ON EDITING GRAPHICS FOR THE BLIND

A manual with examples, and for the interested layman a pictorial overview

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1. PREAMBLE

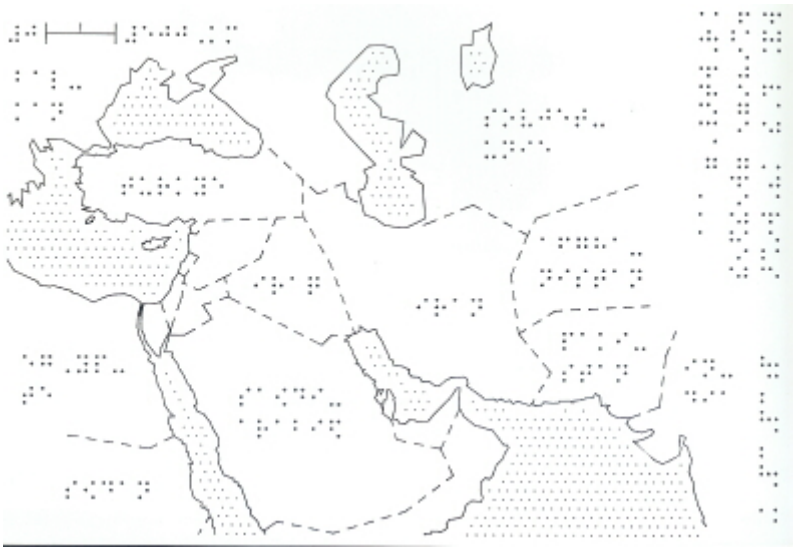
Quite a number of learned articles have been written on relief representations for the blind, but on the May 1988 Stockholm Conference I gathered no comprehensive shop-floor manual was available. So I figured an accessible translation of the manual I'd written in Dutch might come in useful to the workers in this field.
This rewrite into English is the manual's fourth edition: in every edition the general rules expand at the examples' expense, which of course is as it should be in a field as young as this. I guess development still has a long course to run ...
This manual is based on the work I've done at the Netherlands Library for Audio Books and Braille, which was almost exclusively on books for secondary schools. I have never occupied myself with mobility maps, and I think they're entirely different from my kind of relief drawings.
My graphics are put into relief on the stereo paper produced by Matsumoto, Osaka. As this paper has a finer grain, or is more sensitive than the Swedish product, it allows for stronger contrasts, like fine dots and thin lines next to solid black areas: it is more versatile. It's also more expensive, though, and unfortunately less pleasant to the touch too.

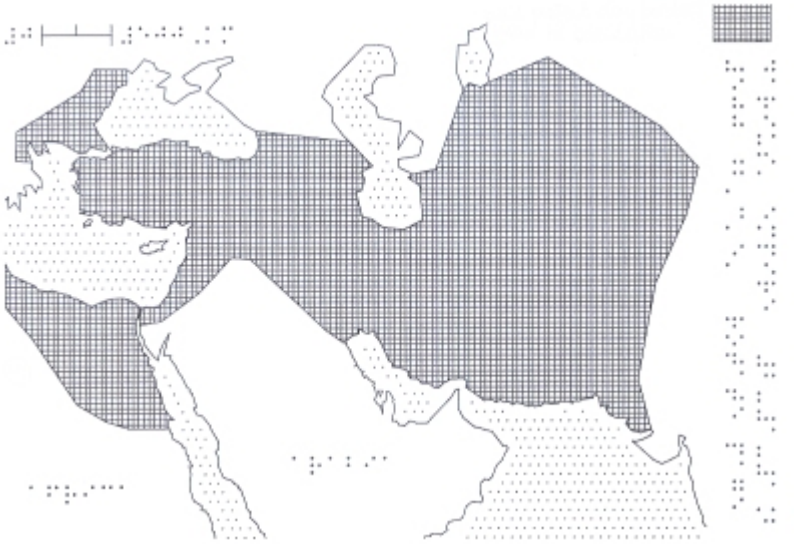
2. INTRODUCTION

In creating graphics for the blind one has to take into account that the fingers' discerning ability is so much less than the eyes', that in most cases magnification will be necessary; and of course text in and around the drawings will have to be put into braille; but I think most graphic material will need more editing to make sense to the blind reader.
One might argue that editing is wrong, that the blind ought to be taught reading graphics that are basically the same as in inkprint; maybe there's a point in this, it's paternalistic, but I'm afraid extensive editing is often the only way of rendering a figure meaningful to the vision impaired.
Some of the other editing is a choice, because I think it's best to do a drawing this way.
For instance, while the seeing person will generally have an overview of a picture at first glance, the blind reader has to go through most of the details in a picture to understand what it's all about: so adding a good title to a drawing is absolutely essential, as a surrogate for this overview-at-first-glance.

