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☞ TEXPIC – DESIGN AND IMPLEMENTATION
OF A PICTURE GRAPHICS LANGUAGE IN T_EX À
LA PIC

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texpic — Design and Implementation of a Picture Graphics Language in T_EX à la pic

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Résumé

texpic est une implémentation T_EX d'un langage graphique similaire à *pic*, pré-processeur de *troff*.

De nombreuses fonctionnalités de *pic* sont accessibles, par exemple différents objets graphiques (boîtes, cercles, ellipses, lignes, flèches et autres), la direction du déplacement, le contrôle de la taille des objets avec une valeur par défaut variable, le positionnement relatif ou absolu de chaque objet ou de l'ensemble d'un dessin (les objets peuvent être référencés par des étiquettes ou bien par leur coins) et beaucoup d'autres choses.

Il y a deux améliorations majeures. Les objets adaptent leur taille à leur contenu, par exemple un cercle peut contenir un tableau d'équations mathématiques, une boîte peut contenir ce cercle, etc. Les commandes *texpic* et T_EX — ou L^AT_EX — peuvent être imbriquées à volonté.

L'implémentation est constituée de deux parties, une série complexe de macros T_EX et un post-processeur écrit en C, qui réalise le dessin dans le fichier *dvi*. Il faut souligner que *texpic* est totalement portable, c'est à dire que chaque version de T_EX, chaque visionneuse d'écran et chaque pilote d'imprimante (correctement écrit) fonctionnera avec *texpic*.

La seule précaution d'emploi concerne M^LT_EX. Les commandes de *texpic* sont délimitées par un point virgule, or M^LT_EX redéfinit le point virgule comme étant

un caractère actif (`\catcode' =13`) afin de pouvoir gérer correctement l'espace qui le précède. Il faut donc redéfinir le point virgule comme un caractère inactif (`\catcode' =12`) avant de faire appel à une commande de *texpic*.

Abstract

texpic is a T_EX implementation of a graphics language similar to KERNIGHAN's *troff* pre-processor *pic*.

Many features of the original *pic* are supported, including a variety of graphical objects (boxes, circles, ellipses, lines, arrows and others), directions of motion, controlling sizes of objects with variable and appropriate defaults, relative and absolute positioning of single objects or whole pictures (labels and corners are allowed), and much more.

There are two significant enhancements. Objects adapt to the size of their contents; that is, a circle may contain a table with mathematical equations, a box may contain the circle, etc. *texpic* objects and T_EX —or L^AT_EX— commands may be combined at will.

The implementation consists of two parts, a set of elaborate T_EX macros and a post-processor for drawing (in the *dvi* file), written in C. It should be emphasized that *texpic* is fully portable, ie, every T_EX version, every preview and even every (correctly written) printer driver will work together with *texpic*.

1. Preface

Some years ago I attended a lecture on text processing. At that time I had just discovered T_EX and was filled with enthusiasm, but unfortunately the lecture dealt mainly with another system: the troff typesetting software, widely used under UNIX.

There ensued a friendly competition between the lecturer and me — with the goal being to typeset things the other one couldn't do. One time he won, another time I made a point, so the race was rather even.

With introducing pic one day, a powerful, but easy to use language for drawing pictures, implemented as a pre-processor to troff, the tables turned. Because T_EX has little to retort, I began to lose very often. To catch up, I decided to implement something similar in T_EX, not knowing what frustration (and fun) this would be!

2. Boxes — The Cornerstone of T_EX

Boxes are probably the only objects which are easy to implement *in* T_EX. This is because T_EX also uses a box concept which offers two possibilities. If we have specified width and height explicitly, we obtain just a box with these dimensions. Otherwise the smallest box is chosen which fits around its contents. For the frame of the box we need only horizontal and vertical lines — suitable commands already exist. Consequently we require the following:

- Boxes have a minimum size.
- Between contents and frame there is a certain amount of free space.
- Boxes adapt to the size of their contents.

- Boxes are centered perpendicular to the current direction of movement.
- Minimum size, free space and the thickness of the lines are locally or globally changeable.

The resulting T_EX macros are relatively straightforward. Producing a box with *tezpic*, the complete syntax of the corresponding command is:¹

```
\tpbox [attributes] [parameters]
      [contents];
```

An *attribute* such as *invis* describes a quality and is typically one word, whereas a *parameter* such as *width 3cm* influences the size of an object and consists of several words. Finally, the *contents* begin behind the last *parameter* or *attribute*, stop at the next semicolon and are often ordinary text. Subsequent sections will illustrate this.

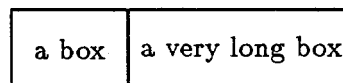
2.1. “Growing” Boxes with Minimum Size

```
\tpbox; a box
```



As we can see, the box is centered on an imaginary horizontal line.

```
\tpbox a box;
\tpbox a very long box;
```



```
\tpbox \vbox{
\hbox{boxes}
\hbox{also}
\hbox{stretch}
\hbox{to the}
\hbox{top}
};
```

¹“tp” as a prefix for all names relating to *tezpic* and should avoid name conflicts.

boxes also stretch to the top

In the next example the current direction of movement is vertical which changes the centering of the box:

```
\par
\tpbox;
```

--

2.2. Local and Global Changes

With *parameters* we can change various sizes of *one* object:

```
\tpbox width 3cm wide;
\tpbox width 1cm narrow;
```

wide	narrow
------	--------

```
\tpbox width 0cm height 0cm narrower;
\tpbox height 0cm width 0cm fill 0cm
very narrow;
```

narrower	very narrow
----------	-------------

Parameters which control the size of an object, control only the minimum size, ie, if the contents don't fit, the object will still grow. The space between frame and contents is changed through *fill*. The thickness of the lines is also adjustable:

```
\tpbox thickness 4pt thick lines; \
\tpbox thickness 8pt very thick lines;
```

thick lines	very thick lines
-------------	------------------

To achieve global changes we can simply change corresponding variables. As usual, braces control the scope:

```
{
\tpboxwd=35pt \tpboxht=20pt
\tpbox all; \tpbox boxes; \tpbox have;
\tpbox equal; \tpbox size;
}
```

all	boxes	have	equal	size
-----	-------	------	-------	------

```
\tpbox normal;
```

normal

```
{
\tpboxwd=0pt \tpboxht=0pt
\tpboxfill=0pt
\tpbox all; \tpbox boxes; \tpbox have;
\tpbox minimal; \tpbox size;
}
```

all boxes have minimal size

2.3. Sharing Attributes

With the attribute *same* we can make an object have the same size of the last one, provided that the contents fit:

```
\tpbox boxes have;
\tpbox same the same;
\tpbox same size;
```

boxes have	the same	size
------------	----------	------

The first *same* is the attribute, the second is ordinary text! *\tpphantom* can be used, if the biggest box is not the first one:

```
\tpboxwd=0in \tpboxht=0in
\tpphantom{\tpbox 1234;};
%
\tpbox same 1; \tpbox same 12;
\tpbox same 123; \tpbox same 1234;
```

1	12	123	1234
---	----	-----	------

With *invis* we can make an object invisible, ie, we suppress the frame. This attribute will prove useful later, when we want to position objects at different places:

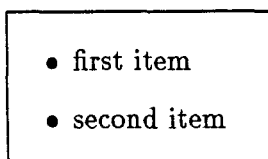
```
\tpbox an;
\tpbox invis invisible;
\tpbox box;
```

an	invisible	box
----	-----------	-----

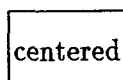
2.4. Boxes Around Other Objects

More complicated examples are possible — boxes are *bona fide* members of the T_EX world:

```
\tpbox
\hbox to 3cm{\vbox{
\begin{itemize}
\item first item
\item second item
\end{itemize}
}\has}
;
```

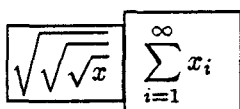


```
\centerline{
\tpbox centered;
}
```



Notice, that `\item` would use the entire line, therefore `\hbox` is used to limit line length. Similarly, `\centerline` pushes the `\tpbox` to the middle.

```
\tpbox
$\displaystyle\sqrt{\sqrt{\sqrt{x}}}$
;
\tpbox
$\displaystyle\sum_{i=1}^{\infty}x_i$
;
```



```
\tpboxwd=0pt \tpboxht=0pt \tpboxfill=1pt
\tpbox{\tpbox{\tpbox{\tpbox{\tpbox{%
```



The last example shows a particularly valuable feature: nesting. Most L^AT_EX macros also work with *terpic* boxes. So a box around a `tabular` or a box inside a `tabular` can be used. This is very useful for positioning.

3. Circles — Do they have to be so special?

Now on to the circles which should provide exactly the same features as the boxes above. As we will see, however, circles are much more complicated than boxes.

3.1. Two Dead Ends

To draw circles there are two approaches which will not work, at least not very well or with considerable restrictions:

1. Drawing in T_EX is possible, but this is very slow and there are also limitations regarding the number of circles, ie, points, on the same page. See also the preface from the P_IC_TE_X Manual.
2. Use of a printer language for drawing is possible with the `\special` command, though this means a commitment to one printer and therefore a loss of portability.

The second solution would be sufficient at the moment, but as in the original `pic`, references to objects should eventually be implemented. Because there is no way to get the current coordinates on the page in T_EX, we could have transferred this problem to the printer language as well. However, this would certainly not improve any portability aspects.


3.2. A Post-Processor for Drawing

Looking for other ways to obtain the coordinates of an object we discover the `dvi` file which is absolutely device independent. Reading this file (and some `tfm` files to get the widths of single characters) we are able to track the current position.

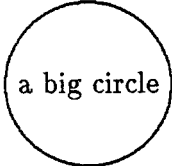
The main point, however, is that we can draw in the `dvi` files. This is a

bit subtle, since we must pay attention to some pointers. With the use of the `\special` command and a post-processor written in C, the same features as for boxes are possible:


```
\tpcircle;
```



```
\tpcircle a big circle;
```



```
\tpcircrad=0pt \tpcircfill=1pt
\tpcircle{\tpcircle{\tpcircle%
\tpcircle{\tpcircle{\tpcircle;}}}}};
```



4. Directions and Movements

— Not quite the same

Changing the current direction of movement in pic is possible at any time — “north”, “south”, “west” and “east” are allowed. Besides that, we can change the current point by a movement. Both features can be implemented in T_EX, however, with some restrictions.

4.1. Directions

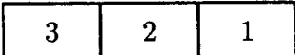
Because we want to allow arbitrary objects, we require the following points:

- All four points of the compass are allowed.
- Macros `\tp...begin` and `\tp...end` enclose the objects of one “row”.
- Inside a “row” all arbitrary objects are possible.

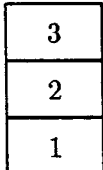
- Every single object must be surrounded by braces.

In the following examples the default sizes have been decreased a little:

```
\tpleftbegin
{\tpbox 1;} {\tpbox 2;} {\tpbox 3;}
\tpleftend
```

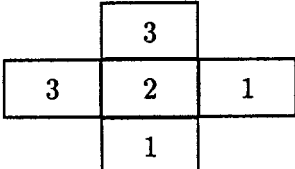


```
\tpupbegin
{\tpbox 1;} {\tpbox 2;} {\tpbox 3;}
\tpupend
```

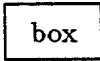



Directions can be combined with other objects as usual:

```
\tpleftbegin
{\tpbox 1;}
{\tpupbegin
{\tpbox 1;} {\tpbox 2;} {\tpbox 3;}
\tpupend}
{\tpbox 3;}
\tpleftend
```



```
\tprightbegin
{From a } {\tpbox box;}
{ to a } {\tpcircle circle.;}
\tprightend
```

From a  to a 

Especially for positioning objects these features are very useful.

4.2. Movements

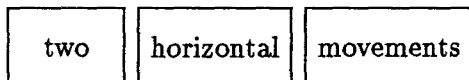
An arbitrary change of the current position is not possible in T_EX, therefore the

design of movements is poor and rather restricted:

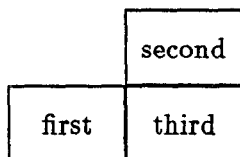
- A single `\tpmove` changes the reference point for a default value in the current direction.
- Specifying an optional direction will move only the next object.
- All default values are changeable locally and globally.

The first example shows the “normal” use of `\tpmove`, the second moves only one object:

```
\tpbox two;
\tpmove width 5pt;
\tpbox horizontal;
\tpmove same;
\tpbox movements;
```



```
\tpbox first;
\tpmove up {\tpbox second;};
\tpbox third;
```



The `\tpmove` command in the last example does not change the reference point!

5. Arrows and Corners — Tying objects together

As said before, `pic` supports a “link” mechanism:

```
... to 3rd last circle ...
```

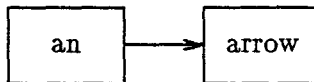
Since the actual position on a page is not available, this feature cannot be implemented in `TEX`. Because we are

already using a post-processor for drawing circles, it is not very difficult to extend the C program to store the positions of the objects. The communication is done again with the `\special` command of `TEX`.

5.1. Arrows

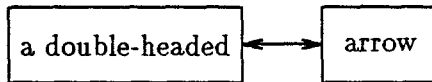
To work not only with lines we implement arrows:

```
\tpbox an;
\tparrow;
\tpbox arrow;
```

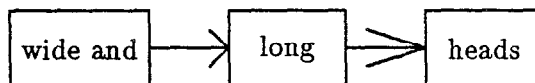


`TEX` does not support slanted lines and `LATEX` does not permit arbitrary slopes. Therefore, the arrowhead is drawn by the post-processor. There are two new *parameters* and one new *attribute* relating to the arrowheads:

```
\tpbox a double-headed;
\tparrow double;
\tpbox arrow;
```



```
\tpbox wide and;
\tparrow headwidth 0.2in; \tpbox long;
\tparrow same headheight 0.3in;
\tpbox heads;
```



5.2. Links

Links to objects are much better than coordinates for connecting objects with lines or arrows. Because the original syntax of `pic` is not ideal for scanning, I changed the syntax slightly from line from 2nd box to 3rd circle to `\tpline` from 2.box to 3.circle;:

```
\tpcircle; \par \hskip 3cm \tpcircle;
\tpline from 1.circle to 2.circle;
```




Counting up results in absolute links. Relative links are constructed by counting backwards:

```
\tpcircle; \par \hskip 3cm \tpcircle;
\tparrow from 2.circle to 3.circle;
\tparrow from -2.circle to -1.circle;
```



If one link is missing the current position is used:

```
\tpbox; \par
A link from a
\tpline from 1.box;
text.
```



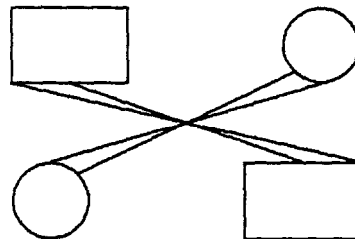
A link from a text.

5.3. Corners

Links can even refer to eight compass points on the perimeter of an object:

```
\tpbox; \hskip 2cm \tpcircle;
\par \vskip 1cm
\noindent \tpcircle; \hskip 2cm \tpbox;
```

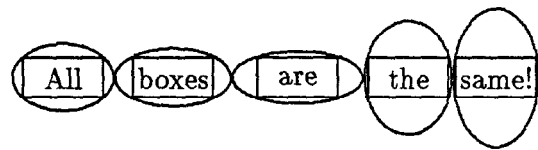
```
\tpline from -1.box.n to -2.box.s;
\tpline from -1.box.ne to -2.box.sw;
\tpline from -1.circle.n
to -2.circle.s;
\tpline from -1.circle.ne
to -2.circle.sw;
```



As you can see, circles also have "corners". With these features fancy pictures become possible. However, they require too much code to be shown here, see figure 1.

6. Ellipses — Circles with a catch

Unfortunately, ellipses differ considerably from circles since there is not just *one* smallest suitable ellipse around an object:



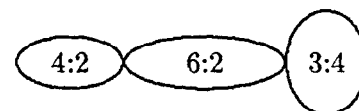
Because an ellipse has *two* major axes, it seems reasonable to require a fixed ratio for them:

```
\tpboxwd=30pt \tpboxht=15pt
%
\tpellipse {\tpbox invis};
\tpellipse {\tpbox invis width 40pt};
\tpellipse {\tpbox invis height 30pt};
```



If width or height are specified, the shape of the ellipse will change:

```
\tpelliwd=30pt \tpelliht=20pt
\tpellifill=0pt
%
\tpellipse width 40pt 4:2;
\tpellipse width 60pt 6:2;
\tpellipse height 40pt 3:4;
```



Within each ellipse the ratio of its axes is displayed.

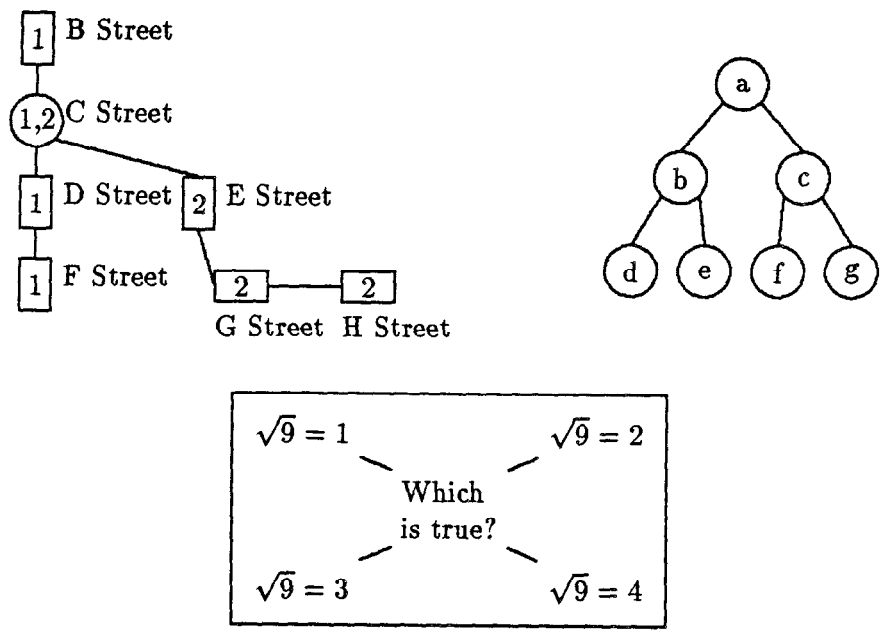
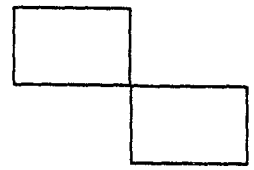


Figure 1 : Some fancy pictures.

7. Shifted Objects — With and without size

Sometimes it is useful to move whole objects. To do this, there are two new attributes: `with` and `at`. Unlike `at`, `from`, and `to`, `with` does not permit a link:

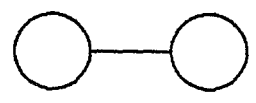
```
\tpbox;
\tpbox with .nw at -1.box.se;
```



Again with the C post-processor, the implementation is simple: only one change in position has to be made. But there is a problem: objects which are to be moved must be set without any size; otherwise, they will need some place on the page and after being moved this place would be empty! So the user has to worry about the space.

The “corners” of lines and arrows are abbreviated with ‘s’ for ‘start’ and ‘e’ for ‘end’:

```
\tpbox invis;
\tpline;
\tpcircle with .e at -1.line.s;
\tpcircle with .w at -1.line.e;
```



Without the `with` attribute, the center of the desired object is used:

```
\tpbox;
\tpcircle at -1.box;
\tpellipse at -1.box;
```



Once again, more elaborated pictures are possible, see figure 2 to 4.

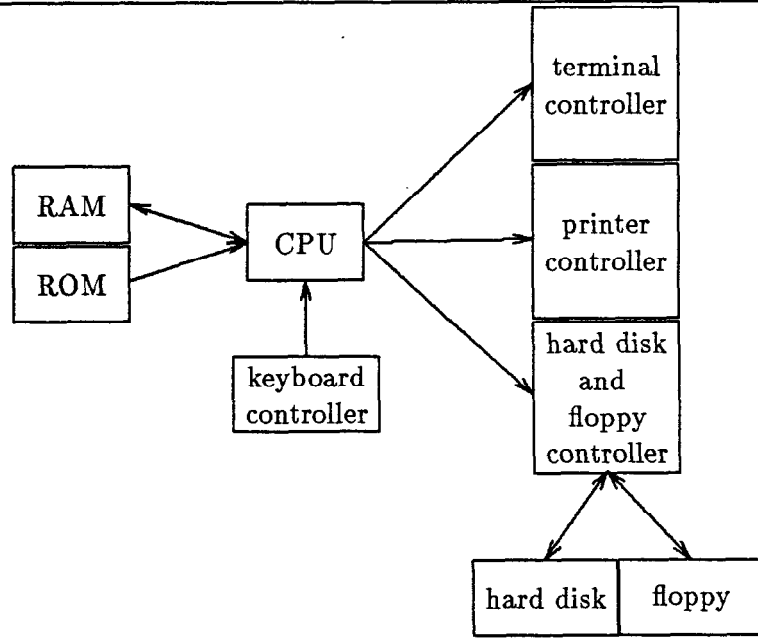


Figure 2 : An example of graph.

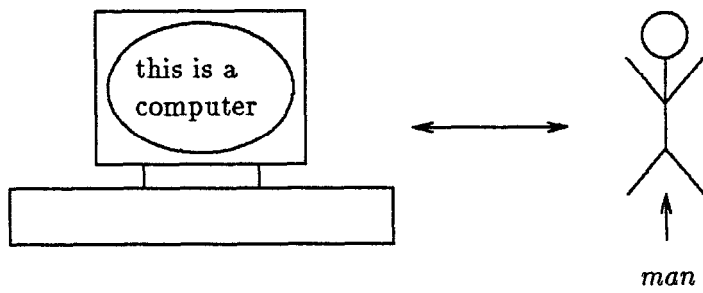


Figure 3 : Other examples of what can be done.

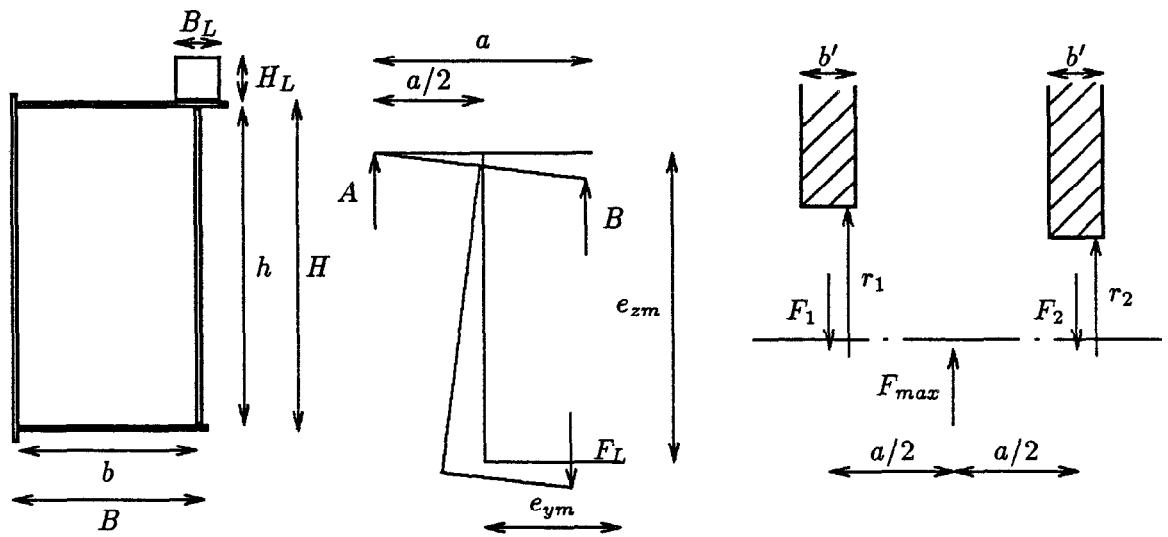


Figure 4 : A friend of mine, a mechanical engineer, supplied those pictures, which I would never have thought possible.

8. Conclusion

8.1. What has been done

Using *texpic* simple pictures in the style of *pic* can be drawn within a \TeX document. Graphical objects have been implemented which may be used with several attributes and positioned in different ways. *pic* syntax was modified slightly to accommodate \TeX conventions. Furthermore, there are two significant enhancements:

- Objects adapt to the size of their contents.
- The contents may be almost anything.

This results in a very smooth integration of text and line drawings. Through a C program as a post-processor operating on the *dvi* file, we achieved a very portable and absolutely device independent solution. Some points of the original *pic* were not implemented:

- *pic* itself serves as a target language for other pre-processors (*grap*, *chem*, etc.) New features in *texpic*, however,

will most likely have to be constructed within \TeX as well.

- In *pic* a picture can be scaled to near arbitrary dimensions. I see no way to do this in \TeX .

8.2. What can be done

A few more features are probably practical:

- Generalization of the corners, for example *nnw* or *sssee*. This requires only a little bit of mathematics.
- Arcs of a circle and splines. This is possible with some mathematics and the C program.
- References to the dimensions of an object, eg,
... -1.box.ht ...
- Local scopes for objects. This requires an extension to the management of object stacks.
- Labels for objects or whole pictures, as in:

```
\tpbox name ellipsoid;
\tpline from ellipsoid.w ...
```

- Coordinates with addition and subtraction. This is very simple, because we already have the coordinates in the C program. The only thing to do is to build an interface to T_EX, eg,

```
\tpbox with .n at -1.box.s
      minus (12,15);
```
- Interpolating a point, eg,

```
\tparrow from <1/3,-1.box.n
      ,-2.box.s> ...
```

There is a syntactical problem: a link must consist of one word.
- Projecting object coordinates, eg,

```
\tparrow from (1.box.s,
      -2.ellipse.n) ...
```
- Printing and positioning text. The ideal would be along the lines of “printf”, because this is simple to implement in C.

8.3. What might be done

I am afraid the following features would be rather difficult to implement:

- Grids with automatic scaling. There is a question: what should a good grid look like?
- Drawing arbitrary functions. This requires all sorts of mathematical and syntactical support.
- Simple graphics in the style of *grap*, a pre-processor of *pic*.
- Rotation of objects. This would result in substantial changes since then every object must be drawn by the post-processor.

It is interesting to note that further refinement of features appears to shift

more and more responsibility out of T_EX and on to the post-processor. Is the ideal solution a graphical co-processor to T_EX?

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