user to get a group of regularly spaced columns.

Note: The order of the above features is immaterial; they need not be separated by spaces, except as indicated above to avoid ambiguities involving point size and font changes. Thus a numerical column entry in italic font and 12 point type with a minimum width of 2.5 inches and separated by 6 ens from the next column could be specified as

```
np12w(2.5i)fI 6
```

Alternative notation — Instead of listing the format of successive lines of a table on consecutive lines of the format section, successive line formats may be given on the same line, separated by commas, so that the format for the example above might have been written:

```
c s s, l n n .
```

Default — Column descriptors missing from the end of a format line are assumed to be **L**. The longest line in the format section, however, defines the number of columns in the table; extra columns in the data are ignored silently.

3) DATA. The data for the table are typed after the format. Normally, each table line is typed as one line of data. Very long input lines can be broken: any line whose last character is \ is combined with the following line (and the \ vanishes). The data for different columns (the table entries) are separated by tabs, or by whatever character has been specified in the option *tabs* option. There are a few special cases:

Troff commands within tables — An input line beginning with a '**.**' followed by anything but a number is assumed to be a command to *troff* and is passed through unchanged, retaining its position in the table. So, for example, space within a table may be produced by ''**.**sp'' commands in the data.

Full width horizontal lines — An input *line* containing only the character _ (underscore) or = (equal sign) is taken to be a single or double line, respectively, extending the full width of the *table.*

Single column horizontal lines — An input table *entry* containing only the character _ or **=** is taken to be a single or double line extending the full width of the *column.* Such lines are extended to meet horizontal or vertical lines adjoining this column. To obtain these characters explicitly in a column, either precede them by \& or follow them by a space before the usual tab or newline.

Short horizontal lines — An input table *entry* containing only the string **_** is taken to be a single line as wide as the contents of the column. It is not extended to meet adjoining lines.

Repeated characters — An input table *entry* containing only a string of the form **\R***x* where *x* is any character is replaced by repetitions of the character *x* as wide as the data in the column. The sequence of *x*'s is not extended to meet adjoining columns.

Vertically spanned items — An input table entry containing only the character string \^ indicates that the table entry immediately above spans downward over this row. It is equivalent to a table format key-letter of '^'.

Text blocks — In order to include a block of text as a table entry, precede it by **T{** and follow it by **T}**. Thus the sequence

> **. . . T{**
> *block of*
> *text*
> **T} . . .**

is the way to enter, as a single entry in the table, something that cannot conveniently be typed as a simple string between tabs. Note that the **T}** end delimiter must begin a line; additional columns of data may follow after a tab on the same line. See the example on page 10 for an illustration of included text blocks in a table. If more than twenty or thirty text blocks are used in a table, various limits in the *troff* program are likely to be exceeded, producing diagnostics such as 'too many string/macro names' or 'too many number registers.'

Text blocks are pulled out from the table, processed separately by *troff,* and replaced in the table as a solid block. If no line length is specified in the *block of text* itself, or in the table format, the default is to use $L \times C/(N+1)$ where L is the current line length, C is the number of table columns spanned by the text, and N is the total number of columns in the table. The other parameters (point size, font, etc.) used in setting the *block of text* are those in effect at the beginning of the table (including the effect of the ''.TS'' macro) and any table format specifications of size, spacing and font, using the **p**, **v** and **f** modifiers to the column key-letters. Commands within the text block itself are also recognized, of course. However, *troff* commands within the table data but not within the text block do not affect that block.

Warnings: — Although any number of lines may be present in a table, only the first 200 lines are used in calculating the widths of the various columns. A multi-page table, of course, may be arranged as several single-page tables if this proves to be a problem. Other difficulties with formatting may arise because, in the calculation of column widths all table entries are assumed to be in the font and size being used when the ''.TS'' command was encountered, except for font and size changes indicated (a) in the table format section and (b) within the table data (as in the entry \s+3\fIdata\fP\s0). Therefore, although arbitrary *troff* requests may be sprinkled in a table, care must be taken to avoid confusing the width calculations; use requests such as '.ps' with care.

4) ADDITIONAL COMMAND LINES. If the format of a table must be changed after many similar lines, as with sub-headings or summarizations, the ''.T&'' (table continue) command can be used to change column parameters. The outline of such a table input is:

```
.TS
options ;
format .
data
. . .
.T&
format .
data
.T&
format .
data
.TE
```

as in the examples on pages 10 and 12. Using this procedure, each table line can be close to its corresponding format line.

Warning: it is not possible to change the number of columns, the space between columns, the global options such as *box,* or the selection of columns to be made equal width.

Usage.

On UNIX, *tbl* can be run on a simple table with the command

```
tbl input-file | troff
```

but for more complicated use, where there are several input files, and they contain equations and *ms* memorandum layout commands as well as tables, the normal command would be

```
tbl file-1 file-2 . . . | eqn | troff −ms
```

and, of course, the usual options may be used on the *troff* and *eqn* commands. The usage for *nroff* is similar to that for *troff*, but only TELETYPE® Model 37 and Diablo-mechanism (DASI or GSI) terminals can print boxed tables directly.

For the convenience of users employing line printers without adequate driving tables or post-filters, there is a special *−TX* command line option to *tbl* which produces output that does not have fractional line motions in it. The only other command line options recognized by *tbl* are *−ms* and *−mm* which are turned into commands to fetch the corresponding macro files; usually it is more convenient to place these arguments on the *troff* part of the command line, but they are accepted by *tbl* as well.

Note that when *eqn* and *tbl* are used together on the same file *tbl* should be used first. If there are no equations within tables, either order works, but it is usually faster to run *tbl* first, since *eqn* normally produces a larger expansion of the input than *tbl.* However, if there are equations within tables (using the *delim* mechanism in *eqn*), *tbl* must be first or the output will be scrambled. Users must also beware of using equations in **n**-style columns; this is nearly always wrong, since *tbl* attempts to split numerical format items into two parts and this is not possible with equations. The user can defend against this by giving the *delim(xx)* table option; this prevents splitting of numerical columns within the delimiters. For example, if the *eqn* delimiters are *$$*, giving *delim($$)* a numerical column such as ‘‘1245 $+- 16$’’ will be divided after 1245, not after 16.

Tbl limits tables to twenty columns; however, use of more than 16 numerical columns may fail because of limits in *troff,* producing the ‘too many number registers’ message. *Troff* number registers used by *tbl* must be avoided by the user within tables; these include two-digit names from 31 to 99, and names of the forms #*x*, *x*+, *x* |, ^*x*, and *x*–, where *x* is any lower case letter. The names ##, #–, and #^ are also used in certain circumstances. To conserve number register names, the **n** and **a** formats share a register; hence the restriction above that they may not be used in the same column.

For aid in writing layout macros, *tbl* defines a number register TW which is the table width; it is defined by the time that the ‘‘.TE’’ macro is invoked and may be used in the expansion of that macro. More importantly, to assist in laying out multi-page boxed tables the macro T# is defined to produce the bottom lines and side lines of a boxed table, and then invoked at its end. By use of this macro in the page footer a multi-page table can be boxed. In particular, the *ms* macros can be used to print a multi-page boxed table with a repeated heading by giving the argument H to the ‘‘.TS’’ macro. If the table start macro is written

```
.TS H
```

a line of the form

```
.TH
```

must be given in the table after any table heading (or at the start if none). Material up to the ‘‘.TH’’ is placed at the top of each page of table; the remaining lines in the table are placed on several pages as required. Note that this is *not* a feature of *tbl,* but of the *ms* layout macros.

Examples.

Here are some examples illustrating features of *tbl.* The symbol ⓣ in the input represents a tab character.