Point out King Darius' heartland
As another example, look at this historical map. There are no names, but the sighted reader will most likely recognize the area, and that will bring to mind other maps and data of the area that he or she has seen in the past; but to the blind reader it's most likely just a blur with some lines and dots.

I think we have to provide the information that's not obvious to the blind, but that's taken for granted by the mapmakers for the sighted.
So I have added a map 'Present-day Countries' in the same outlines, and I have identified some of the surrounding areas in the original map.





I thank my former and present department heads, Mr Leon Knierum and Mr Herman Philipsen, and my former and present immediate superiors, Mrs Nieuwpoort, Mr Van den Assem and Ms Hélène Vos, for putting and keeping me in this position and allowing me time to think and write about the development of the field; and I thank the members of my staff, especially Marlon Macville, Walter Smekens and Leen Verkijk for their examples and instructive mistakes.
One of the ideas on maps I got from from Colin McEvedy's beautiful historical atlases (Penguin); some inkprint graphs etc. were taken from The Economist.

3. BASICS

MINIMUM DISTANCE

As a blind person won't be able to discern two points as separate entities if they're closer together than 2.5mm, this 2.5mm is about the minimum distance between different items in relief drawings.

THE FINGERTIP WINDOW

Also important to keep in mind is the concept of the fingertip 'window', about the size of a Braille cell. Cut a hole about this size in a piece of paper, move that over a drawing to get an idea of a blind reader's perception.
Also, if for instance you have to show that a line is interrupted, the break shouldn't exceed this window.

STAINLESS

Keep your drawings clean, free of stains: the blind reader won't recognize smudges for what they are, but will think they're part of the picture.

EXCELLENCE

Strive for excellence in draughting: either make a good drawing or none at all: no halfway house. Understanding graphics will never be easy to the blind, and an unintelligible drawing will put our readers off and is going to amplify the notions about the usefulness of our work. If you are not sure whether a particular drawing makes sense, consult a blind reader, and when still in doubt abort or try a radically different rendering.

THINK FIRST

Ideally one should ask oneself at each figure what its meaning is and how best to represent that to our readers. Of course in many uncomplicated drawings that won't be necessary, but one should be wary of unexpected unclarities and have possible elucidation in mind all the time. One should never unthinkingly copy inkprint, but look for the best way to render the subject to our readers: put things in or leave them out, change, separate, comment, go for a partial or complete description. Consequently the drawings I find hardest to re-create are in the fields that I do not understand the method of, like psychology or economics (I was raised in physical sciences): as I do not understand clearly what their schemes mean I do not know what's important and what isn't, so I don't know which things are to be displayed prominently and which elements might be left out, and I cannot really describe these drawings accurately.
So otherwise one has to be careful about editing drawings from subjects one is not familiar with.

ENLARGING, SPACE

Only a few drawings need no magnifying. Sometimes, when recognition of a specific form is asked for, a small figure will do better; but in general draw your graphics as big as possible. If text and key might take up space needed for your graphics, don't hesitate to transfer them to a separate page.

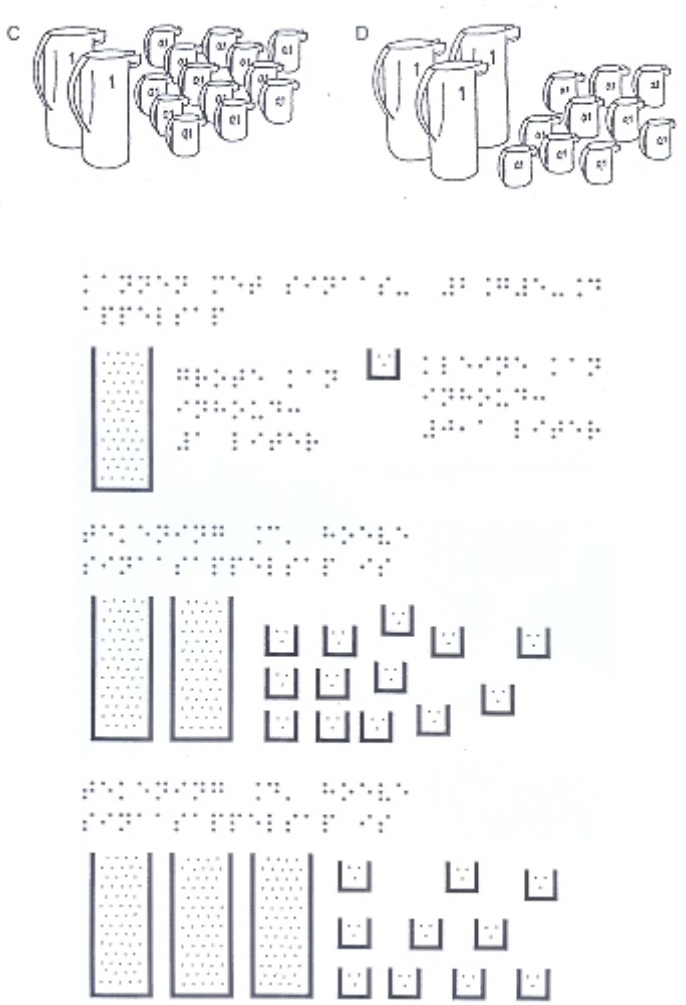
CONTRASTS

Not only should your drawing be large, but also have its elements contrast as much as possible, thin lines and fat lines, no hatchings that look about the same. I think drawings that have a bold, solid look are best.

EXPLAIN, SIMPLIFY

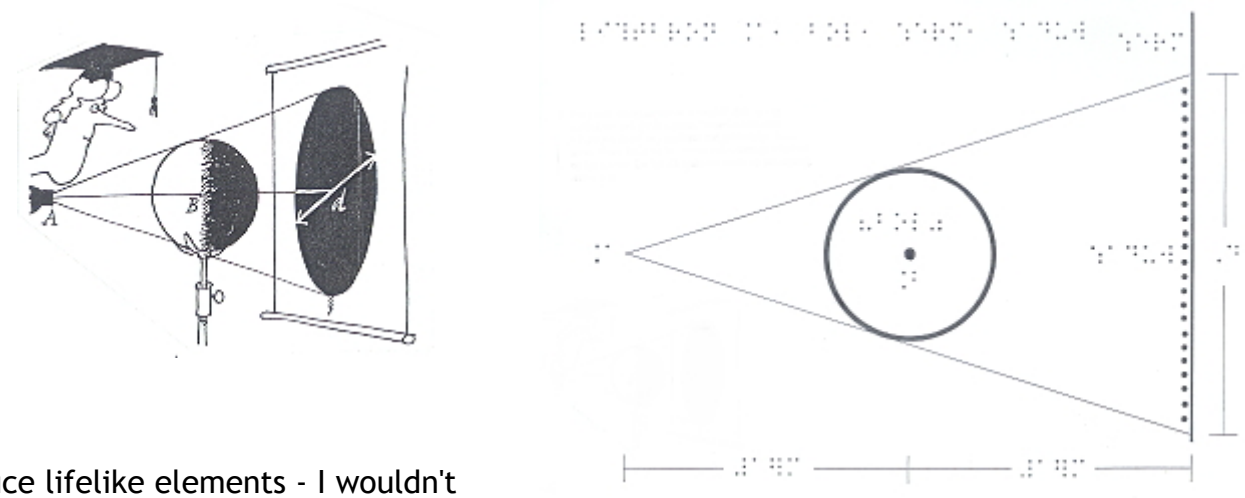
Some drawings contain small real-life parts, unrecognizable to a blind reader: simplify these figures and explain them in key or with an accompanying word.

1. Formalize, Reduce to Essentials



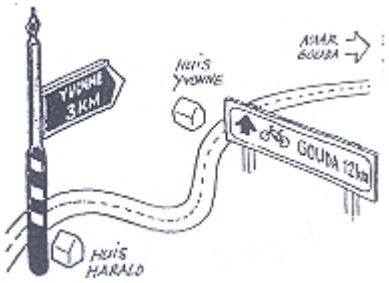
True pictures of pitchers will be hard to recognize. Note that the pitchers are all drawn separately, overlapping would make them hard to recognize. Also note that the pitchers are not empty, for those would just look like a crooked line.

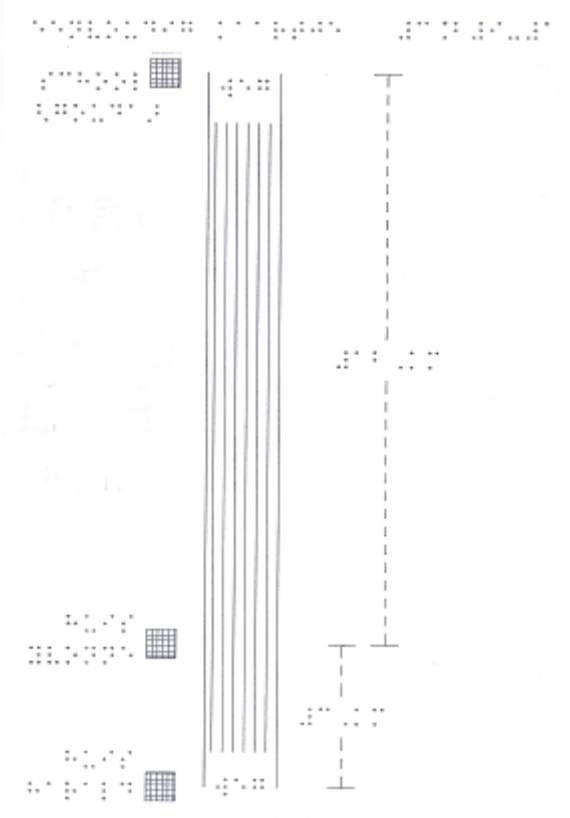
2. Simplify, Explain



Reduce lifelike elements - I wouldn't want my readers having to waste time puzzling over the professor's head. Lightpoint A, 2 meters from screen; ball with center B, radius 30cm; line AB perpendicular to screen, AB=1m.

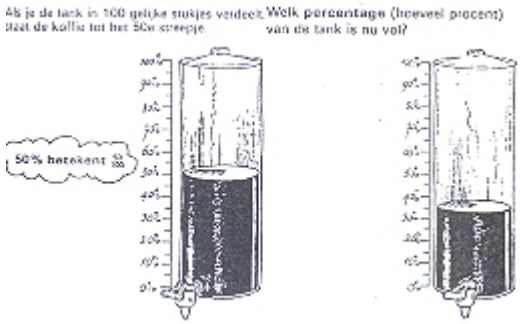
3. Reduce to Essentials

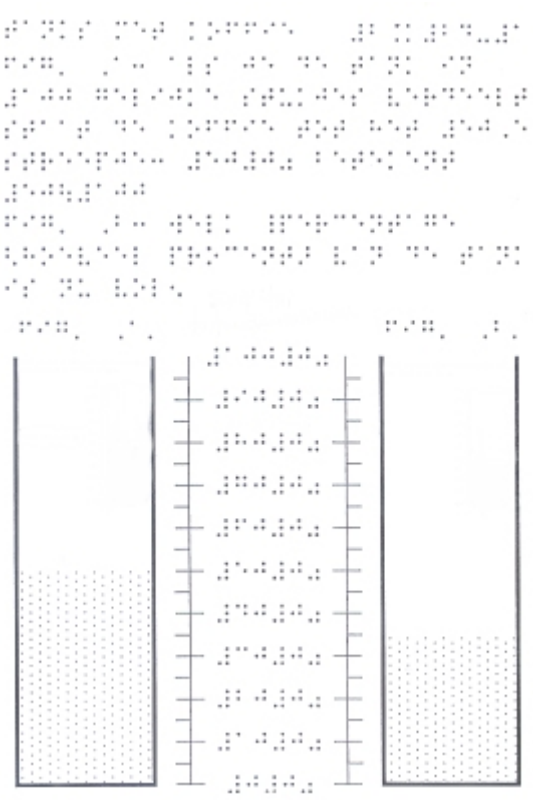




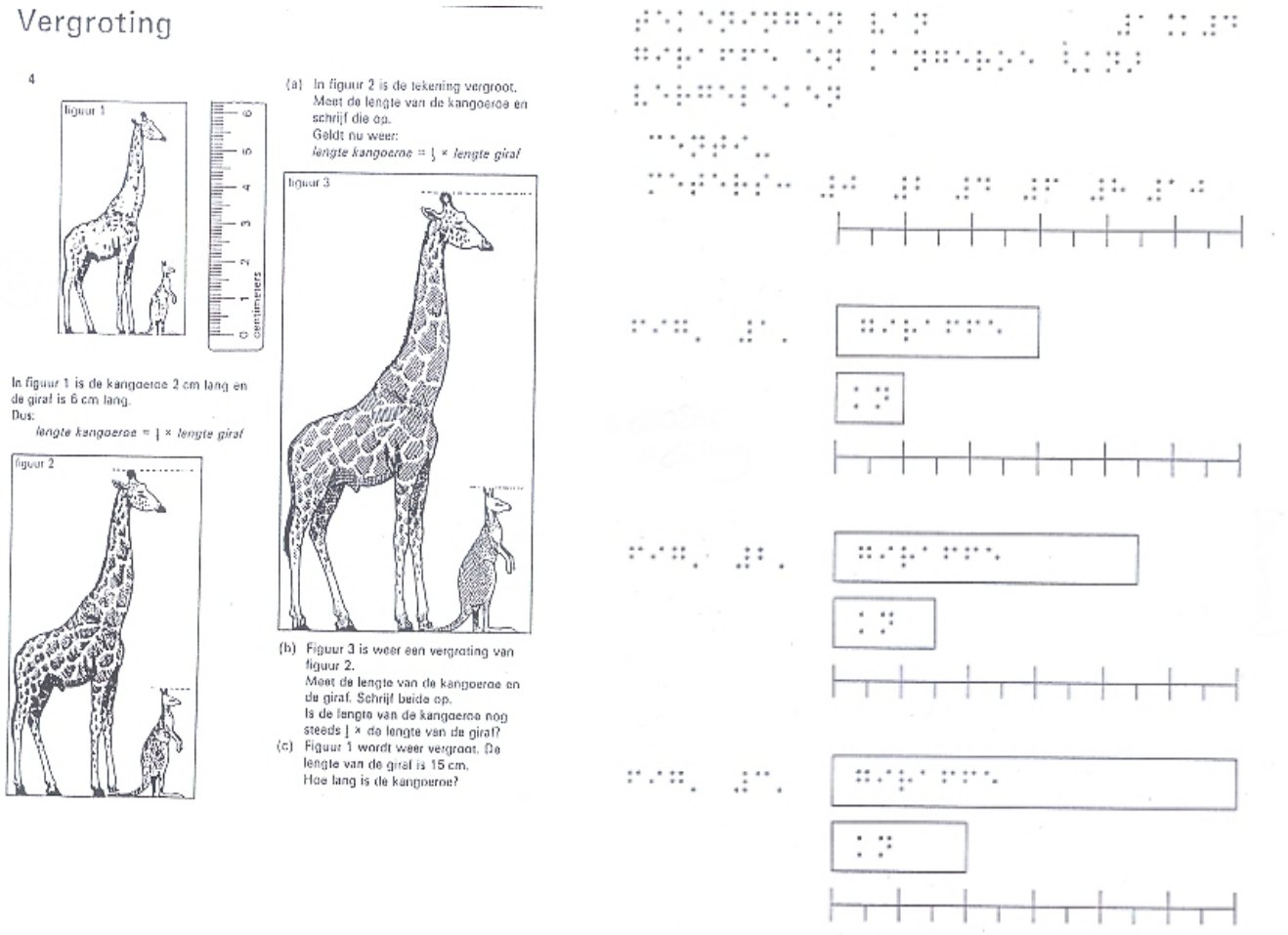
Would the house shape make more sense than a square?

4. Formalize, reduce to essentials





5. Formalize, Reduce to essentials



Vergroting

4

figuur 1

In figuur 1 is de kangoeroe 2 cm lang en de giraf is 6 cm lang.
Dus:
lengte kangoeroe = $\frac{1}{3}$ × *lengte giraf*

figuur 2

(a) In figuur 2 is de tekening vergroot. Meet de lengte van de kangoeroe en schrijf die op.
Geldt nu weer:
lengte kangoeroe = $\frac{1}{3}$ × *lengte giraf*

figuur 3

(b) Figuur 3 is weer een vergroting van figuur 2.
Meet de lengte van de kangoeroe en de giraf. Schrijf beide op.
Is de lengte van de kangoeroe nog steeds $\frac{1}{3}$ × de lengte van de giraf?

(c) Figuur 1 wordt weer vergroot. De lengte van de giraf is 15 cm.
Hoe lang is de kangoeroe?

Turn the giraffe and kangaroo into named boxes. The direction has changed from vertical to horizontal to facilitate writing. Also note that a ruler is provided with each drawing, for the blind readers may not have a measuring rod as readily available as the sighted reader.

UNIFORMITY

Graphics being hard for the blind anyway we had best ease the burden by striving for uniformity. If our readers are able to recognize quickly the kind of drawing and its usual items, they only have to touch these lightly, saving time to focus on the particular elements.

TIME

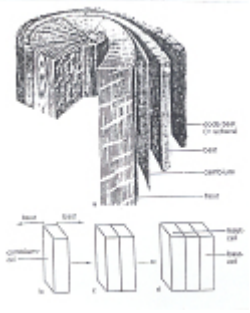
The sighted take in pictures at a glance, but to the blind reader it is always a matter of minutes, a series of maps might take some ten to fifteen minutes; so the draughtsperson should ask himself if this amount of time taken is justified in view of the kind of information provided in these graphics. Imagine a blind student poring over some maps for twenty minutes to answer a petty question in an examination.

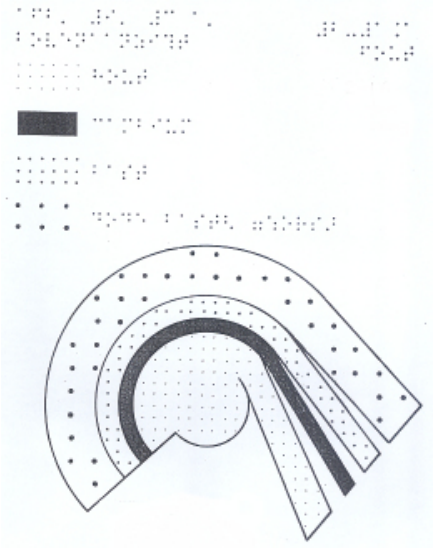
4. THREE EXAMPLES

In editing complicated graphics, the draughtsperson should look for the print picture's meaning, and render it in the most simple and/or clearest way to a blind reader.

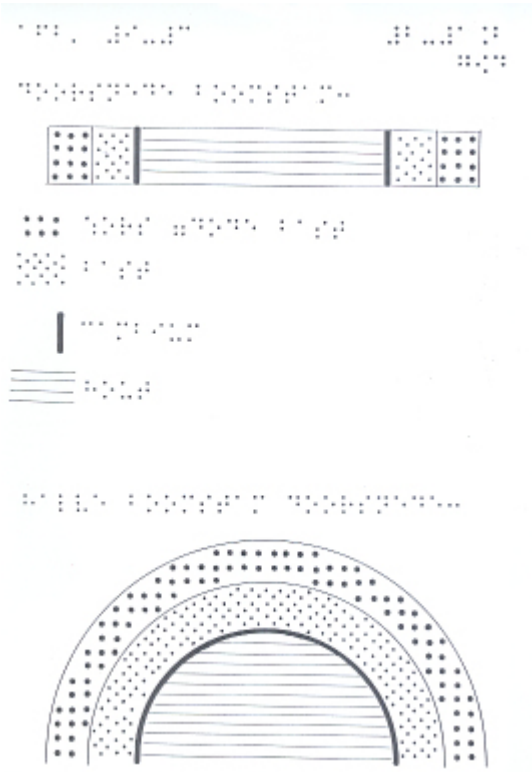
Example 1:

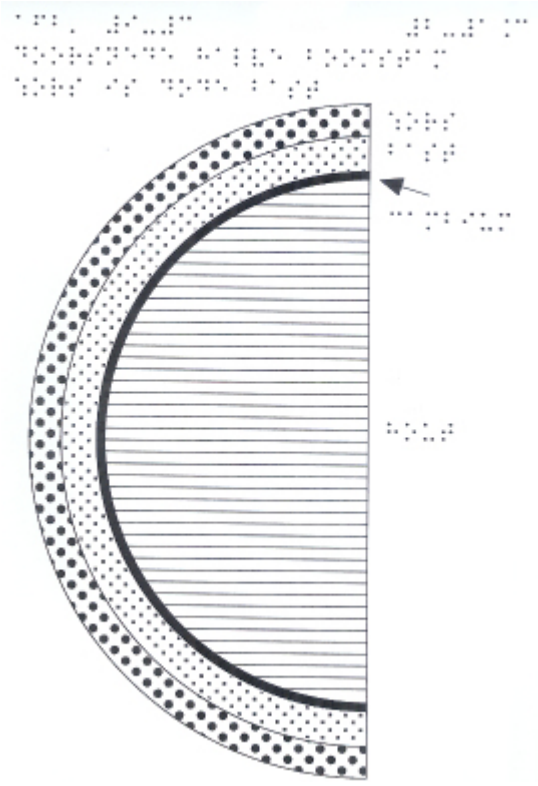
Take a look at this transverse section through a tree trunk. In print, the different elements have been fanned out: one wonders what kind of impression the faithful copy will make on a blind reader. Do trees look like that? A less complicated, more realistic rendering of the material will make more sense.





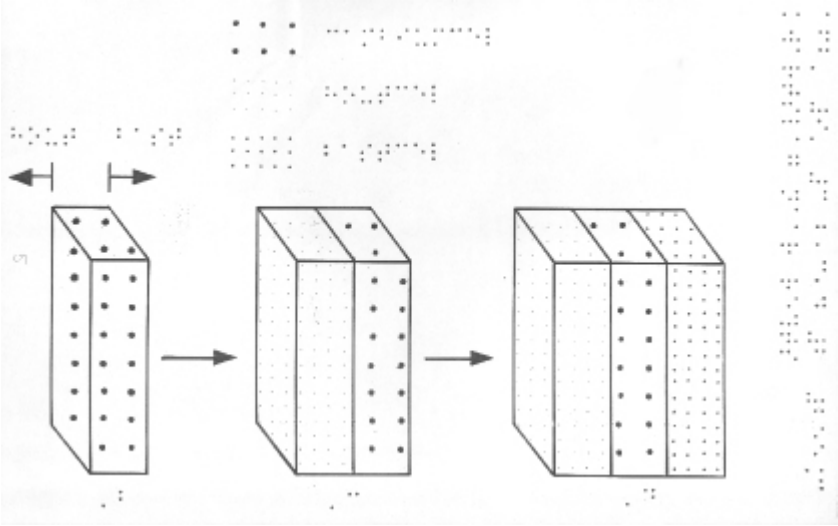
Wrong: can we expect the blind reader to make the leap of imagination to see this as a cut through a tree?



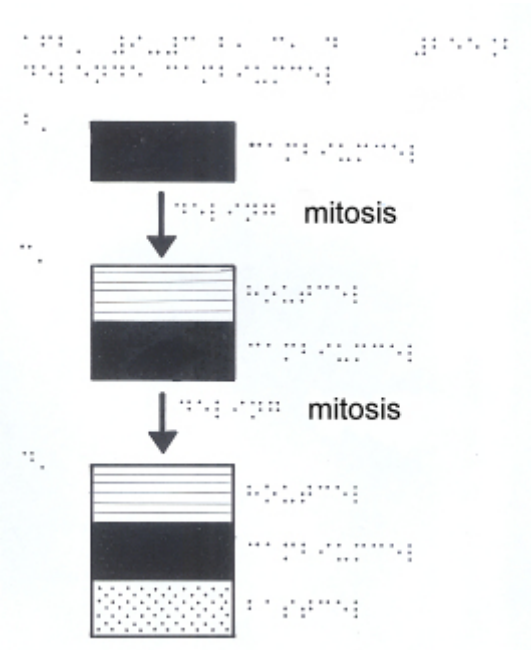


Better, but could use a key. See the image to the left.

In the cell mitosis drawings that go with the tree trunk, I wonder if drawing a cell spatially will be very useful: representing a cell by a rectangle will make the drawing far easier to read. Also note the addition of the word 'mitosis' at the arrows.

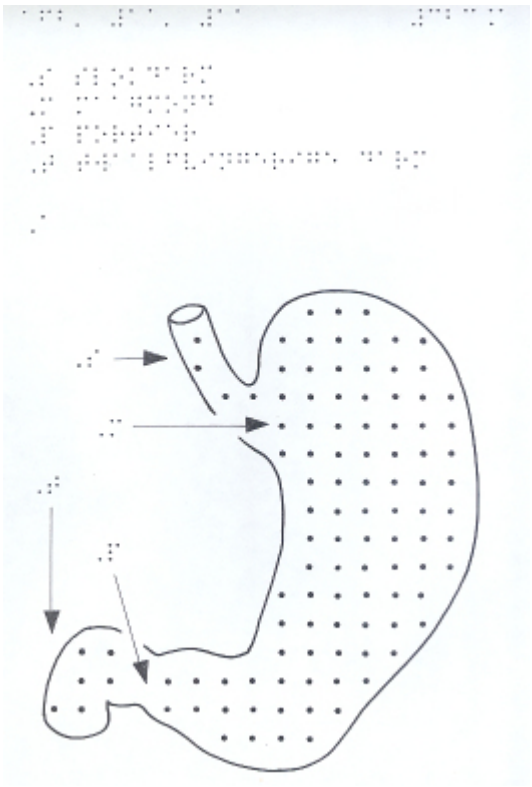


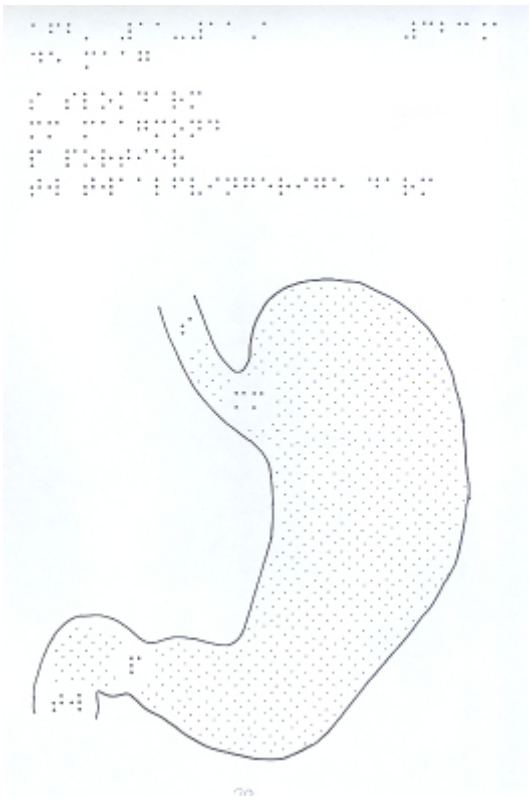
Will the spatial drawing with broken lines mean anything to the blind reader?



Also note the addition of the word 'mitosis' in braille.

Two stomach drawings look all right at first glance, but the second one will actually be much clearer to the blind reader.





6 mistakes:

1. Spatial elements

The stomach's entrance and exit are drawn spatially, an ellipsis and an arc: will this make sense to the reader? What will the ellipsis mean to him? In the second drawing it is immediately clear what the stomach's openings are.

And besides, the drawing is of a section through: not spatial, not the stomach taken out, so representing entrance and exit as openings makes more sense.

2. Hatching

A hatch is meant to show something's extent. In the first drawing the big dots are so far apart that the reader might easily gather that they are meant to represent something like holes or moles. Ideally a hatch's elements should not be individually discernible.

3. Arrows

What exactly do arrows point at? Isn't there a choice in 2-3A at the arrows indicating the duodenum and oesophagus? Placing one or two characters in the right place is unequivocal, leaves no room for doubt. Sometimes an arrow is the only way of identifying an element, but I think they should be used sparingly.

4. Title

The title is missing. To find out what's in this drawing the reader will have to look it up in the text volume, or he'll have to infer it from the names in the drawing. The small addition 'The stomach' will greatly enhance this drawing's value.

5. Figure number

The figure number is split over two lines, 11.11 in the first line, A in the sixth. Why not simply fig. 11.11-A in the first line?

6. point 6 - There is no need for point 6 in biology.

5. GENERAL

GRAPHICS VOLUMES

In a book of only a few drawings these are added to the text volumes and given 'A' page numbers (89A, 22A, 22B etc.), so as not to be restricted to a fixed number. If the number of drawings exceeds say 15, we dedicate one or more volumes to graphics; these volumes are numbered A, B, C etc. so as again to be at liberty, as I generally find it very hard to guess their number correctly beforehand.
The title page of a graphics volume should look like the text volumes' title page. It should state:

- title
- subtitle, if any
- author(s)
- number of impression and/or edition (if any)
- volume number (A-)
- in case of two or more volumes, it might be useful to state which chapters' graphics are contained in this volume
- inkprint publisher, city, year
- braille publisher, city, year

TEXT

The rendering of mathematics etc. in a drawing of course has to be uniform with the other text. Formerly most of the text in a drawing, lists of abbreviations etc. were put in the text volumes, but some time ago we have argued at our library that though somewhat more expensive, it is to be preferred to have the graphics volumes stand on their own, so as they can be read without having to look up explanations etc. somewhere else.
But we still expect the text volumes to carry the complete titles of graphic material, reference numbers, and besides that the data that are not essential in reading a drawing, like its source or author.

PAGES

In The Hague we are at the moment experimenting on having related pages face each other, but there are some doubts as to the relief rubbing off and pages going to stick to each other. If these objections are met it's of course quite useful, not having to turn the page to get at the key etc.

NUMBERS

The figure or page number is placed at the right-hand upper corner of the page. In general stick to inkprint figure numbers; if missing make them up yourself, preferably relate to chapter and paragraph (fig.3-2 rather than fig.16). Figure numbers are absolutely indispensable for reference in graphics volumes.

TITLE

Never forget to put a title title a drawing, to give the reader an idea what's in store; state also what kind of drawing it is: graph, bar chart, triangle, etc. Do not copy inkprint unthinkingly, but have your title say exactly what your drawing is going to show.
Occasionally key or explanation of abbreviations might work as a title, like stating what x and y stand for will introduce a graph.
The blind reader will not automatically understand a drawing to be part of a series or an enlargement of a detail, so state those things clearly in your title or at the end of your drawing, 'enlargement detail', 'to be continued on the next page,' etc.

PAGE ROTATION

As we use the A4-format, short side on top, drawings that have more width than heighth will have

to be put on a rotated page; rotate clockwise, or else the reader will have to reach over the facing stack of pages. Use some standard text in cases like this, 'turn page to the right' or 'rotate page clockwise'. (My fonts print this line at one keystroke.) Preferably put key and other text (except number and title) in the direction that the drawing is to be read, also when on seperate pages. It is not a good idea to switch direction within a series, but sometimes it cannot be helped.

MARGINS

Drawings should stay clear of the paper's edges. At the left side a margin of about two centimeters will have to be kept clear for binding; on the other sides a space of about one centimeter is best left open to avoid losses in xeroxing. On a facing left-page the 2cm margin will be at the right of course.
Unfortunately our plotter restricts us to a height of 27.2cm anyway.

START

I prefer to begin a drawing by putting down number and title, so as not to encounter a limitation there after having finished the graphic part. When graphics need all available space I limit text to two, or very occasionally one line.

ABBREVIATIONS

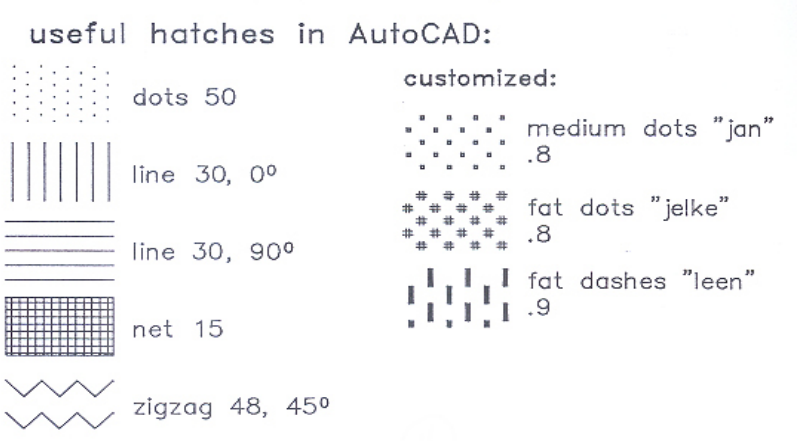
Though a complete word will occasionally nicely fill out an area, long words will not point clearly at one element in the drawing, and as they generally take too much space anyway, abbreviations are to be used. We mostly utilize one- or two-character indicators in relief graphics. For ease in reading, try to work out abbreviations that still show something of the original word. Try to use existing abbreviations.
List the abbreviations and their explanations in alphabetical order, or, if you really understand what a drawing is about, in the order it should be read. