

An environment for multicolumn output^{*†}

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Abstract

This article describes the use and the implementation of the `multicols` environment. This environment allows switching between one and multicolumn format on the same page. Footnotes are handled correctly (for the most part), but will be placed at the bottom of the page and not under each column. L^AT_EX's oat mechanism, however, is partly disabled in the current implementation. At the moment only page-wide oats (i.e., star-forms) can be used within the scope of the environment.

Preface to version 1.5 + 1.6

The 1.5 release contains two major changes: `multicols` will now support up to 10 columns and two more tuning possibilities have been added to the balancing routine. The balancing routine

now checks the badness of the resulting columns and rejects solutions that are larger than a certain threshold. At the same time `multicols` has been upgraded to run under L^AT_EX 2_ε.

Later changes to 1.5 include `\columnbreak` and `multicols*`.

For version 1.6 micro-spacing around the boxes produced by `multicols` has been improved to allow for baseline-grid typesetting.

1 Introduction

Switching between two column and one column layout is possible in L^AT_EX, but every use of `\twocolumn` or `\onecolumn` starts a new page. Moreover, the last page of two column output isn't balanced and this often results in an empty, or nearly empty, right column. When I started to write macros for `doc.sty` (see "The `doc-Option`", *TUGboat* volume

10 #2, pp. 245–273) I thought that it would be nice to place the index on the same page as the bibliography. And balancing the last page would not only look better, it also would save space; provided of course that it is also possible to start the next article on the same page. Rewriting the index environment was comparatively easy, but the next goal, designing an environ-

ment which takes care of footnotes, oats etc., was a harder task. It took me a whole weekend¹ to get together the few lines of code below and there is still a good chance that I missed something after all.

Try it and, hopefully, enjoy it; and *please* direct bug reports and suggestions back to Mainz.

^{*}This file has version number v1.6g, last revised 2006/02/23.

[†]Note: This package is released under terms which affect its use in commercial applications. Please see the details at the top of the source file.

¹I started with the algorithm given in the T_EXbook on page 417. Without this help a weekend would not have been enough. (This remark was made in the documentation of the initial release, since then several hundreds more hours went into it improving the original code.)

2 The User Interface

To use the environment one simply says

```
\begin{multicols}{\langle number \rangle}
  \langle multicolumn text \rangle
\end{multicols}
```

where $\langle number \rangle$ is the required number of columns and $\langle multicolumn text \rangle$ may contain arbitrary L^AT_EX commands, except that `oats` and `marginpars` are not allowed in the current implementation².

As its first action, the `multicols` environment measures the current page to determine whether there is enough room for some portion of multicolumn output. This is controlled by the $\langle dimen \rangle$ variable `\premulticols` which can be changed by the user with ordinary L^AT_EX commands. If the space is less than `\premulticols`, a new page is started. Otherwise, a `\vskip` of `\multicolsep` is added.³

When the end of the `multicols` environment is encountered, an analogous mechanism is employed, but now we test whether there is a space larger than `\postmulticols` available. Again we add `\multicolsep` or start a new page.

It is often convenient to spread some text over all columns, just before the multicolumn output, without any page break in between. To achieve this the `multicols` environment has an optional second argument which can be used for this purpose. For example, the text you are now reading was started with

```
\begin{multicols}{3}
[\section{The User
```

```
Interface}] ...
```

If such text is unusually long (or short) the value of `\premulticols` might need adjusting to prevent a bad page break. We therefore provide a third argument which can be used to overwrite the default value of `\premulticols` just for this occasion. So if you want to combine some longer single column text with a `multicols` environment you could write

```
\begin{multicols}{3}
[\section{Index}
  This index contains ...]
[6cm]
...
```

The space between columns is controlled by the length parameter `\columnsep`. The width for the individual columns is automatically calculated from this parameter and the current `\linewidth`. In this article a value of 18.0pt was used.

Separation of columns with vertical rules is achieved by setting the parameter `\columnseprule` to some positive value. In this article a value of .4pt was used.

Since narrow columns tend to need adjustments in interline spacing we also provide a $\langle skip \rangle$ parameter called `\multicolbaselineskip` which is added to the `\baselineskip` parameter inside the `multicols` environment. Please use this parameter with care or leave it alone; it is intended only for package file designers since even

small changes might produce totally unexpected changes to your document.

2.1 Balancing columns

Besides the previously mentioned parameters, some others are provided to influence the layout of the columns generated.

Paragraphing in T_EX is controlled by several parameters. One of the most important is called `\tolerance`: this controls the allowed ‘looseness’ (i.e. the amount of blank space between words). Its default value is 200 (the L^AT_EX `\fussy`) which is too small for narrow columns. On the other hand the `\sloppy` declaration (which sets `\tolerance` to 10000 = ∞) is too large, allowing really bad spacing.⁴

We therefore use a `\multicoltolerance` parameter for the `\tolerance` value inside the `multicols` environment. Its default value is 9999 which is less than infinity but ‘bad’ enough for most paragraphs in a multicolumn environment. Changing its value should be done outside the `multicols` environment. Since `\tolerance` is set to `\multicoltolerance` at the beginning of every `multicols` environment one can locally overwrite this default by assigning `\tolerance_{}=\langle desired value \rangle`. There also exists a `\multicolpretolerance` parameter holding the value for `\pretolerance` within a `multicols` environment. Both parameters are usually used only by package designers.

²This is dictated by lack of time. To implement `oats` one has to reimplement the whole L^AT_EX output routine.

³Actually the added space may be less because we use `\addvspace` (see the L^AT_EX manual for further information about this command).

⁴Look at the next paragraph, it was set with the `\sloppy` declaration.

Generation of multicolumn output can be divided into two parts. In the first part we are collecting material for a page, shipping it out, collecting material for the next page, and so on. As a second step, balancing will be done when the end of the `multicols` environment is reached. In the first step \TeX might consider more material whilst finding the final columns than it actually use when shipping out the page. This might cause a problem if a footnote is encountered in the part of the input considered, but not used, on the current page. In this case the footnote might show up on the current page, while the `footnotemark` corresponding to this footnote might be set on the next one.⁵ Therefore the `multicols` environment gives a warning message⁶ whenever it is unable to use all the material considered so far.

If you don't use footnotes too often the chances of something actually going wrong are very slim, but if this happens you can help \TeX by using a `\pagebreak` command in the final document. Another way to influence the behavior of \TeX in this respect is given by the counter variable 'collectmore'. If you use the `\setcounter` declaration to set this counter to $\langle number \rangle$, \TeX will consider $\langle number \rangle$ more (or less) lines before making its final decision. So a value of -1 may solve all your problems at the cost of slightly less optimal columns.

In the second step (balancing columns) we have other bells and whistles. First of all you can say `\raggedcolumns` if you don't want the bottom lines to be aligned. The default is

`\flushcolumns`, so \TeX will normally try to make both the top and bottom baselines of all columns align.

Additionally you can set another counter, the 'unbalance' counter, to some positive $\langle number \rangle$. This will make all but the right-most column $\langle number \rangle$ of lines longer than they would normally have been. 'Lines' in this context refer to normal text lines (i.e. one `\baselineskip` apart); thus, if your columns contain displays, for example, you may need a higher $\langle number \rangle$ to shift something from one column into another.

Unlike 'collectmore,' the 'unbalance' counter is reset to zero at the end of the environment so it only applies to one `multicols` environment.

The two methods may be combined but I suggest using these features only when fine tuning important publications.

Two more general tuning possibilities were added with version 1.5. \TeX allows to measure the badness of a column in terms of an integer value, where 0 means optimal and any higher value means a certain amount of extra white space. 10000 is considered to be infinitely bad (\TeX does not distinguish any further). In addition the special value 100000 means overfull (i.e., the column contains more text than could possibly fit into it).

The new release now measures every generated column and ignores solutions where at least one column has a badness being larger than the value of the counter `columnbadness`. The default value for this counter is 10000, thus \TeX will accept all solutions except those being overfull. By setting the counter to a smaller value you can force the algorithm to search for solutions that do not have columns with a

⁵The reason behind this behavior is the asynchronous character of the \TeX *page_builder*. However, this could be avoided by defining very complicated output routines which don't use \TeX primitives like `\insert` but do everything by hand. This is clearly beyond the scope of a weekend problem.

⁶This message will be generated even if there are no footnotes in this part of the text.

lot of white space.

However, if the setting is too low, the algorithm may not find any acceptable solution at all and will then finally choose the extreme solution of placing all text into the first column.

Often, when columns are balanced, it is impossible to find a solution that distributes the text evenly over all columns. If that is the case the last column usually has less text than the others. In the earlier releases this text was stretched to produce a column with the same height as all others, sometimes resulting in really ugly looking columns.

In the new release this stretching is only done if the badness of the final column is not larger than the value of the counter `finalcolumnbadness`. The default setting is 9999, thus preventing the stretching for all columns that \TeX would consider infinitely bad. In that case the final column is allowed to run short which gives a much better result.

And there are two more parameters of some experimental nature, one called `\multicolovershoot` the other `\multicolundershoot`. They control the amount of space a column is allowed to be “too full” or “too short” without affecting the column badness. They are set to 0pt and 2pt, respectively.

2.2 Not balancing the columns

Although this package was written to solve the problem of balancing columns, I got repeated requests to provide a version where all white space is automatically placed in the last column or columns. Since version v1.5q this now exists: if you use `multicols*` instead of the usual environment the columns on the last page are not balanced.

Of course, this environment only works on top-level, e.g., inside a box one has to balance to determine a column height in absence of a fixed value.

2.3 Manually breaking columns

Another request often voiced was: “How to I tell \LaTeX that it should break the first column after this particular line?”. The `\pagebreak` command (which works with the two-column option of \LaTeX) is of no use here since it would end the collection phase of `multicols` and thus all columns on that page. So with version 1.5u the `\columnbreak` command was added. If used within a paragraph it marks the end of the current line as the desired breakpoint. You can observe its effect on the previous page where three lines of text have been artificially forced into the second column (resulting in some white space between paragraphs in the first column).

2.4 Floats inside a multicols environment

Within the `multicols` environment the usual star oat commands are available but their function is somewhat different as in the two-column mode of standard \LaTeX . Stared oats, e.g., `figure*`, denote page wide oats that are handled in a similar fashion as normal oats outside the `multicols` environment. However, they will never show up on the page where they are encountered. In other words, one can influence their placement by specifying a combination of `t`, `b`, and/or `p` in their optional argument, but `h` doesn’t work because the first possible place is the top of the next page. One should also note,

that this means that their placement behavior is determined by the values of `\topfraction`, etc. rather than by `\dbl...`

2.5 Warnings

Under certain circumstances the use of the `multicols` environment may result in some warnings from \TeX or \LaTeX . Here is a list of the important ones and the possible cause:

Underfull \hbox (badness ...)

As the columns are often very narrow \TeX wasn’t able to find a good way to break the paragraph. Underfull denotes a loose line but as long the badness value is below 10000 the result is probably acceptable.

Underfull \vbox ... while \output is active

If a column contains an character with an unusual depth, for example a ‘(’, in the bottom line then this message may show up. It usually has no significance as long as the value is not more than a few points.

LaTeX Warning: I moved some lines to the next page

As mentioned above, `multicols` sometimes screws up the footnote numbering. As a precaution, whenever there is a footnote on a page that where `multicols` had to leave a remainder for the following page this warning appears. Check the footnote numbering on this page. If it turns out that it is wrong you have to manually break the page using `\newpage` or `\pagebreak[...]`.

Floats and marginpars not allowed inside ‘multicols’ environment!

This message appears if you try to use the `\marginpar` command or an unstared version of the figure or table environment. Such oats will disappear!

Very deep columns! Grid alignment might be broken

This message can only appear if the option `grid` was chosen. In that case it will show up if a column has a very large depth so that `multicols` is unable to back up to its baseline. This is only relevant if one tries to produce a document where all text lines are aligned at an invisible grid, something that requires careful adjustment of many parameters and macros, e.g., heading definitions.

2.6 Tracing the output

To understand the reasoning behind the decisions `TeX` makes

when processing a `multicols` environment, a tracing mechanism is provided. If you set the counter ‘`tracingmulticols`’ to a positive $\langle number \rangle$ you then will get some tracing information on the terminal and in the transcript file:

$\langle number \rangle = 1$. `TeX` will now tell you, whenever it enters or leaves a `multicols` environment, the number of columns it is working on and its decision about starting a new page before or after the environment.

$\langle number \rangle = 2$. In this case you also get information from the balancing routine: the heights tried for the left and right-most columns, information about shrinking if the `\raggedcolumns` declaration is in force and the value of the ‘`unbalance`’ counter if positive.

$\langle number \rangle = 3$. Setting

$\langle number \rangle$ to this value will additionally trace the mark handling algorithm. It will show what marks are found, what marks are considered, etc. To fully understand this information you will probably have to read carefully through the implementation.

$\langle number \rangle \geq 4$. Setting $\langle number \rangle$ to such a high value will additionally place an `\hrule` into your output, separating the part of text which had already been considered on the previous page from the rest. Clearly this setting should *not* be used for the final output. It will also activate even more debugging code for mark handling.

3 Prefaces to older versions

3.1 Preface to version 1.4

Beside fixing some bugs as mentioned in the `multicol.bug` file this new release enhances the `multicols` environment by allowing for balancing in arbitrary contexts. It is now, for example, possible to balance text within a `multicols` or a `minipage` as shown in 2 where a `multicols` environment within a `quote` environment was used. It is now even possible to nest `multicols` environments.

The only restriction to such inner `multicols` environments (nested, or within `TeX`’s internal vertical mode) is that such vari-

ants will produce a box with the balanced material in it, so that they can not be broken across pages or columns.

Additionally I rewrote the algorithm for balancing so that it will now produce slightly better results.

I updated the source documentation but like to apologize in advance for some ‘left over’ parts that slipped through the revision.

A note to people who like to improve the balancing algorithm of `multicols`: The balancing routine is now placed into

a single macro which is called `\balance@columns`. This means that one can easily try different balancing routines by rewriting this macro. The interface for it is explained in table 1. There are several improvements possible, one can think of integrating the `\badness` function of `TeX3`, define a faster algorithm for finding the right column height, etc. If somebody thinks he/she has an enhancement I would be pleased to learn about it. But please obey the copyright notice and don’t change `multicol.dtx` directly!

3.2 Preface to version 1.2

After the article about the `multicols` environment was published in *TUGboat* 10#3, I got numer-

ous requests for these macros. However, I also got a changed version of my style file, together

with a letter asking me if I would include the changes to get better paragraphing results in the case

The macro `\balance@columns` that contains the code for balancing gathered material is a macro without parameters. It assumes that the material for balancing is stored in the box `\mult@box` which is a `\vbox`. It also “knows” about all parameters set up by the `multicols` environment, like `\col@number`, etc. It can also assume that `\@colroom` is the still available space on the current page.

When it finishes it must return the individual columns in boxes suitable for further processing with `\page@sofar`. This means that the left column should be stored in box reg-

ister `\mult@gfirstbox`, the next in register `\mult@firstbox + 2, \dots`, only the last one as an exception in register `\mult@grightbox`. Furthermore it has to set up two the macros `\kept@firstmark` and `\kept@botmark` to hold the values for the first and bottom mark as found in the individual columns. There are some helper functions defined in section 5.1 which may be used for this. Getting the marks right “by hand” is non-trivial and it may pay off to first take a look at the documentation and implementation of `\balance@columns` below before trying anew.

Table 1: Interface description for `\balance@columns`

of narrow lines. The main differences to my original style option were additional parameters (like `\multicoladjdemerits` to be used for `\adjdemerits`, etc.) which would influence the line breaking algorithm.

But actually resetting such parameters to zero or even worse to a negative value won’t give better line breaks inside the `multicols` environment. \TeX ’s line breaking algorithm will only look at those possible line breaks which can be reached without a badness higher than the current value of `\tolerance` (or `\pretolerance` in the first pass). If this isn’t possible, then, as a last resort, \TeX will produce overfull boxes. All those (and only those) possible break points will be considered and finally the sequence which results in the fewest demerits will be chosen. This means that a value of -1000 for `\adjdemerits` instructs \TeX to prefer visibly in-

compatible lines instead of producing better line breaks.

However, with \TeX 3.0 it is possible to get decent line breaks even in small columns by setting `\emergencystretch` to an appropriate value. I implemented a version which is capable of running both in the old and the new \TeX (actually it will simply ignore the new feature if it is not available). The calculation of `\emergencystretch` is probably incorrect. I made a few tests but of course one has have much more experience with the new possibilities to achieve the maximum quality.

Version 1.1a had a nice ‘feature’: the penalty for using the forbidden oats was their ultimate removal from \LaTeX ’s `\@freelist` so that after a few `\marginpars` inside the `multicols` environment oats were disabled forever. (Thanks to Chris Rowley for pointing this out.) I

removed this misbehaviour and at the same time decided to allow at least oats spanning all columns, e.g., generated by the `figure*` environment. You can see the new functionality in table 2 which was inserted at this very point. However single column oats are still forbidden and I don’t think I will have time to tackle this problem in the near future. As an advice for all who want to try: wait for \TeX 3.0. It has a few features which will make life much easier in multi-column surroundings. Nevertheless we are working here at the edge of \TeX ’s capabilities, really perfect solutions would need a different approach than it was done in \TeX ’s page builder.

The text below is nearly unchanged, I only added documentation at places where new code was added.

`\setemergencystretch`: This is a hook for people who like to play around. It is supposed to set the `\emergencystretch` *<dimen>* register provided in the new T_EX 3.0. The first argument is the number of columns and the second one is the current `\hsize`. At the moment the default definition is

`4pt × #1`, i.e. the `\hsize` isn't used at all. But maybe there are better formulae.

`\set@floatcmds`: This is the hook for the experts who like to implement a full oat mechanism for the `multicols` environment. The `@` in the name should signal that this might not be easy.

Table 2: The new commands of `multicol.sty` version 1.2. Both commands might be removed if good solutions to these open problems are found. I hope that these commands will prevent that nearly identical style files derived from this one are oating around.

4 The Implementation

We are now switching to two-column output to show the abilities of this environment (and bad layout decisions).

4.1 The documentation driver file

The next bit of code contains the documentation driver file for T_EX, i.e., the file that will produce the documentation you are currently reading. It will be extracted from this file by the `docstrip` program. Since this is the first code in this file one can produce the documentation simply by running L^AT_EX on the `.dtx` file.

```
1 <*driver>
2 \documentclass{ltxdoc}
```

We use the `balancingshow` option when loading `multicols` so that full tracing is produced. This has to be done before the `doc` package is loaded, since `doc` otherwise requires `multicols` without any options.

```
3 \usepackage{multicol}[1999/05/25]
4 \usepackage{doc}
```

First we set up the page layout suitable for this article.

```
5 \setlength{\textwidth}{39pc}
6 \setlength{\textheight}{54pc}
7 \setlength{\parindent}{1em}
8 \setlength{\parskip}{0pt plus 1pt}
9 \setlength{\oddsidemargin}{0pc}
10 \setlength{\marginparwidth}{0pc}
11 \setlength{\topmargin}{-2.5pc}
12 \setlength{\headsep}{20pt}
13 \setlength{\columnsep}{1.5pc}
```

We want a rule between columns.

```
14 \setlength{\columnseprule}{.4pt}
```

We also want to ensure that a new `multicols` environment finds enough space at the bottom of the

page.

```
15 \setlength{\premulticols}{6\baselineskip}
```

When balancing columns we disregard solutions that are too bad. Also, if the last column is too bad we typeset it without stretch.

```
16 \setcounter{columnbadness}{7000}
17 \setcounter{finalcolumnbadness}{7000}
```

The index is supposed to come out in four columns. And we don't show macro names in the margin.

```
18 \setcounter{IndexColumns}{4}
19 \let\DescribeMacro\SpecialUsageIndex
20 \let\DescribeEnv\SpecialEnvIndex
21 \renewcommand\PrintMacroName[1]{ }
22 \CodelineIndex
23 %\DisableCrossrefs           % Partial index
24 \RecordChanges               % Change log
```

Line numbers are very small for this article.

```
25 \renewcommand{\theCodelineNo}
26 { \scriptsize\rm\arabic{CodelineNo}}
27 \settowidth\MacroIndent{\scriptsize\rm 00\ }
28
29 \begin{document}
30 \typeout
31 {*****}
32 ^^J* Expect some Under- and overfull boxes.
33 ^^J*****}
34 \DocInput{multicol.dtx}
35 \end{document}
36 </driver>
```


4.2 Identification and option processing

We start by identifying the package. Since it makes use of features only available in L^AT_EX 2_ε we ensure that this format is available. (Now this is done earlier in the file.)

```
37 <*package>
38 % \NeedsTeXFormat{LaTeX2e}
39 % \ProvidesPackage{multicol}[.../.../...
40 % v... multicol formatting]
```

Next we declare options supported by multicol. Twocolumn mode and multicol do not work together so we warn about possible problems. However, since you can revert to \onecolumn in which case multicol does work, we don't make this an error.

```
41 \DeclareOption{twocolumn}
42   {\PackageWarning{multicol}{May not work
43    with the twocolumn option}}
```

Tracing is done using a counter. However it is also possible to invoke the tracing using the options de-

clared below.

```
44 \newcount\c@tracingmulticols
45 \DeclareOption{errorshow}
46   {\c@tracingmulticols\z@}
47 \DeclareOption{infoshow}
48   {\c@tracingmulticols\@ne}
49 \DeclareOption{balancingshow}
50   {\c@tracingmulticols\tw@}
51 \DeclareOption{markshow}
52   {\c@tracingmulticols\thr@@}
53 \DeclareOption{debugshow}
54   {\c@tracingmulticols\relax}
```

The next option is intended for typesetting on a \baselineskip grid. Right now it doesn't do anything other than warning if it thinks that the grid got lost.

```
55 \let\mc@gridwarn\maxdimen
56 \DeclareOption{grid}{\def\mc@gridwarn{\maxdepth}}
57 \ProcessOptions
```

4.3 Starting and Ending the multicol Environment

As mentioned before, the multicol environment has one mandatory argument (the number of columns) and up to two optional ones. We start by reading the number of columns into the \col@number register.

```
58 \def\multicols#1{\col@number#1\relax}
```

If the user forgot the argument, T_EX will complain about a missing number at this point. The error recovery mechanism will then use zero, which isn't a good choice in this case. So we should now test whether everything is okay. The minimum is two columns at the moment.

```
59 \ifnum\col@number<\tw@
60   \PackageWarning{multicol}%
61     {Using '\number\col@number'
62      columns doesn't seem a good idea.^^J
63      I therefore use two columns instead}%
64   \col@number\tw@ \fi
```

We have only enough box registers for ten columns, so we need to check that the user hasn't asked for more.

```
65 \ifnum\col@number>10
66   \PackageError{multicol}%
67     {Too many columns}%
68     {Current implementation doesn't
69      support more than 10 columns.%
70      \MessageBreak
71      I therefore use 10 columns instead}%
72   \col@number10 \fi
```

Within the environment we need a special version of the kernel \@footnotetext command since the original sets the \hsize to \columnwidth which is not correct in the multicol environment. Here \columnwidth refers to the width of the individual column and the footnote should be in \textwidth. Since \@footnotetext has a different definition inside a minipage environment we do not redefine it directly. Instead we locally set \columnwidth to \textwidth and call the original (current) definition stored in \orig@footnotetext. If the multicol environment is nested inside another multicol environment then the redefinition has already happened. So be better test for this situation. Otherwise, we will get a T_EX stack overflow as this would generate a self-referencing definition. .

```
73 \ifx\@footnotetext\mult@footnotetext\else
74   \let\orig@footnotetext\@footnotetext
75   \let\@footnotetext\mult@footnotetext
76 \fi
```

Now we can safely look for the optional arguments.

```
77 \@ifnextchar[\mult@cols{\mult@cols[]}]
```

```
78 \long\def\mult@footnotetext#1{\begingroup
79   \columnwidth\textwidth
80   \orig@footnotetext{#1}\endgroup}
```

The \mult@cols macro grabs the first optional argument (if any) and looks for the second one.


```
81 \def\mult@cols[#1]{\@ifnextchar[%
```

This argument should be a $\langle dimen \rangle$ denoting the minimum free space needed on the current page to start the environment. If the user didn't supply one, we use `\premulticols` as a default.

```
82 {\mult@cols{#1}}%
83 {\mult@cols{#1}[\premulticols]}}
```

After removing all arguments from the input we are able to start with `\mult@cols`.

```
84 \def\mult@cols#1[#2]{%
```

First thing we do is to decide whether or not this is an unbounded multicols environment, i.e. one that may split across pages, or one that has to be typeset into a box. If we are in \TeX 's "inner" mode (e.g., inside a box already) then we have a boxed version of multicols therefore we set the `@boxedmulticols` switch to true. The multicols should start in vertical mode. If we are not already there we now force it with `\par` since otherwise the test for "inner" mode wouldn't show if we are in a box.

```
85 \par
86 \ifinner \@boxedmulticolstrue
```

Otherwise we check `\doublecol@number`. This counter is zero outside a multicols environment but positive inside (this happens a little later on). In the second case we need to process the current multicols also in "boxed mode" and so change the switch accordingly.

```
87 \else
88 \ifnum \doublecol@number>\z@
89 \@boxedmulticolstrue
90 \fi
91 \fi
```

Then we look to see if statistics are requested:

```
92 \mult@info\z@
93 {Starting environment with
94 \the\col@number\space columns%
```

In boxed mode we add some more info.

```
95 \if@boxedmulticols\MessageBreak
96 (boxed mode)\fi
97 }%
```

Then we measure the current page to see whether a useful portion of the multicolumn environment can be typeset. This routine might start a new page.

```
98 \enough@room{#2}%
```

Now we output the first argument and produce vertical space above the columns. (Note that this argument corresponds to the first optional argument of the multicols environment.) For many releases this argument was typeset in a group to get a similar effect as `\twocolumn[...]` where the argument

is also implicitly surrounded by braces. However, this conflicts with local changes done by things like sectioning commands (which account for the majority of commands used in that argument) messing up vertical spacing etc. later in the document so that from version v1.5q on this argument is again typeset at the outer level.

```
99 #1\par\addvspace\multicolsep
```

When the last line of a paragraph had a positive depth then this depth normally taken into account by the `baselineskip` calculation for the next line. However, the columns produced by a following `multicol` are rigid and thus the distance from the baseline of a previous text line to the first line in a `multicol` would differ depending on the depth of the previous line. To account for this we add a negative space unless the depth is `-1000pt` which signals something special to \TeX and is not supposed to be a real depth.

```
100 \ifdim \prevdepth = -\@m\p@
101 \else
```

The actual generation of this corrective space is a little bit more complicated as it doesn't make sense to always back up to the previous baseline (in case an object with a very large depth was placed there, e.g., a centered tabular). So we only back up to the extent that we are within the `\baselineskip` grid. We know that the box produced by multicols has `\topskip` at its top so that also needs to be taken into account.

```
102 \@tempcnta\prevdepth
103 \@tempcntb\baselineskip
104 \divide\@tempcnta\@tempcntb
105 \advance\@tempcnta\@ne
106 \dimen@\prevdepth
107 \advance\dimen@ -\@tempcnta\baselineskip
108 \advance\dimen@ \topskip
109 \kern-\dimen@
110 \fi
```

We start a new grouping level to hide all subsequent changes (done in `\prepare@multicols` for example).

```
111 \begingroup
112 \prepare@multicols
```

If we are in boxed mode we now open a box to typeset all material from the multicols body into it, otherwise we simply go ahead.

```
113 \if@boxedmulticols
114 \setbox\mult@box\vbox\bgroup
```

We may have to reset some parameters at this point, perhaps `\parboxrestore` would be the right action but I leave it for the moment.

```
115 \fi
```

We finish by suppressing initial spaces.

```
116 \ignorespaces}
```

Here is the switch and the box for “boxed” multicols code.

```
117 \newif\if@boxedmulticols
118 \@boxedmulticolsfalse
119 \newbox\mult@box
```

The `\enough@room` macro used above isn’t perfect but works reasonably well in this context. We measure the free space on the current page by subtracting `\pagetotal` from `\pagegoal`. This isn’t entirely correct since it doesn’t take the ‘shrinking’ (i.e. `\pageshrink`) into account. The ‘recent contribution list’ might be nonempty so we start with `\par` and an explicit `\penalty`.⁷ Actually, we use `\addpenalty` to ensure that a following `\addvspace` will ‘see’ the vertical space that might be present. The use of `\addpenalty` will have the effect that all items from the recent contributions will be moved to the main vertical list and the `\pagetotal` value will be updated correctly. However, the penalty will be placed in front of any dangling glue item with the result that the main vertical list may already be overfull even if \TeX is not invoking the output routine.

```
120 \def\enough@room#1{%
```

Measuring makes only sense when we are not in “boxed mode” so the routine does nothing if the switch is true.

```
121 \if@boxedmulticols\else
122 \par
```

To empty the contribution list the first release contained a penalty zero but this had the result that `\addvspace` couldn’t detect preceding glue. So this was changed to `\addpenalty`. But this turned out to be not enough as `\addpenalty` will not add a penalty when `@nobreak` is true. Therefore we force this switch locally to false. As a result there may be a break between preceding text and the start of a multicols environment, but this seems acceptable since there is the optional argument for exactly this reason.

```
123 \bgroup\@nobreakfalse\addpenalty\z@\egroup
124 \page@free \pagegoal
125 \advance \page@free -\pagetotal
```

To be able to output the value we need to assign it to a register first since it might be a register (default) in which case we need to use `\the` or it might be a plain value in which case `\the` would be wrong.

```
126 \@tempskipa#1\relax
```

Now we test whether tracing information is required:

```
127 \mult@info\z@
128 {Current page:\MessageBreak
129 height=%
130 \the\pagegoal: used \the\pagetotal
131 \space -> free=\the\page@free
132 \MessageBreak
133 needed \the\@tempskipa
134 \space(for #1)}%
```

Our last action is to force a page break if there isn’t enough room left.

```
135 \ifdim \page@free <#1\newpage \fi
136 \fi}
```

When preparing for multicolumn output several things must be done.

```
137 \def\prepare@multicols{%
```

We start saving the current `\@totalleftmargin` and then resetting the `\parshape` in case we are inside some list environment. The correct indentation for the multicols environment in such a case will be produced by moving the result to the right by `\multicol@leftmargin` later on. If we would use the value of `\@totalleftmargin` directly then lists inside the multicols environment could cause a shift of the output.

```
138 \multicol@leftmargin\@totalleftmargin
139 \@totalleftmargin\z@
140 \parshape\z@
```

We also set the register `\doublecol@number` for later use. This register should contain $2 \times \text{col@number}$. This is also an indicator that we are within a multicols environment as mentioned above.

```
141 \doublecol@number\col@number
142 \multiply\doublecol@number\tw@
143 \advance\doublecol@number\mult@rightbox
144 \if@boxedmulticols
145 \let\l@kept@firstmark\kept@firstmark
146 \let\l@kept@botmark\kept@botmark
147 \global\let\kept@firstmark\@empty
148 \global\let\kept@botmark\@empty
149 \else
```

We add an empty box to the main vertical list to ensure that we catch any insertions (held over or inserted at the top of the page). Otherwise it might happen that the `\eject` is discarded without calling the output routine. Inside the output routine we remove this box again. Again this code applies only if we are on the main vertical list and not within a box. However, it is not enough to turn off interline spacing, we also have to clear `\topskip` before

⁷See the documentation of `\endmulticols` for further details.

adding this box, since `\topskip` is always inserted before the first box on a page which would leave us with an extra space of `\topskip` if `\multicols` start on a fresh sheet.

```
150 \nointerlineskip {\topskip\z@null}%
151 \output{%
152   \global\setbox\partial@page\vbox
153   {%
```

Now we have to make sure that we catch one special situation which may result in loss of text! If the user has a huge amount of vertical material within the first optional argument that is larger than `\premulticols` and we are near the bottom of the page then it can happen that not the `\eject` is triggering this special output routine but rather the overfull main vertical list. In that case we get another breakpoint through the `\eject` penalty. As a result this special output routine would be called twice and the contents of `\partial@page`, i.e. the material before the `\multicols` environment gets lost. There are several solutions to avoid this problem, but for now we will simply detect this and inform the user that he/she has to enlarge the `\premulticols` by using a suitable value for the second argument.

```
154 <*check>
155   \ifvoid\partial@page\else
156     \PackageError{multicol}%
157     {Error saving partial page}%
158     {The part of the page before
159      the multicols environment was
160      nearly full with^^Jthe result
161      that starting the environment
162      will produce an overfull
163      page. Some^^Jtext may be lost!
164      Please increase \premulticols
165      either generally or for this%
166      ^^Jenvironment by specifying a
167      suitable value in the second
168      optional argument to^^Jthe
169      multicols environment.}
170   \unvbox\partial@page
171   \box\last@line
172   \fi
173 </check>
174   \unvbox\@cclv
175   \global\setbox\last@line\lastbox
176   }%
```

Finally we need to record the marks that are present within the `\partial@page` so that we can construct correct first and bottom marks later on. This is done by the following code.

```
177   \prep@keptmarks
```

Finally we have to initialize `\kept@topmark` which should ideally be initialized with the mark that is

current on “top” of this page. Unfortunately we can’t use `\topmark` because this register will not always contain what its name promises because \LaTeX sometimes calls the output routine for oat management.⁸ Therefore we use the second best solution by initializing it with `\firstmark`. In fact, for our purpose this doesn’t matter as we use `\kept@topmark` only to initialize `\firstmark` and `\botmark` of a following page if we don’t find any marks on the current one.

```
178   \global\let\kept@topmark\firstmark
179   }\eject
```

The next thing to do is to assign a new value to `\vsize`. \LaTeX maintains the free room on the page (i.e. the page height without the space for already contributed oats) in the register `\@colroom`. We must subtract the height of `\partial@page` to put the actual free room into this variable.

```
180   \advance\@colroom-\ht\partial@page
```

Then we have to calculate the `\vsize` value to use during column assembly. `\set@mult@vsize` takes an argument which allows to make the setting local (`\relax`) or global (`\global`). The latter variant is used inside the output routine below. At this point here we have to make a local change to `\vsize` because we want to get the original value for `\vsize` restored in case this `\multicols` environment ends on the same page where it has started.

```
181   \set@mult@vsize\relax
```

Now we switch to a new `\output` routine which will be used to put the gathered column material together.

```
182   \output{\multi@column@out}%
```

Finally we handle the footnote insertions. We have to multiply the magnification factor and the extra skip by the number of columns since each footnote reduces the space for every column (remember that we have pagewide footnotes). If, on the other hand, footnotes are typeset at the very end of the document, our scheme still works since `\count\footins` is zero then, so it will not change. To allow even further customization the setting of the `\footins` parameters is done in a separate macro.

```
183   \init@mult@footins
```

For the same reason (pagewide footnotes), the `<dimen>` register controlling the maximum space used for footnotes isn’t changed. Having done this, we must reinsert all the footnotes which are already present (i.e. those encountered when the material saved in `\partial@page` was first processed). This will reduce the free space (i.e. `\pagetotal`) by the

⁸During such a call the `\botmark` gets globally copied to `\topmark` by the \TeX program.

appropriate amount since we have changed the magnification factor, etc. above.

```
184 \reinsert@footnotes
```

All the code above was only necessary for the unrestricted multicols version, i.e. the one that allows page breaks. If we are within a box there is no point in setting up special output routines or `\vsize`, etc.

```
185 \fi
```

But now we are coming to code that is necessary in all cases. We assign new values to `\vbadness`, `\hbadness` and `\tolerance` since it's rather hard for \TeX to produce 'good' paragraphs within narrow columns.

```
186 \vbadness\@Mi \hbadness5000
```

```
187 \tolerance\multicoltolerance
```

Since nearly always the first pass will fail we ignore it completely telling \TeX to hyphenate directly. In fact, we now use another register to keep the value for the multicol pre-tolerance, so that a designer may allow to use `\pretolerance`.

```
188 \pretolerance\multicolpretolerance
```

For use with the new \TeX we set `\emergencystretch` to `\col@number × 4pt`. However this is only a guess so at the moment this is done in a macro `\setemergencystretch` which gets the current `\hsize` and the number of columns as arguments. Therefore users are able to figure out their own formula.

```
189 \setemergencystretch\col@number\hsize
```

Another hook to allow people adding their own extensions without making a new package is `\set@floatcmds` which handles any redefinitions of \LaTeX 's internal float commands to work with the multicols environment. At the moment it is only used to redefine `\@dblfloat` and `\end@dblfloat`.

```
190 \set@floatcmds
```

Additionally, we advance `\baselineskip` by `\multicolbaselineskip` to allow corrections for narrow columns.

```
191 \advance\baselineskip\multicolbaselineskip
```

The `\hsize` of the columns is given by the formula:

$$\frac{\text{\linewidth} - (\text{\col@number} - 1) \times \text{\columnsep}}{\text{\col@number}}$$

The formula above has changed from release to release. We now start with the current value of

`\linewidth` so that the column width is properly calculated when we are inside a minipage or a list or some other environment. This will be achieved with:

```
192 \hsize\linewidth \advance\hsize\columnsep
```

```
193 \advance\hsize-\col@number\columnsep
```

```
194 \divide\hsize\col@number
```

We also set `\linewidth` and `\columnwidth` to `\hsize`. In the past `\columnwidth` was left unchanged. This is inconsistent, but `\columnwidth` is used only by oats (which aren't allowed in their current implementation) and by the `\footnote` macro. Since we want pagewide footnotes⁹ this simple trick saved us from rewriting the `\footnote` macros. However, some applications referred to `\columnwidth` as the "width of the current column" to typeset displays (the `amsmath` package, for example) and to allow the use of such applications together with `multicol` this is now changed.

Before we change `\linewidth` to the new value we record its old value in some register called `\full@width`. This value is used later on when we package all columns together.

```
195 \full@width\linewidth
```

```
196 \linewidth\hsize
```

```
197 \columnwidth\hsize
```

```
198 }
```

This macro is used to set up the parameters associated with footnote oats. It can be redefined by applications that require different amount of spaces when typesetting footnotes.

```
199 \def\init@mult@footins{%
```

```
200 \multiply\count\footins\col@number
```

```
201 \multiply\skip\footins\col@number
```

```
202 }
```

Since we have to set `\col@number` columns on one page, each with a height of `\@colroom`, we have to assign `\vsize = \col@number × \@colroom` in order to collect enough material before entering the `\output` routine again. In fact we have to add another $(\text{\col@number} - 1) \times (\text{\baselineskip} - \text{\topskip})$ if you think about it.

```
203 \def\set@mult@vsize#1{%
```

```
204 \vsize\@colroom
```

```
205 \@tempdima\baselineskip
```

```
206 \advance\@tempdima-\topskip
```

```
207 \advance\vsize\@tempdima
```

```
208 \vsize\col@number\vsize
```

```
209 \advance\vsize-\@tempdima
```

⁹I'm not sure that I really want pagewide footnotes. But balancing of the last page can only be achieved with this approach or with a multi-path algorithm which is complicated and slow. But it's a challenge to everybody to prove me wrong! Another possibility is to reimplement a small part of the *fire_up* procedure in \TeX (the program). I think that this is the best solution if you are interested in complex page makeup, but it has the disadvantage that the resulting program cannot be called \TeX thereafter.

But this might not be enough since we use `\vsplit` later to extract the columns from the gathered material. Therefore we add some ‘extra lines,’ one for each column plus a corrective action depending on the value of the ‘collectmore’ counter. The final value is assigned globally if #1 is `\global` because we want to use this macro later inside the output routine too.

```
210 \advance\size\col@number\baselineskip
211 #1\advance\size
212 \c@collectmore\baselineskip}
```

Here is the `dimen` register we need for saving away the outer value of `\@totalleftmargin`.

```
213 \newdimen\multicol@leftmargin
```

When the end of the `multicols` environment is sensed we have to balance the gathered material. Depending on whether or not we are inside a boxed `multicol` different things must happen. But first we end the current paragraph with a `\par` command.

```
214 \def\endmulticols{\par
215 \if@boxedmulticols
```

In boxed mode we have to close the box in which we have gathered all material for the columns.

```
216 \egroup
```

Now we call `\balance@columns` the routine that balances material stored in the box `\mult@box`.

```
217 \balance@columns
```

After balancing the result has to be returned by the command `\page@sofar`. But before we do this we reinsert any marks found in box `\mult@box`.

```
218 \return@nonemptymark{first}%
219 \kept@firstmark
220 \return@nonemptymark{bot}%
221 \kept@botmark
222 \page@sofar
223 \global\let\kept@firstmark
224 \l@kept@firstmark
225 \global\let\kept@botmark
226 \l@kept@botmark
227 <*marktrace>
228 \mult@info\tw@
229 {Restore kept marks to\MessageBreak
230 first: \meaning\kept@firstmark
231 \MessageBreak bot\space\space:
232 \meaning\kept@botmark }%
233 </marktrace>
```

This finishes the code for the “boxed” case.

```
234 \else
```

If there was a `\columnbreak` on the very last line all material will have been moved to the `\colbreak@box`. Thus the the galley will be empty and no output routine gets called so that the text is lost. To avoid this problem (though unlikely) we check if the current galley is empty and the `\colbreak@box` contains text and if so return that to the galley. If the galley is non-empty any material in `\colbreak@box` is added in the output routine since it needs to be put in front.

```
235 <*colbreak>
236 \ifdim\pagegoal=\maxdimen
237 \ifvoid\colbreak@box\else
238 \mult@info\@ne{Re-adding forced
239 break(s) for splitting}%
240 \unvbox\colbreak@box\fi
241 \fi
242 </colbreak>
```

If we are in an unrestricted `multicols` environment we end the current paragraph above with `\par` but this isn’t sufficient since `TeX’s page_builder` will not totally empty the contribution list.¹⁰ Therefore we must also add an explicit `\penalty`. Now the contribution list will be emptied and, if its material doesn’t all fit onto the current page then the output routine will be called before we change it. At this point we need to use `\penalty` not `\addpenalty` to ensure that a) the recent contributions are emptied and b) that the very last item on the main vertical list is a valid break point so that `TeX` breaks the page in case it is overfull.

```
243 \penalty\z@
```

The processed material might consist of a last line with a decender in which case the `\prevdepth` will be non-zero. However, this material is getting reformatted now so that this value is likely to be wrong. We therefore normalize the situation by pretending that the depth is zero and arrange later that the box containing the assembled columns has in fact this property.

```
244 \prevdepth\z@
```

Now it’s safe to change the output routine in order to balance the columns.

```
245 \output{\balance@columns@out}\eject
```

If the `multicols` environment body was completely empty or if a multi-page `multicols` just ends at a page boundary we have the unusual case that the `\eject` will have no effect (since the main vertical list is empty)—thus no output routine is called at all. As a result the material preceding the `multicols`

¹⁰This once caused a puzzling bug where some of the material was balanced twice, resulting in some overprints. The reason was the `\eject` which was placed at the end of the contribution list. Then the `page_builder` was called (an explicit `\penalty` will empty the contribution list), but the line with the `\eject` didn’t fit onto the current page. It was then reconsidered after the output routine had ended, causing a second break after one line.

(stored in `\partial@page` will get lost if we don't take of this by hand.

```

246   \ifvbox\partial@page
247     \unvbox\partial@page\fi

After the output routine has acted we restore the
kept marks to their initial value.

248   \global\let\kept@firstmark\@empty
249   \global\let\kept@botmark\@empty
250   (*marktrace)
251   \mult@info\tw@
252     {Make kept marks empty}%
253   (/marktrace)
254   \fi

```

The output routine above will take care of the `\vsize` and reinsert the balanced columns, etc. But it can't reinsert the `\footnotes` because we first have to restore the `\footins` parameter since we are returning to one column mode. This will be done in the next line of code; we simply close the group started in `\multicols`.

To fix an obscure bug which is the result of the current definition of the `\begin ... \end` macros, we check that we are still (logically speaking) in the `multicols` environment. If, for example, we forget to close some environment inside the `multicols` environment, the following `\endgroup` would be incorrectly considered to be the closing of this environment.

```

255   \@checkend{multicols}%
256   \endgroup

```

We also set the 'unbalance' counter to its default. This is done globally since L^AT_EX counters are always changed this way.¹¹

```

257   \global\c@unbalance\z@

```

Now it's time to return any footnotes if we are in unrestricted mode:

```

258   \if@boxedmulticols\else
259     \reinsert@footnotes

```

We also take a look at the amount of free space on the current page to see if it's time for a page break. The vertical space added thereafter will vanish if `\enough@room` starts a new page.

But there is one catch. If the `\end{multicols}` is at the top of which can happen if there is a break point just before it (such as end ending environment) which was chosen. In that case we would do the next page using the internal `\vsize` for multicol collection which is a disaster. So we better catch this

case. Fortunately we can detect it by looking at `\pagegoal`.

```

260   \ifdim \pagegoal=\maxdimen
261     \global\vsize\colroom
262   \else
263     \enough@room\postmulticols
264   \fi
265   \fi
266   \addvspace\multicolsep

```

If statistics are required we finally report that we have finished everything.

```

267   \mult@info\z@
268     {Ending environment
269       \if@boxedmulticols
270         \space(boxed mode)\fi
271     }}

```

Let us end this section by allocating all the registers used so far.

```

272 \newcount\c@unbalance
273 \newcount\c@collectmore

```

In the new L^AT_EX release `\col@number` is already allocated by the kernel, so we don't allocate it again.

```

274 %\newcount\col@number
275 \newcount\doublecol@number
276 \newcount\multicoltolerance
277 \newcount\multicolpretolerance
278 \newdimen\full@width
279 \newdimen\page@free
280 \newdimen\premulticols
281 \newdimen\postmulticols
282 \newskip\multicolsep
283 \newskip\multicolbaselineskip
284 \newbox\partial@page
285 \newbox\last@line

```

And here are their default values:

```

286 \c@unbalance = 0
287 \c@collectmore = 0

```

To allow checking whether some macro is used within the `multicols` environment the counter `\col@number` gets a default of 1 outside the the environment.

```

288 \col@number = 1
289 \multicoltolerance = 9999
290 \multicolpretolerance = -1
291 \premulticols = 50pt
292 \postmulticols = 20pt
293 \multicolsep = 12pt plus 4pt minus 3pt
294 \multicolbaselineskip=0pt

```

¹¹Actually, we are still in a group started by the `\begin` macro, so `\global` must be used anyway.

4.4 The output routines

We first start with some simple macros. When typesetting the page we save the columns either in the box registers 0, 2, 4, ... (locally) or 1, 3, 5, ... (globally). This is PLAIN T_EX policy to avoid an overflow of the save stack.

Therefore we define a `\process@cols` macro to help us in using these registers in the output routines below. It has two arguments: the first one is a number; the second one is the processing information. It loops starting with `\count@=#1` (`\count@` is a scratch register defined in PLAIN T_EX), processes argument #2, adds two to `\count@`, processes argument #2 again, etc. until `\count@` is higher than `\doublecol@number`. It might be easier to understand it through an example, so we define it now and explain its usage afterwards.

```
295 \def\process@cols#1#2{\count@#1\relax
296   \loop
297   < *debug>
298   \typeout{Looking at box \the\count@}
299   < /debug>
300   #2%
301   \advance\count@\tw@
302   \ifnum\count@<\doublecol@number
303   \repeat}
```

We now define `\page@sofar` to give an example of the `\process@cols` macro. `\page@sofar` should output everything prepared by the balancing routine `\balance@columns`.

```
304 \def\page@sofar{%
```

`\balance@columns` prepares its output in the even numbered scratch box registers. Now we output the columns gathered assuming that they are saved in the box registers 2 (left column), 4 (second column), ... However, the last column (i.e. the rightmost) should be saved in box register 0.¹² First we ensure that the columns have equal width. We use `\process@cols` for this purpose, starting with `\count@ = \mult@rightbox`. Therefore `\count@` loops through `\mult@rightbox`, `\mult@rightbox + 2`, ... (to `\doublecol@number`).

```
305   \process@cols\mult@rightbox
```

We have to check if the box in question is void, because the operation `\wd<number>` on a void box will *not* change its dimension (sigh).

```
306   {\ifvoid\count@
307     \setbox\count@\hbox to\hsize{}}%
308   \else
```

```
309     \wd\count@\hsize
310   \fi}%
```

Now we give some tracing information.

```
311   \count@\col@number \advance\count@\m@ne
312   \mult@info{z@
313     {Column spec: \the\full@width\space = indent
314       + columns + sep =\MessageBreak
315       \the\multicol@leftmargin\space
316       + \the\col@number\space
317       x \the\hsize\space
318       + \the\count@\space
319       x \the\columnsep
320     }%}
```

At this point we should always be in vertical mode.

```
321 \ifvmode\else\errmessage{Multicol Error}\fi
```

Now we put all columns together in an `\hbox` of width `\full@width` (shifting it by `\multicol@leftmargin` to the right so that it will be placed correctly if we are within a list environment)

The box containing the columns has a large height and thus will always result in using `\lineskip` if the normal `\baselineskip` calculations are used. We therefore better cancel that process.

```
322   \nointerlineskip
```

As mentioned earlier we want to have the reference point of the box we put on the page being at the baseline of the last line of the columns but we also want to ensure that the box has no depth so that any following skip is automatically starting from that baseline. We achieve this by recording the depths of all columns and then finally backing up by the maximum. (perhaps a simpler method would be to assemble the box in a register and set the depth of that box to zero (not checked).

We need a global scratch register for this; using standard T_EX conventions we choose `\dimen2` and initialize it with the depth of the character “p” since that is one of the depths that compete for the maximum.

```
323   \setbox\z@\hbox{p}\global\dimen\tw@\dp\z@
324   \moveright\multicol@leftmargin
325   \hbox to\full@width{%
```

and separating the columns with a rule if desired.

```
326   \process@cols\mult@gfirstbox{%
```

If the depth of the current box is larger than the maximum found so far in `\dimen2` we update that register.

¹²You will see the reason for this numbering when we look at the output routines `\multi@column@out` and `\balance@columns@out`.


```

327 \ifdim\dp\count@>\dimen\tw@
328 \global\dimen\tw@\dp\count@ \fi
329 \box\count@
330 \hss{\normalcolor\vrule
331 \width\columnseprule}\hss}%

```

As you will have noticed, we started with box register `\mult@gfirstbox` (i.e. the left column). So this time `\count@` looped through 2, 4, ... (plus the appropriate offset). Finally we add box 0 and close the `\hbox`. Again we may have to update `\dimen\tw@`.

```

332 \ifdim\dp\mult@rightbox>\dimen\tw@
333 \global\dimen\tw@\dp\mult@rightbox \fi
334 \box\mult@rightbox

```

The depths of the columns depend on their last lines. To ensure that we will always get a similar look as far as the rules are concerned we force the depth at least the depth of a letter ‘p’.

```

335 \rlap{\phantom p}%
336 }%

```

Now after typesetting the box we mack up to its baseline by using the value stored in `\dimen2`.

```

337 \kern-\dimen\tw@

```

However, in case of of the columns was unusually deep `TeX` may have tried some corrective actions in which case backing up by the ahve value will not bring us back to the baseline. A good indication for this is a depth of `\maxdepth` though it is not an absolute proof. If the option `grid` is used `\mc@gridwarn` will expand to this, otherwise to `\maxdimen` in which case this warning will not show up.

```

338 \ifdim\dimen\tw@ = \mc@gridwarn
339 \PackageWarning{multicol}%
340 {Very deep columns!\MessageBreak
341 Grid alignment might be broken}%
342 \fi
343 }

```

Before we tackle the bigger output routines we define just one more macro which will help us to find our way through the mysteries later. `\reinsert@footnotes` will do what its name indicates: it reinserts the footnotes present in `\footinbox` so that they will be reprocessed by `TeX`’s *page_builder*.

Instead of actually reinserting the footnotes we insert an empty footnote. This will trigger insertion mechanism as well and since the old footnotes are still in their box and we are on a fresh page `\skipfootins` should be correctly taken into account.

```

344 \def\reinsert@footnotes{\ifvoid\footins\else
345 \insert\footins{}\fi}

```

Now we can’t postpone the difficulties any longer. The `\multi@column@out` routine will be called in

two situations. Either the page is full (i.e. we have collected enough material to generate all the required columns) or a oat or marginpar (or a `\clearpage` is sensed. In the latter case the `\outputpenalty` is less than `-10000`, otherwise the penalty which triggered the output routine is higher. Therefore it’s easy to distinguish both cases: we simply test this register.

```

346 \def\multi@column@out{%
347 \ifnum\outputpenalty <-\@M

```

If this was a `\clearpage`, a oat or a marginpar we call `\speci@ls`

```

348 \speci@ls \else

```

otherwise we construct the final page. For the next block of code see comments in section 7.2.

```

349 <*colbreak>
350 \ifvoid\colbreak@box\else
351 \mult@info\@ne{Re-adding forced
352 break(s) for splitting}%
353 \setbox\@cclv\vbox{%
354 \unvbox\colbreak@box
355 \penalty-\@Mv\unvbox\@cclv}%
356 \fi
357 </colbreak>

```

Let us now consider the normal case. We have to `\vsplit` the columns from the accumulated material in box 255. Therefore we first assign appropriate values to `\splittopskip` and `\splitmaxdepth`.

```

358 \splittopskip\topskip
359 \splitmaxdepth\maxdepth

```

Then we calculate the current column height (in `\dimen@`). Note that the height of `\partial@page` is already subtracted from `\@colroom` so we can use its value as a starter.

```

360 \dimen@\@colroom

```

But we must also subtract the space occupied by footnotes on the current page. Note that we first have to reset the skip register to its normal value. Again, the actual action is carried out in a utility macro, so that other applications can modify it.

```

361 \divide\skip\footins\col@number
362 \ifvoid\footins \else
363 \leave@mult@footins
364 \fi

```

Now we are able to `\vsplit` off all but the last column. Recall that these columns should be saved in the box registers 2, 4, ... (plus offset).

```

365 \process@cols\mult@gfirstbox{%
366 \setbox\count@
367 \vsplit\@cclv to\dimen@

```

After splitting we update the kept marks.

```

368 \set@keptmarks

```

If `\raggedcolumns` is in force we add a `vfill` at the bottom by unboxing the split box.

```

369         \ifshr@nking
370         \setbox\count@
371             \vbox to\dimen@
372             {\unvbox\count@\vfill}%
373         \fi
374     }%

```

Then the last column follows.

```

375 \setbox\mult@rightbox
376 \vsplit\@cclv to\dimen@
377 \set@keptmarks
378 \ifshr@nking
379     \setbox\mult@rightbox\vbox to\dimen@
380     {\unvbox\mult@rightbox\vfill}%
381 \fi

```

Having done this we hope that box 255 is emptied. If not, we reinsert its contents.

```

382 \ifvoid\@cclv \else
383     \unvbox\@cclv
384     \penalty\outputpenalty

```

In this case a footnote that happens to fall into the leftover bit will be typeset on the wrong page. Therefore we warn the user if the current page contains footnotes. The older versions of `multicols` produced this warning regardless of whether or not footnotes were present, resulting in many unnecessary warnings.

```

385 \ifvoid\footins\else
386     \PackageWarning{multicol}%
387     {I moved some lines to
388     the next page.\MessageBreak
389     Footnotes on page
390     \thepage\space might be wrong}%
391 \fi

```

If the ‘`tracingmulticols`’ counter is 4 or higher we also add a rule.

```

392 \ifnum \c@tracingmulticols>\thr@@
393     \hrule\allowbreak \fi
394 \fi

```

To get a correct marks for the current page we have to (locally) redefine `\firstmark` and `\botmark`. If `\kept@firstmark` is non-empty then `\kept@botmark` must be non-empty too so we can use their values. Otherwise we use the value of `\kept@topmark` which was first initialized when we gathered the `\partial@page` and later on was updated to the `\botmark` for the preceding page

```

395 \ifx\@empty\kept@firstmark
396     \let\firstmark\kept@topmark
397     \let\botmark\kept@topmark

```

```

398 \else
399     \let\firstmark\kept@firstmark
400     \let\botmark\kept@botmark
401 \fi

```

We also initialize `\topmark` with `\kept@topmark`. This will make this mark okay for all middle pages of the `multicols` environment.

```

402 \let\topmark\kept@topmark
403 (*marktrace)
404 \mult@info\tw@
405     {Use kept top mark:\MessageBreak
406     \meaning\kept@topmark
407     \MessageBreak
408     Use kept first mark:\MessageBreak
409     \meaning\kept@firstmark
410     \MessageBreak
411     Use kept bot mark:\MessageBreak
412     \meaning\kept@botmark
413     \MessageBreak
414     Produce first mark:\MessageBreak
415     \meaning\firstmark
416     \MessageBreak
417     Produce bot mark:\MessageBreak
418     \meaning\botmark
419     \@gobbletwo}%
420 (/marktrace)

```

With a little more effort we could have done better. If we had, for example, recorded the shrinkage of the material in `\partial@page` it would be now possible to try higher values for `\dimen@` (i.e. the column height) to overcome the problem with the nonempty box 255. But this would make the code even more complex so I skipped it in the current implementation.

Now we use L^AT_EX’s standard output mechanism.¹³ Admittedly this is a funny way to do it.

```

421 \setbox\@cclv\vbox{\unvbox\partial@page
422                     \page@sofar}%

```

The macro `\@makecol` adds all oats assigned for the current page to this page. `\@outputpage` ships out the resulting box. Note that it is just possible that such oats are present even if we do not allow any inside a `multicols` environment.

```

423 \@makecol\@outputpage

```

After the page is shipped out we have to prepare the kept marks for the following page. `\kept@firstmark` and `\kept@botmark` reinitialized by setting them to `\@empty`. The value of `\botmark` is then assigned to `\kept@topmark`.

```

424 \global\let\kept@topmark\botmark
425 \global\let\kept@firstmark\@empty
426 \global\let\kept@botmark\@empty

```

¹³This will produce a lot of overhead since both output routines are held in memory. The correct solution would be to redesign the whole output routine used in L^AT_EX.

```

427 <*marktrace>
428   \mult@info\tw@
429   {(Re)Init top mark:\MessageBreak
430   \meaning\kept@topmark
431   \@gobbletwo}%
432 </marktrace>

```

Now we reset `\@colroom` to `\@colht` which is L^AT_EX's saved value of `\textheight`.

```
433 \global\@colroom\@colht
```

Then we process deferred oats waiting for their chance to be placed on the next page.

```

434 \process@deferreds
435 \@whiles\if@colmade\fi{\@outputpage
436   \global\@colroom\@colht
437   \process@deferreds}%

```

If the user is interested in statistics we inform him about the amount of space reserved for oats.

```

438 \mult@info\@one
439   {Colroom:\MessageBreak
440   \the\@colht\space
441   after float space removed
442   = \the\@colroom \@gobble}%

```

Having done all this we must prepare to tackle the next page. Therefore we assign a new value to `\vsize`. New, because `\partial@page` is now empty and `\@colroom` might be reduced by the space reserved for oats.

```
443 \set@mult@vsize \global
```

The `\footins` skip register will be adjusted when the output group is closed.

```
444 \fi}
```

This macro is used to subtract the amount of space occupied by footnotes for the current space from the space available for the current column. The space current column is stored in `\dimen@`. See above for the description of the default action.

```

445 \def\leave@mult@footins{%
446   \advance\dimen@-\skip\footins
447   \advance\dimen@-\ht\footins
448 }

```

We left out two macros: `\process@deferreds` and `\speci@ls`.

```

449 \def\speci@ls{%
450   \ifnum\outputpenalty <-\@Mi

```

If the document ends in the middle of a multicols environment, e.g., if the user forgot the `\end{multicols}`, T_EX adds a very negative penalty to the end of the galley which is intended to signal the output routine that it is time to prepare for shipping out everything remaining. Since inside multicols the output routine of L^AT_EX is disabled sometimes we better check for this case: if

we find a very negative penalty we produce an error message and run the default output routine for this case.

```

451 \ifnum \outputpenalty<-\@MM
452   \PackageError{multicol}{Document end
453     inside multicols environment}\@ehd
454   \@specialoutput
455 \else

```

For the next block of code see comments in section 7.2.

```

456 <*colbreak>
457   \ifnum\outputpenalty = -\@Mv
458     \mult@info\@one{Forced column
459       break seen}%
460     \global\advance\vsize-\pagetotal
461     \global\setbox\colbreak@box
462       \vbox{\ifvoid\colbreak@box
463         \else
464           \unvbox\colbreak@box
465           \penalty-\@Mv
466         \fi
467         \unvbox\@cclv}
468     \reinsert@footnotes
469   \else
470 </colbreak>

```

If we encounter a oat or a marginpar in the current implementation we simply warn the user that this is not allowed. Then we reinsert the page and its footnotes.

```

471   \PackageWarningNoLine{multicol}%
472   {Floats and marginpars not
473     allowed inside 'multicols'
474     environment!}
475   \unvbox\@cclv\reinsert@footnotes

```

Additionally we empty the `\@currlist` to avoid later error messages when the L^AT_EX output routine is again in force. But first we have to place the boxes back onto the `\@freelist`. (`\@elts` default is `\relax` so this is possible with `\xdef`.)

```

476   \xdef\@freelist{\@freelist\@currlist}%
477   \gdef\@currlist{}%
478 <*colbreak>
479   \fi
480 </colbreak>
481 \fi

```

If the penalty is `-10001` it will come from a `\clearpage` and we will execute `\@doclearpage` to get rid of any deferred oats.

```

482 \else \@doclearpage \fi
483 }

```

`\process@deferreds` is a simplified version of L^AT_EX's `\@startpage`. We first call the macro `\@floatplacement` to save the current user parameters in internal registers. Then we start a new group

and save the `\@deferlist` temporarily in the macro `\@tempb`.

```
484 \def\process@deferreds{%
485   \@floatplacement
486   \@tryfcolumn\@deferlist
487   \if@fcolmade\else
488     \begingroup
489     \let\@tempb\@deferlist
```

Our next action is to (globally) empty `\@deferlist` and assign a new meaning to `\@elt`. Here `\@scolelt` is a macro that looks at the boxes in a list to decide whether they should be placed on the next page (i.e. on `\@toplist` or `\@botlist`) or should wait for further processing.

```
490   \gdef\@deferlist{}%
491   \let\@elt\@scolelt
```

Now we call `\@tempb` which has the form

```
\@elt<box register>\@elt<box register>...
```

So `\@elt` (i.e. `\@scolelt`) will distribute the boxes to the three lists.

```
492   \@tempb \endgroup
493   \fi}
```

The `\raggedcolumns` and `\flushcolumns` declarations are defined with the help of a new `\if...` macro.

```
494 \newif\ifshr@nking
```

The actual definitions are simple: we just switch to `true` or `false` depending on the desired action. To avoid extra spaces in the output we enclose these changes in `\@bsphack... \@esphack`.

```
495 \def\raggedcolumns{%
496   \@bsphack\shr@nkingtrue\@esphack}
497 \def\flushcolumns{%
498   \@bsphack\shr@nkingfalse\@esphack}
```

Now for the last part of the show: the column balancing output routine. Since this code is called with an explicit penalty (`\eject`) there is no need to check for something special (eg oats). We start by balancing the material gathered.

```
499 \def\balance@columns@out{%
```

For this we need to put the contents of box 255 into `\mult@box`.

```
500 <-colbreak> \setbox\mult@box
501 <-colbreak>   \vbox{\unvbox\@cc1v}%
```

For the next block of code see comments in section 7.2.

```
502 <*colbreak>
503   \setbox\mult@box\vbox{%
504     \ifvoid\colbreak@box\else
505       \unvbox\colbreak@box\break
```

```
506       \mult@info\@ne{Re-adding
507         forced break(s) in balancing}%
508     \fi
509     \unvbox\@cc1v}%
510 </colbreak>
511   \balance@columns
```

This will bring us into the position to apply `\page@sofar`. But first we have to set `\vsize` to a value suitable for one column output.

```
512   \global\vsize\@colroom
513   \global\advance\vsize\ht\partial@page
```

Then we `\unvbox` the `\partial@page` (which may be void if we are not processing the first page of this `\multicols` environment).

```
514   \unvbox\partial@page
```

Then we return the first and bottom mark and the gathered material to the main vertical list.

```
515   \return@nonemptymark{first}\kept@firstmark
516   \return@nonemptymark{bot}\kept@botmark
517   \page@sofar
```

We need to add a penalty at this point which allows to break at this point since calling the output routine may have removed the only permissible break point thereby “glueing” any following skip to the balanced box. In case there are any weird settings for `\multicolsep` etc. this could produce funny results.

```
518   \penalty\z@
519 }
```

As we already know, reinserting of footnotes will be done in the macro `\endmulticols`.

This macro now does the actual balancing.

```
520 \def\balance@columns{%
```

We start by setting the kept marks by updating them with any marks from this box. This has to be done *before* we add a penalty of -10000 to the top of the box, otherwise only an empty box will be considered.

```
521   \get@keptmarks\mult@box
```

We then continue by resetting trying to remove any discardable stuff at the end of `\mult@box`. This is rather experimental. We also add a forced break point at the very beginning, so that we can split the box to height zero later on, thereby adding a known `\splittopskip` glue at the beginning.

```
522   \setbox\mult@box\vbox{%
523     \penalty-\@M
524     \unvbox\mult@box
525     \remove@discardable@items
526   }%
```

Then follow values assignments to get the `\vsplitting` right. We use the natural part of `\topskip` as the natural part for `\splittopskip` and allow for a bit of undershoot and overshoot by adding some stretch and shrink.

```
527 \@tempdima\topskip
528 \splittopskip\@tempdima
529 \@plus\multicolundershoot
530 \@minus\multicolovershoot
531 \splitmaxdepth\maxdepth
```

The next step is a bit tricky: when \TeX assembles material in a box, the first line isn't preceded by interline glue, i.e. there is no parameter like `\boxtopskip` in \TeX . This means that the baseline of the first line in our box is at some unpredictable point depending on the height of the largest character in this line. But of course we want all columns to align properly at the baselines of their first lines. For this reason we have opened `\mult@box` with a `\penalty -10000`. This will now allow us to split off from `\mult@box` a tiny bit (in fact nothing since the first possible break-point is the first item in the box). The result is that `\splittopskip` is inserted at the top of `\mult@box` which is exactly what we like to achieve.

```
532 \setbox\@tempboxa\vsplit\mult@box to\z@
```

Next we try to find a suitable starting point for the calculation of the column height. It should be less than the height finally chosen, but large enough to reach this final value in only a few iterations. The formula which is now implemented will try to start with the nearest value which is a multiple of `\baselineskip`. The coding is slightly tricky in \TeX and there are perhaps better ways ...

```
533 \@tempdima\ht\mult@box
534 \advance\@tempdima\dp\mult@box
535 \divide\@tempdima\col@number
```

The code above sets `\@tempdima` to the length of a column if we simply divide the whole box into equal pieces. To get to the next lower multiple of `\baselineskip` we convert this `dimen` to a number (the number of scaled points) then divide this by `\baselineskip` (also in scaled points) and then multiply this result with `\baselineskip` assigning the result to `\dimen@`. This makes `\dimen@` \leq to `\@tempdimena`.

```
536 \count@\@tempdima
537 \divide\count@\baselineskip
538 \dimen@\count@\baselineskip
```

Next step is to correct our result by taking into account the difference between `\topskip` and `\baselineskip`. We start by adding `\topskip`; if

this makes the result too large then we have to subtract one `\baselineskip`.

```
539 \advance\dimen@\topskip
540 \ifdim \dimen@ >\@tempdima
541 \advance\dimen@-\baselineskip
542 \fi
```

At the user's request we start with a higher value (or lower, but this usually only increases the number of tries).

```
543 \advance\dimen@\c@unbalance\baselineskip
```

We type out statistics if we were asked to do so.

```
544 \mult@info\@ne
545 {Balance columns\on@line:
546 \ifnum\c@unbalance=\z@\else
547 (off balance=\number\c@unbalance)\fi
548 \@gobbletwo}%
```

But we don't allow nonsense values for a start.

```
549 \ifnum\dimen@<\topskip
550 \mult@info\@ne
551 {Start value
552 \the\dimen@ \space ->
553 \the\topskip \space (corrected)}%
554 \dimen@\topskip
555 \fi
```

Now we try to find the final column height. We start by setting `\vbadness` to infinity (i.e. 10000) to suppress underfull box reports while we are trying to find an acceptable solution. We do not need to do it in a group since at the end of the output routine everything will be restored. The setting of the final columns will nearly always produce underfull boxes with badness 10000 so there is no point in warning the user about it.

```
556 \vbadness\@M
```

We also allow for overfull boxes while we trying to split the columns.

```
557 \vfuzz \col@number\baselineskip
```

The variable `\last@try` will hold the dimension used in the previous trial splitting. We initialize it with a negative value.

```
558 \last@try-\p@
559 \loop
```

In order not to clutter up \TeX 's valuable main memory with things that are no longer needed, we empty all globally used box registers. This is necessary if we return to this point after an unsuccessful trial. We use `\process@cols` for this purpose, starting with `\mult@grightbox`. Note the extra braces around this macro call. They are needed since \TeX 's `\loop...\repeat` mechanism cannot be nested on the same level of grouping.

```
560 {\process@cols\mult@grightbox
```



```

561      {\global\setbox\count@
562        \box\voidb{x}}}%

```

The contents of box `\mult@box` are now copied globally to box `\mult@grightbox`. (This will be the right-most column, as we shall see later.)

```

563      \global\setbox\mult@grightbox
564        \copy\mult@box

```

We start with the assumption that the trial will be successful. If we end up with a solution that is too bad we set `too@bad` to `true`.

```

565 <*badness>
566   \global\too@badfalse
567 </badness>

```

Using `\vsplit` we extract the other columns from box register `\mult@grightbox`. This leaves box register `\mult@box` untouched so that we can start over again if this trial was unsuccessful.

```

568   {\process@cols\mult@firstbox{%
569     \global\setbox\count@
570     \vsplit\mult@grightbox to\dimen@

```

After every split we check the badness of the resulting column, normally the amount of extra white in the column.

```

571 <*badness>
572   \ifnum\c@tracingmulticols>\@ne
573     \@tempcnta\count@
574     \advance\@tempcnta-\mult@grightbox
575     \divide\@tempcnta \tw@
576     \message{^^JColumn
577       \number\@tempcnta\space
578       badness: \the\badness\space}%
579   \fi

```

If this badness is larger than the allowed column badness we reject this solution by setting `too@bad` to `true`.

```

580   \ifnum\badness>\c@columnbadness
581     \ifnum\c@tracingmulticols>\@ne
582       \message{too bad
583         (>\the\c@columnbadness)}%
584     \fi
585     \global\too@badtrue
586   \fi
587 </badness>
588   }%

```

There is one subtle point here: while all other constructed boxes have a depth that is determined by `\splitmaxdepth` the last box will get a natural depth disregarding the original setting and the value of `\splitmaxdepth` or `\boxmaxdepth`. This means that we may end up with a very large depth in box `\mult@grightbox` which would make the result of

the testing incorrect. So we change the value by unboxing the box into itself.

```

589   \boxmaxdepth\maxdepth
590   \global\setbox\mult@grightbox
591     \vbox{\unvbox\mult@grightbox}%

```

We also save a copy `\mult@firstbox` at its “natural” size for later use.

```

592   \setbox\mult@nat@firstbox
593     \vbox{\unvcopy\mult@firstbox}%

```

After `\process@cols` has done its job we have the following situation:

```

      box \mult@rightbox ← all material
      box \mult@gfirstbox ← first column
      box \mult@gfirstbox + 2 ← second column
      :
      :
      box \mult@grightbox ← last column

```

We report the height of the first column, in brackets the natural size is given.

```

594   \ifnum\c@tracingmulticols>\@ne
595     \message{^^JFirst column
596       = \the\dimen@\space
597       (\the\ht\mult@nat@firstbox)}\fi

```

If `\raggedcolumns` is in force older releases of this file also shrank the first column to its natural height at this point. This was done so that the first column doesn’t run short compared to later columns but it is actually producing incorrect results (overprinting of text) in boundary cases, so since version v1.5q `\raggedcolumns` means allows for all columns to run slightly short.

```

598 %   \ifshr@nking
599 %     \global\setbox\mult@firstbox
600 %       \copy\mult@nat@firstbox
601 %   \fi

```

Then we give information about the last column.¹⁴

```

602   \ifnum\c@tracingmulticols>\@ne
603     \message{<> last column =
604       \the\ht\mult@grightbox^^J}%

```

Some tracing code that we don’t compile into the production version unless asked for. It will produce huge listings of the boxes involved in balancing in the transcript file.

```

605 <*debug>
606   \ifnum\c@tracingmulticols>4
607     {\showoutput
608       \batchmode
609       \process@cols\mult@grightbox
610       {\showbox\count@}}%
611     \errorstopmode
612   \fi

```

¹⁴With T_EX version 3.141 it is now possible to use L^AT_EX’s `\newlinechar` in the `\message` command, but people with older T_EX versions will now get `^^J` instead of a new line on the screen.

```
613 </debug>
614 \fi
```

We check whether our trial was successful. The test used is very simple: we merely compare the first and the last column. Thus the intermediate columns may be longer than the first if `\raggedcolumns` is used. If the right-most column is longer than the first then we start over with a larger value for `\dimen@`.

```
615 \ifdim\ht\mult@grightbox >\dimen@
```

If the height of the last box is too large we mark this trial as unsuccessful.

```
616 <*badness>
617 \too@badtrue
618 \ifnum\c@tracingmulticols>\@ne
619 \typeout{Rejected: last
620 column too large!}%
621 \fi
622 \else
```

To ensure that there isn't a forced break in the last column we try to split off a box of size `\maxdimen` from `\mult@grightbox` (or rather from a copy of it). This should result in a void box after the split, unless there was a forced break somewhere within the column in which case the material after the break would have stayed in the box.

```
623 <*colbreak>
624 \setbox\@tempboxa
625 \copy\mult@grightbox
626 \setbox\z@\vsplit\@tempboxa to\maxdimen
627 \ifvoid\@tempboxa
628 </colbreak>
```

Thus if `\@tempboxa` is void we have a valid solution. In this case we take a closer look at the last column to decide if this column should be made as long as all other columns or if it should be allowed to be shorter. For this we first have to rebox the column into a box of the appropriate height. If tracing is enabled we then display the badness for this box.

```
629 \global\setbox\mult@grightbox
630 \vbox to\dimen@
631 {\unvbox\mult@grightbox}%
632 \ifnum\c@tracingmulticols>\@ne
633 \message{Final badness:
634 \the\badness}%
635 \fi
```

We then compare this badness with the allowed badness for the final column. If it does not exceed this value we use the box, otherwise we rebox it once more and add some glue at the bottom.

```
636 \ifnum\badness>\c@finalcolumnbadness
```

```
637 \global\setbox\mult@grightbox
638 \vbox to\dimen@
639 {\unvbox\mult@grightbox\vfill}%
640 \ifnum\c@tracingmulticols>\@ne
641 \message{ setting natural
642 (> \the\c@finalcolumnbadness)}%
643 \fi
644 \fi
```

If `\@tempboxa` above was not void our trial was unsuccessful and we report this fact and try again.

```
645 <*colbreak>
646 \else
647 \too@badtrue
648 \ifnum\c@tracingmulticols>\@ne
649 \typeout{Rejected: unprocessed
650 forced break(s) in last column!}%
651 \fi
652 \fi
653 </colbreak>
654 \fi
```

If the natural height of the first box is smaller than the current trial size but is larger than the previous trial size it is likely that we have missed a potentially better solution. (This could have happened if for some reason our first trial size was too high.) In that case we dismiss this trial and restart using the natural height for the next trial.

```
655 \ifdim\ht\mult@nat@firstbox<\dimen@
656 \ifdim\ht\mult@nat@firstbox>\last@try
657 \too@badtrue
658 \ifnum\c@tracingmulticols>\@ne
659 \typeout{Retry: using natural
660 height of first column!}%
661 \fi
662 \dimen@\ht\mult@nat@firstbox
663 \last@try\dimen@
664 \advance\dimen@-\p@
665 \fi
666 \fi
```

Finally the switch `too@bad` is tested. If it was made true either earlier on or due to a rightmost column being too large we try again with a slightly larger value for `\dimen@`.

```
667 \iftoo@bad
668 </badness>
669 \advance\dimen@\p@
670 \repeat
```

At that point `\dimen@` holds the height that was determined by the balancing loop. If that height for the columns turns out to be larger than the available space (which is `\colroom`) we squeeze the columns into the space assuming that they will have enough

¹⁵This might be wrong, since the shrinkability that accounts for the amount of material might be present only in some columns. But it is better to try than to give up directly.

shrinkability to allow this.¹⁵ However, this squeezing should only be done if we are balancing columns on the main galley and *not* if we are building a boxed multicol (in the latter case the current `\colroom` is irrelevant since the produced box might be moved anywhere at a later stage).

```
671 \ifboxedmulticols\else
672 \ifdim\dimen@>\colroom
673 \dimen@=\colroom
674 \fi
675 \fi
```

Then we move the contents of the odd-numbered box registers to the even-numbered ones, shrinking them if requested. We have to use `\vbox` not `\vtop` (as it was done in the first versions) since otherwise

the resulting boxes will have no height (*TEXbook* page 81). This would mean that extra `\topskip` is added when the boxes are returned to the page-builder via `\page@sofar`.

```
676 \process@cols\mult@rightbox
677 {\@tempcnta\count@
678 \advance\@tempcnta\@ne
679 \setbox\count@\vbox to\dimen@
680 {%
681 \vskip \z@
682 \@plus-\multicolundershoot
683 \@minus-\multicolovershoot
684 \unvbox\@tempcnta
685 \ifshr@nking\vfill\fi}}%
686 }
```

4.5 The box allocations

Early releases of these macros used the first box registers 0, 2, 4, ... for global boxes and 1, 3, 5, ... for the corresponding local boxes. (You might still find some traces of this setup in the documentation, sigh.) This produced a problem at the moment we had more than 5 columns because then officially allocated boxes were overwritten by the algorithm. The new release now uses private box registers

```
687 \newbox\mult@rightbox
688 \newbox\mult@grightbox
689 \newbox\mult@gfirstbox
```

```
690 \newbox\mult@firstbox
691 \newbox\@tempa\newbox\@tempa
692 \newbox\@tempa\newbox\@tempa
693 \newbox\@tempa\newbox\@tempa
694 \newbox\@tempa\newbox\@tempa
695 \newbox\@tempa\newbox\@tempa
696 \newbox\@tempa\newbox\@tempa
697 \newbox\@tempa\newbox\@tempa
698 \newbox\@tempa\newbox\@tempa
699 \newbox\@tempa
700 \let\@tempa\relax
```

5 New macros and hacks for version 1.2

If we don't use \TeX 3.0 `\emergencystretch` is undefined so in this case we simply add it as an unused `\dimen` register.

```
701 \@ifundefined{emergencystretch}
702 {\newdimen\emergencystretch}{}
```

My tests showed that the following formula worked pretty well. Nevertheless the `\setemergencystretch` macro also gets `\hsize` as second argument to enable the user to try different formulae.

```
703 \def\setemergencystretch#1#2{%
704 \emergencystretch 4pt
705 \multiply\emergencystretch#1}
```

Even if this should be used as a hook we use a `@` in the name since it is more for experts.

```
706 \def\set@floatcmds{%
707 \let\@dblfloat\@dbflt
708 \def\end@dblfloat{\par
709 \vskip\z@
710 \@minipagefalse
```

```
711 \egroup
712 \color@endbox
713 \@largefloatcheck
714 \outer@nobreak
```

This is cheap (deferring the oats until after the current page) but any other solution would go deep into \LaTeX 's output routine and I don't like to work on it until I know which parts of the output routine have to be reimplemented anyway for \LaTeX 3.

```
715 \ifnum\@floatpenalty<\z@
```

We have to add the oat to the `\@deferlist` because we assume that outside the `multicols` environment we are in one column mode. This is not entirely correct, I already used the `multicols` environment inside of \LaTeX 's `\twocolumn` declaration but it will do for most applications.

```
716 \@cons\@deferlist\@currbox
717 \fi
718 \ifnum\@floatpenalty=-\@Mii
719 \@Esphack
720 \fi}}
```

5.1 Maintaining the mark registers

This section contains the routines that set the marks so that they will be handled correctly. They have been introduced with version 1.4.

First thing we do is to reserve three macro names to hold the replacement text for \TeX 's primitives `\firstmark`, `\botmark` and `\topmark`. We initialize the first two to be empty and `\kept@topmark` to contain two empty pair of braces. This is necessary since `\kept@topmark` is supposed to contain the last mark from a preceding page and in \LaTeX any “real” mark must contain two parts representing left and right mark information.

```
721 \def\kept@topmark{{}{}}
722 \let\kept@firstmark\@empty
723 \let\kept@botmark\@empty
```

Sometimes we want to return the value of a “kept” mark into a `\mark` node on the main vertical list. This is done by the function `\return@nonemptymark`. As the name suggests it only acts if the replacement text of the kept mark is non-empty. This is done to avoid adding an empty mark when no mark was actually present. If we would nevertheless add such a mark it would be regarded as a valid `\firstmark` later on.

```
724 \def\return@nonemptymark#1#2{%
725   \ifx#2\@empty
726     \else
```

For debugging purposes we take a look at the value of the kept mark that we are about to return. This code will get stripped out for production.

```
727 (*marktrace)
728   \mult@info\tw@
729   {Returned #1 mark:\MessageBreak
730     \meaning#2}%
731 %   \nobreak
732 %   \fi
733 </marktrace>
```

Since the contents of the mark may be arbitrary \LaTeX code we better make sure that it doesn't get expanded any further. (Some expansion have been done already during the execution of `\markright` or `\markboth`.) We therefore use the usual mechanism of a toks register to prohibit expansion.¹⁶

```
734   \toks@\expandafter{#2}%
735   \mark{\the\toks@}%
```

We don't want any breakpoint between such a returned mark and the following material (which is usually just the box where the mark came from).

```
736   \nobreak
737   \fi}
```

If we have some material in a box register we may want to get the first and the last mark out of this box. This can be done with `\get@keptmarks` which takes one argument: the box register number or its nick name defined by `\newbox`.

```
738 \def\get@keptmarks#1{%
```

For debugging purposes we take a look at the current dimensions of the box since in earlier versions of the code I made some mistakes in this area.

```
739 (*debug)
740   \typeout{Mark box #1 before:
741           ht \the\ht#1, dp \the\dp#1}%
742 </debug>
```

Now we open a new group and locally copy the box to itself. As a result any operation, i.e. `\vsplit`, will only have a local effect. Without this trick the box content would get lost up to the level where the last assignment to the box register was done.

```
743   \begingroup
744   \vbadness\@M
745   \setbox#1\copy#1%
```

Now we split the box to the maximal possible dimension. This should split off the full contents of the box so that effectively everything is split off. As a result `\splitfirstmark` and `\splitbotmark` will contain the first and last mark in the box respectively.

```
746   \setbox#1\vsplit#1to\maxdimen
```

Therefore we can now set the kept marks which is a global operation and afterwards close the group. This will restore the original box contents.

```
747   \set@keptmarks
748 \endgroup
```

For debugging we take again a look at the box dimension which shouldn't have changed.

```
749 (*debug)
750   \typeout{Mark box #1 \space after:
751           ht \the\ht#1, dp \the\dp#1}%
752 </debug>
753 }
```

The macro `\set@keptmarks` is responsible for setting `\kept@firstmark` and `\kept@botmark`, by checking the current values for `\splitfirstmark` and `\splitbotmark`.

```
754 \def\set@keptmarks{%
```

¹⁶Due to the current definition of `\markright` etc. it wouldn't help to define the `\protect` command to prohibit expansion as any `\protect` has already vanished due to earlier expansions.

If `\kept@firstmark` is empty we assume that it isn't set. This is strictly speaking not correct as we lose the ability to have marks that are explicitly empty, but for standard L^AT_EX application it is sufficient. If it is non-empty we don't change the value—within the output routines it will then be restored to `\@empty`.

```
755 \ifx\kept@firstmark\@empty
```

We now put the contents of `\splitfirstmark` into `\kept@firstmark`. In the case that there wasn't any mark at all `\kept@firstmark` will not change by that operation.

```
756 \expandafter\gdef\expandafter
757 \kept@firstmark
758 \expandafter{\splitfirstmark}%
```

When debugging we show the assignment but only when something actually happened.

```
759 (*marktrace)
760 \ifx\kept@firstmark\@empty\else
761 \mult@info\tw@
762 {Set kept first mark:\MessageBreak
763 \meaning\kept@firstmark%
764 \@gobbletwo}%
765 \fi
766 \marktrace)
767 \fi
```

We always try to set the bottom mark to the `\splitbotmark` but of course only when there has been a `\splitbotmark` at all. Again, we assume that an empty `\splitbotmark` means that the split off box part didn't contain any marks at all.

```
768 \expandafter\def\expandafter\@tempa
769 \expandafter{\splitbotmark}%
770 \ifx\@tempa\@empty\else
771 \global\let\kept@botmark\@tempa
772 (*marktrace)
773 \mult@info\tw@
774 {Set kept bot mark:\MessageBreak
775 \meaning\kept@botmark%
776 \@gobbletwo}%
777 \marktrace)
778 \fi}%
```

The `\prep@keptmarks` function is used to initialize the kept marks from the contents of `\partial@page`, i.e. the box that holds everything from the top of the current page prior to starting the multicols environment. However, such a box is only available if we are not producing a boxed multicols.

```
779 \def\prep@keptmarks{%
780 \if@boxedmulticols \else
781 \get@keptmarks\partial@page
782 \fi}
```

```
783 \def\remove@discardable@items{%
784 (*debug)
785 \edef\@tempa{s=\the\lastskip,
786 p=\the\lastpenalty,
787 k=\the\lastkern}%
788 \typeout\@tempa
789 \debug)
790 \unskip\unpenalty\unkern
791 (*debug)
792 \edef\@tempa{s=\the\lastskip,
793 p=\the\lastpenalty,
794 k=\the\lastkern}%
795 \typeout\@tempa
796 \debug)
797 \unskip\unpenalty\unkern
798 (*debug)
799 \edef\@tempa{s=\the\lastskip,
800 p=\the\lastpenalty,
801 k=\the\lastkern}%
802 \typeout\@tempa
803 \debug)
804 \unskip\unpenalty\unkern
805 (*debug)
806 \edef\@tempa{s=\the\lastskip,
807 p=\the\lastpenalty,
808 k=\the\lastkern}%
809 \typeout\@tempa
810 \debug)
811 \unskip\unpenalty\unkern
812 }
```

```
813 (*badness)
814 \newif\iftoo@bad
```

```
815 \newcount\c@columnbadness
816 \c@columnbadness=10000
817 \newcount\c@finalcolumnbadness
818 \c@finalcolumnbadness=9999
819
820 \newdimen\last@try
821
```

```
822 \newdimen\multicolovershoot
823 \newdimen\multicolundershoot
824 \multicolovershoot=0pt
825 \multicolundershoot=2pt
826 \newbox\mult@nat@firstbox
827 \badness)
```

A helper for producing info messages

```
828 \def\mult@info#1#2{%
829 \ifnum\c@tracingmulticols>#1%
830 \GenericWarning
831 {(multicol)\@spaces\@spaces}%
832 {Package multicol: #2}%
833 \fi
834 }
```

6 Fixing the `\columnwidth`

If we store the current column width in `\columnwidth` we have to redefine the internal `\@footnotetext` macro to use `\textwidth` for the width of the footnotes rather than using the original definition.

Starting with version v1.5r this is now done in a way that the original definition is still used, except that locally `\columnwidth` is set to `\textwidth`.

This solves two problems: first redefinitions of

`\@footnotetext` done by a class will correctly survive and second if `multicols` is used inside a `minipage` environment the special definition of `\@footnotetext` in that environment will be picked up and not the one for the main galley (the latter would result in all footnotes getting lost in that case).

See the definition of the `\multicols` command further up for the exact code.

7 Further extensions

This section does contain code for extensions added to this package over time. Not all of them may be active, some might sit dormant and wait for being activated in some later release.

7.1 Not balancing the columns

This is fairly trivial to implement. we just have to disable the balancing output routine and replace it by the one that ships out the other pages.

The code for this environment was suggested by Matthias Clasen.

```
835 \<nobalance>
836 \<namedef{multicols*}{%
```

If we are not on the main galley, i.e., inside a box of some sort, that approach will not work since we don't have a vertical size for the box so we better warn that we balance anyway.

```
837 \ifinner
838 \PackageWarning{multicol}%
839 {multicols* inside a box does
840 not make sense.\MessageBreak
841 Going to balance anyway}%
842 \else
843 \let\balance@columns@out
844 \multi@column@out
845 \fi
846 \begin{multicols}
847 }
```

When ending the environment we simply end the inner `multicols` environment, except that we better also stick in some stretchable vertical glue so that the last column still containing text is not vertically stretched out.

```
848 \<namedef{endmulticols*}{\vfill
849 \end{multicols}}
850 \</nobalance>
```

7.2 Manual column breaking

The problem with manual page breaks within `multicols` is the fact that during collection of material for all columns a page-forcing penalty (i.e. -10000 or higher) would stop the collecting pass which is not quite what is desired. On the other hand, using a penalty like -9999 would mean that there would be occasions where the `\vsplitting` operations within `multicols` would ignore that penalty and still choose a different break point.

For this reason the current implementation uses a completely different approach. In a nutshell it extends the `LATEX` output routine handling by introducing an additional penalty `ag` (i.e., a penalty which is forcing but higher than -10000 so that the output routine can look at this value and thus knows why it has been called).

Inside the output routine we test for this value and if it appears we do two things: save the galley up to this point in a special box for later use and reduce the `\vsize` by the height of the material seen. This way the forcing penalty is now hidden in that box and we can restart the collection process for the remaining columns. (This is done in `\speci@ls` above.)

In the output routines that do the `\vsplitting` either for balancing or for a full page we simply combine box 255 with the saved box thus getting a single box for splitting which now contains forcing breaks in the right positions.

`\columnbreak` is modelled after `\pagebreak` except that we generate a penalty -10005.

```
851 \<colbreak>
852 \mathchardef\@Mv=10005
853 \def\columnbreak{%
```

We have to ensure that it is only used within a `multicols` environment since if that penalty would be

seen by the unmodified L^AT_EX output routine strange things would happen.

```
854 \ifnum\col@number<\tw@
855   \PackageError{multicol}%
856     {\noexpand\columnbreak outside multicol}%
857     {This command can only be used within
858       a multicol or multicol* environment.}%
859 \else
860   \ifvmode
861     \penalty -\@Mv\relax
862   \else
863     \@bsphack
864     \vadjust{\penalty -\@Mv\relax}%
865     \@esphack
866   \fi
867 \fi}
```

Need a box to collect the galley up to the column break.

```
868 \newbox\colbreak@box
869 \colbreak
870 \package
```

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