Input:

```
.TS
box;
c c c
l l l.
LanguageⓣAuthorsⓣRuns on

FortranⓣManyⓣAlmost anything
PL/1ⓣIBMⓣ360/370
CⓣBTLⓣ11/45,H6000,370
BLISSⓣCarnegie-MellonⓣPDP-10,11
IDSⓣHoneywellⓣH6000
PascalⓣStanfordⓣ370
.TE
```

Output:

Language	Authors	Runs on
Fortran	Many	Almost anything
PL/1	IBM	360/370
C	BTL	11/45,H6000,370
BLISS	Carnegie-Mellon	PDP-10,11
IDS	Honeywell	H6000
Pascal	Stanford	370

Input:

```
.TS
allbox;
c s s
c c c
n n n.
AT&T Common Stock
YearⓣPriceⓣDividend
1971ⓣ41-54ⓣ$2.60
2ⓣ41-54ⓣ2.70
3ⓣ46-55ⓣ2.87
4ⓣ40-53ⓣ3.24
5ⓣ45-52ⓣ3.40
6ⓣ51-59ⓣ.95*
.TE
* (first quarter only)
```

Output:

AT&T Common Stock		
Year	Price	Dividend
1971	41-54	$2.60
2	41-54	2.70
3	46-55	2.87
4	40-53	3.24
5	45-52	3.40
6	51-59	.95*

* (first quarter only)

Input:

```
.TS
box;
c s s
c | c | c
l | l | n.
Major New York Bridges
=
BridgeⓉDesignerⓉLength
_
BrooklynⓉJ. A. RoeblingⓉ1595
ManhattanⓉG. LindenthalⓉ1470
WilliamsburgⓉL. L. BuckⓉ1600
_
QueensboroughⓉPalmer &Ⓣ1182
Ⓣ   Hornbostel
_
ⓉⓉ1380
TriboroughⓉO. H. AmmannⓉ_
ⓉⓉ383
_
Bronx WhitestoneⓉO. H. AmmannⓉ2300
Throgs NeckⓉO. H. AmmannⓉ1800
_
George WashingtonⓉO. H. AmmannⓉ3500
.TE
```

Output:

Major New York Bridges		
Bridge	Designer	Length
Brooklyn	J. A. Roebling	1595
Manhattan	G. Lindenthal	1470
Williamsburg	L. L. Buck	1600
Queensborough	Palmer & Hornbostel	1182
		1380
Triborough	O. H. Ammann	
		383
Bronx Whitestone	O. H. Ammann	2300
Throgs Neck	O. H. Ammann	1800
George Washington	O. H. Ammann	3500

Input:

```
.TS
c c
np-2 | n | .
ⓉStack
Ⓣ_
1Ⓣ46
Ⓣ_
2Ⓣ23
Ⓣ_
3Ⓣ15
Ⓣ_
4Ⓣ6.5
Ⓣ_
5Ⓣ2.1
Ⓣ_
.TE
```

Output:

	Stack
1	46
2	23
3	15
4	6.5
5	2.1

Input:

```
.TS
box;
L L L
L L _
L L | LB
L L _
L L L.
januaryⓣfebruaryⓣmarch
aprilⓣmay
juneⓣjulyⓣMonths
augustⓣseptember
octoberⓣnovemberⓣdecember
.TE
```

Output:

january	february	march
april	may	
june	july	**Months**
august	september	
october	november	december

Input:

```
.TS
box;
cfB s s s.
Composition of Foods
_
.T&
c | c s s
c | c s s
c  | c | c | c.
FoodⓣPercent by Weight
\^ⓣ_
\^ⓣProteinⓣFatⓣCarbo-
\^ⓣ\^ⓣ\^ⓣhydrate
_
.T&
l | n | n | n.
Applesⓣ.4ⓣ.5ⓣ13.0
Halibutⓣ18.4ⓣ5.2ⓣ. . .
Lima beansⓣ7.5ⓣ.8ⓣ22.0
Milkⓣ3.3ⓣ4.0ⓣ5.0
Mushroomsⓣ3.5ⓣ.4ⓣ6.0
Rye breadⓣ9.0ⓣ.6ⓣ52.7
.TE
```

Output:

Composition of Foods			
Food	Percent by Weight		
	Protein	Fat	Carbo-hydrate
Apples	.4	.5	13.0
Halibut	18.4	5.2	...
Lima beans	7.5	.8	22.0
Milk	3.3	4.0	5.0
Mushrooms	3.5	.4	6.0
Rye bread	9.0	.6	52.7

Input:

```
.TS
allbox;
cfI  s   s
c    cw(1i)   cw(1i)
lp9 lp9 lp9.
New York Area Rocks
EraⓉFormationⓉAge (years)
PrecambrianⓉReading ProngⓉ>1 billion
PaleozoicⓉManhattan ProngⓉ400 million
MesozoicⓉT{
.na
Newark Basin, incl.
Stockton, Lockatong, and Brunswick
formations; also Watchungs
and Palisades.
T}Ⓣ200 million
CenozoicⓉCoastal PlainⓉT{
On Long Island 30,000 years;
Cretaceous sediments redeposited
by recent glaciation.
.ad
T}
.TE
```

Output:

New York Area Rocks		
Era	Formation	Age (years)
Precambrian	Reading Prong	>1 billion
Paleozoic	Manhattan Prong	400 million
Mesozoic	Newark Basin, incl. Stockton, Lockatong, and Brunswick formations; also Watchungs and Palisades.	200 million
Cenozoic	Coastal Plain	On Long Island 30,000 years; Cretaceous sediments redeposited by recent glaciation.

Input:

```
.EQ
delim $$
.EN

. . .

.TS
doublebox;
c c
l l.
NameⓉDefinition
.sp
.vs +2p
GammaⓉ$GAMMA (z) = int sub 0 sup inf  t sup {z-1} e sup -t dt$
SineⓉ$sin (x) = 1 over 2i ( e sup ix - e sup -ix )$
ErrorⓉ$ roman erf (z) = 2 over sqrt pi int sub 0 sup z e sup {-t sup 2} dt$
BesselⓉ$ J sub 0 (z) = 1 over pi int sub 0 sup pi cos ( z sin theta ) d theta $
ZetaⓉ$ zeta (s) = sum from k=1 to inf k sup -s ~~( Re~s > 1)$
.vs -2p
.TE
```

Output:

Name	Definition
Gamma	$\Gamma(z) = \int_0^\infty t^{z-1} e^{-t}\,dt$
Sine	$\sin(x) = \frac{1}{2i}(e^{ix} - e^{-ix})$
Error	$\mathrm{erf}(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2}\,dt$
Bessel	$J_0(z) = \frac{1}{\pi} \int_0^\pi \cos(z \sin\theta)\,d\theta$
Zeta	$\zeta(s) = \sum_{k=1}^\infty k^{-s} \quad (\mathrm{Re}\ s > 1)$

Input:

```
.TS
box, tab(:);
cb s s s s
cp-2 s s s s
c || c | c | c | c
c || c | c | c | c
r2 || n2 | n2 | n2 | n.
Readability of Text
Line Width and Leading for 10-Point Type
=
Line:Set:1-Point:2-Point:4-Point
Width:Solid:Leading:Leading:Leading
_
9 Pica:\-9.3:\-6.0:\-5.3:\-7.1
14 Pica:\-4.5:\-0.6:\-0.3:\-1.7
19 Pica:\-5.0:\-5.1: 0.0:\-2.0
31 Pica:\-3.7:\-3.8:\-2.4:\-3.6
43 Pica:\-9.1:\-9.0:\-5.9:\-8.8
.TE
```

Output:

Readability of Text

Line Width and Leading for 10-Point Type

Line Width	Set Solid	1-Point Leading	2-Point Leading	4-Point Leading
9 Pica	−9.3	−6.0	−5.3	−7.1
14 Pica	−4.5	−0.6	−0.3	−1.7
19 Pica	−5.0	−5.1	0.0	−2.0
31 Pica	−3.7	−3.8	−2.4	−3.6
43 Pica	−9.1	−9.0	−5.9	−8.8

Input:

```
.TS
c s
cip-2 s
l n
a n.
Some London Transport Statistics
(Year 1964)
Railway route milesⓣ244
Tubeⓣ66
Sub-surfaceⓣ22
Surfaceⓣ156
.sp .5
.T&
l r
a r.
Passenger traffic \- railway
Journeysⓣ674 million
Average lengthⓣ4.55 miles
Passenger milesⓣ3,066 million
.T&
l r
a r.
Passenger traffic \- road
Journeysⓣ2,252 million
Average lengthⓣ2.26 miles
Passenger milesⓣ5,094 million
.T&
l n
a n.
.sp .5
Vehiclesⓣ12,521
Railway motor carsⓣ2,905
Railway trailer carsⓣ1,269
Total railwayⓣ4,174
Omnibusesⓣ8,347
.T&
l n
a n.
.sp .5
Staffⓣ73,739
Administrative, etc.ⓣ5,582
Civil engineeringⓣ5,134
Electrical eng.ⓣ1,714
Mech. eng. \- railwayⓣ4,310
Mech. eng. \- roadⓣ9,152
Railway operationsⓣ8,930
Road operationsⓣ35,946
Otherⓣ2,971
.TE
```

Output:

Some London Transport Statistics	
(Year 1964)	
Railway route miles	244
Tube	66
Sub-surface	22
Surface	156
Passenger traffic – railway	
Journeys	674 million
Average length	4.55 miles
Passenger miles	3,066 million
Passenger traffic – road	
Journeys	2,252 million
Average length	2.26 miles
Passenger miles	5,094 million
Vehicles	12,521
Railway motor cars	2,905
Railway trailer cars	1,269
Total railway	4,174
Omnibuses	8,347
Staff	73,739
Administrative, etc.	5,582
Civil engineering	5,134
Electrical eng.	1,714
Mech. eng. – railway	4,310
Mech. eng. – road	9,152
Railway operations	8,930
Road operations	35,946
Other	2,971

Input:

```
.ps 8
.vs 10p
.TS
center box;
c s s
ci s s
c c c
lB l n.
New Jersey Representatives
(Democrats)
.sp .5
NameⓉOffice addressⓉPhone
.sp .5
James J. FlorioⓉ23 S. White Horse Pike, Somerdale 08083Ⓣ609-627-8222
William J. HughesⓉ2920 Atlantic Ave., Atlantic City 08401Ⓣ609-345-4844
James J. HowardⓉ801 Bangs Ave., Asbury Park 07712Ⓣ201-774-1600
Frank Thompson, Jr.Ⓣ10 Rutgers Pl., Trenton 08618Ⓣ609-599-1619
Andrew MaguireⓉ115 W. Passaic St., Rochelle Park 07662Ⓣ201-843-0240
Robert A. RoeⓉU.S.P.O., 194 Ward St., Paterson 07510Ⓣ201-523-5152
Henry HelstoskiⓉ666 Paterson Ave., East Rutherford 07073Ⓣ201-939-9090
Peter W. Rodino, Jr.ⓉSuite 1435A, 970 Broad St., Newark 07102Ⓣ201-645-3213
Joseph G. MinishⓉ308 Main St., Orange 07050Ⓣ201-645-6363
Helen S. MeynerⓉ32 Bridge St., Lambertville 08530Ⓣ609-397-1830
Dominick V. DanielsⓉ895 Bergen Ave., Jersey City 07306Ⓣ201-659-7700
Edward J. PattenⓉNatl. Bank Bldg., Perth Amboy 08861Ⓣ201-826-4610
.sp .5
.T&
ci s s
lB l n.
(Republicans)
.sp .5v
Millicent FenwickⓉ41 N. Bridge St., Somerville 08876Ⓣ201-722-8200
Edwin B. ForsytheⓉ301 Mill St., Moorestown 08057Ⓣ609-235-6622
Matthew J. RinaldoⓉ1961 Morris Ave., Union 07083Ⓣ201-687-4235
.TE
.ps 10
.vs 12p
```

Output:

New Jersey Representatives *(Democrats)*		
Name	Office address	Phone
James J. Florio	23 S. White Horse Pike, Somerdale 08083	609-627-8222
William J. Hughes	2920 Atlantic Ave., Atlantic City 08401	609-345-4844
James J. Howard	801 Bangs Ave., Asbury Park 07712	201-774-1600
Frank Thompson, Jr.	10 Rutgers Pl., Trenton 08618	609-599-1619
Andrew Maguire	115 W. Passaic St., Rochelle Park 07662	201-843-0240
Robert A. Roe	U.S.P.O., 194 Ward St., Paterson 07510	201-523-5152
Henry Helstoski	666 Paterson Ave., East Rutherford 07073	201-939-9090
Peter W. Rodino, Jr.	Suite 1435A, 970 Broad St., Newark 07102	201-645-3213
Joseph G. Minish	308 Main St., Orange 07050	201-645-6363
Helen S. Meyner	32 Bridge St., Lambertville 08530	609-397-1830
Dominick V. Daniels	895 Bergen Ave., Jersey City 07306	201-659-7700
Edward J. Patten	Natl. Bank Bldg., Perth Amboy 08861	201-826-4610
(Republicans)		
Millicent Fenwick	41 N. Bridge St., Somerville 08876	201-722-8200
Edwin B. Forsythe	301 Mill St., Moorestown 08057	609-235-6622
Matthew J. Rinaldo	1961 Morris Ave., Union 07083	201-687-4235

This is a paragraph of normal text placed here only to indicate where the left and right margins are. In this way the reader can judge the appearance of centered tables or expanded tables, and observe how such tables are formatted.

Input:

```
.TS
expand;
c s s s
c c c c
l l n n.
Bell Labs Locations
NameⓉAddressⓉArea CodeⓉPhone
HolmdelⓉHolmdel, N. J. 07733Ⓣ201Ⓣ949-3000
Murray HillⓉMurray Hill, N. J. 07974Ⓣ201Ⓣ582-6377
WhippanyⓉWhippany, N. J. 07981Ⓣ201Ⓣ386-3000
Indian HillⓉNaperville, Illinois 60540Ⓣ312Ⓣ690-2000
.TE
```

Output:

Bell Labs Locations			
Name	Address	Area Code	Phone
Holmdel	Holmdel, N. J. 07733	201	949-3000
Murray Hill	Murray Hill, N. J. 07974	201	582-6377
Whippany	Whippany, N. J. 07981	201	386-3000
Indian Hill	Naperville, Illinois 60540	312	690-2000

Input:

```
.TS
box;
cb   s   s   s
c | c | c   s
ltiw(1i) | ltw(2i) | lp8 | lw(1.6i)p8.
Some Interesting Places
_
NameⓉDescriptionⓉPractical Information
_
T{
American Museum of Natural History
T}ⓉT{
The collections fill 11.5 acres (Michelin) or 25 acres (MTA)
of exhibition halls on four floors.  There is a full-sized replica
of a blue whale and the world's largest star sapphire (stolen in 1964).
T}ⓉHoursⓉ10-5, ex. Sun 11-5, Wed. to 9
\^Ⓣ\^ⓉLocationⓉT{
Central Park West & 79th St.
T}
\^Ⓣ\^ⓉAdmissionⓉDonation: $1.00 asked
\^Ⓣ\^ⓉSubwayⓉAA to 81st St.
\^Ⓣ\^ⓉTelephoneⓉ212-873-4225
_
Bronx ZooⓉT{
About a mile long and .6 mile wide, this is the largest zoo in America.
A lion eats 18 pounds
of meat a day while a sea lion eats 15 pounds of fish.
T}ⓉHoursⓉT{
10-4:30 winter, to 5:00 summer
T}
\^Ⓣ\^ⓉLocationⓉT{
185th St. & Southern Blvd, the Bronx.
T}
\^Ⓣ\^ⓉAdmissionⓉ$1.00, but Tu,We,Th free
\^Ⓣ\^ⓉSubwayⓉ2, 5 to East Tremont Ave.
\^Ⓣ\^ⓉTelephoneⓉ212-933-1759
_
Brooklyn MuseumⓉT{
Five floors of galleries contain American and ancient art.
There are American period rooms and architectural ornaments saved
from wreckers, such as a classical figure from Pennsylvania Station.
T}ⓉHoursⓉWed-Sat, 10-5, Sun 12-5
\^Ⓣ\^ⓉLocationⓉT{
Eastern Parkway & Washington Ave., Brooklyn.
T}
\^Ⓣ\^ⓉAdmissionⓉFree
\^Ⓣ\^ⓉSubwayⓉ2,3 to Eastern Parkway.
\^Ⓣ\^ⓉTelephoneⓉ212-638-5000
_
T{
New-York Historical Society
T}ⓉT{
All the original paintings for Audubon's
.I
Birds of America
.R
are here, as are exhibits of American decorative arts, New York history,
Hudson River school paintings, carriages, and glass paperweights.
T}ⓉHoursⓉT{
Tues-Fri & Sun, 1-5; Sat 10-5
T}
\^Ⓣ\^ⓉLocationⓉT{
Central Park West & 77th St.
T}
\^Ⓣ\^ⓉAdmissionⓉFree
\^Ⓣ\^ⓉSubwayⓉAA to 81st St.
\^Ⓣ\^ⓉTelephoneⓉ212-873-3400
.TE
```

Output:

Some Interesting Places			
Name	Description	Practical Information	
American Museum of Natural History	The collections fill 11.5 acres (Michelin) or 25 acres (MTA) of exhibition halls on four floors. There is a full-sized replica of a blue whale and the world's largest star sapphire (stolen in 1964).	Hours Location Admission Subway Telephone	10-5, ex. Sun 11-5, Wed. to 9 Central Park West & 79th St. Donation: $1.00 asked AA to 81st St. 212-873-4225
Bronx Zoo	About a mile long and .6 mile wide, this is the largest zoo in America. A lion eats 18 pounds of meat a day while a sea lion eats 15 pounds of fish.	Hours Location Admission Subway Telephone	10-4:30 winter, to 5:00 summer 185th St. & Southern Blvd, the Bronx. $1.00, but Tu,We,Th free 2, 5 to East Tremont Ave. 212-933-1759
Brooklyn Museum	Five floors of galleries contain American and ancient art. There are American period rooms and architectural ornaments saved from wreckers, such as a classical figure from Pennsylvania Station.	Hours Location Admission Subway Telephone	Wed-Sat, 10-5, Sun 12-5 Eastern Parkway & Washington Ave., Brooklyn. Free 2,3 to Eastern Parkway. 212-638-5000
New-York Historical Society	All the original paintings for Audubon's *Birds of America* are here, as are exhibits of American decorative arts, New York history, Hudson River school paintings, carriages, and glass paperweights.	Hours Location Admission Subway Telephone	Tues-Fri & Sun, 1-5; Sat 10-5 Central Park West & 77th St. Free AA to 81st St. 212-873-3400

Acknowledgments.

Many thanks are due to J. C. Blinn, who has done a large amount of testing and assisted with the design of the program. He has also written many of the more intelligible sentences in this document and helped edit all of it. All phototypesetting programs on UNIX are dependent on the work of the late J. F. Ossanna, whose assistance with this program in particular had been most helpful. This program is patterned on a table formatter originally written by J. F. Gimpel. The assistance of T. A. Dolotta, B. W. Kernighan, and J. N. Sturman is gratefully acknowledged.

References.

[1] J. F. Ossanna, *NROFF/TROFF User's Manual,* Computing Science Technical Report No. 54, Bell Laboratories, 1976.

[2] K. Thompson and D. M. Ritchie, ''The UNIX Time-Sharing System,'' *Comm. ACM.* **17**, pp. 365–75 (1974).

[3] B. W. Kernighan and L. L. Cherry, ''A System for Typesetting Mathematics,'' *Comm. ACM.* **18**, pp. 151–57 (1975).

[4] M. E. Lesk, *Typing Documents on UNIX,* UNIX Programmer's Manual, Volume 2.

[5] M. E. Lesk and B. W. Kernighan, *Computer Typesetting of Technical Journals on UNIX, Proc. AFIPS NCC*, vol. 46, pp. 879-888 (1977).

[6] J. R. Mashey and D. W. Smith, ''Documentation Tools and Techniques,'' *Proc. 2nd Int. Conf. on Software Engineering,* pp. 177-181 (October, 1976).

List of Tbl Command Characters and Words

<table>
<tr><th>Command</th><th>Meaning</th><th>Section</th></tr>
<tr><td>a A</td><td>Alphabetic subcolumn</td><td>2</td></tr>
<tr><td>allbox</td><td>Draw box around all items</td><td>1</td></tr>
<tr><td>b B</td><td>Boldface item</td><td>2</td></tr>
<tr><td>box</td><td>Draw box around table</td><td>1</td></tr>
<tr><td>c C</td><td>Centered column</td><td>2</td></tr>
<tr><td>center</td><td>Center table in page</td><td>1</td></tr>
<tr><td>doublebox</td><td>Doubled box around table</td><td>1</td></tr>
<tr><td>e E</td><td>Equal width columns</td><td>2</td></tr>
<tr><td>expand</td><td>Make table full line width</td><td>1</td></tr>
<tr><td>f F</td><td>Font change</td><td>2</td></tr>
<tr><td>i I</td><td>Italic item</td><td>2</td></tr>
<tr><td>l L</td><td>Left adjusted column</td><td>2</td></tr>
<tr><td>n N</td><td>Numerical column</td><td>2</td></tr>
<tr><td>nnn</td><td>Column separation</td><td>2</td></tr>
<tr><td>p P</td><td>Point size change</td><td>2</td></tr>
<tr><td>r R</td><td>Right adjusted column</td><td>2</td></tr>
<tr><td>s S</td><td>Spanned item</td><td>2</td></tr>
<tr><td>t T</td><td>Vertical spanning at top</td><td>2</td></tr>
<tr><td>tab (x)</td><td>Change data separator character</td><td>1</td></tr>
<tr><td>T{ T}</td><td>Text block</td><td>3</td></tr>
<tr><td>v V</td><td>Vertical spacing change</td><td>2</td></tr>
<tr><td>w W</td><td>Minimum width value</td><td>2</td></tr>
<tr><td>.xx</td><td>Included troff command</td><td>3</td></tr>
<tr><td>|</td><td>Vertical line</td><td>2</td></tr>
<tr><td>||</td><td>Double vertical line</td><td>2</td></tr>
<tr><td>^</td><td>Vertical span</td><td>2</td></tr>
<tr><td>\^</td><td>Vertical span</td><td>3</td></tr>
<tr><td>=</td><td>Double horizontal line</td><td>2,3</td></tr>
<tr><td>_</td><td>Horizontal line</td><td>2,3</td></tr>
<tr><td>_</td><td>Short horizontal line</td><td>3</td></tr>
<tr><td>\Rx</td><td>Repeat character</td><td>3</td></tr>
</table>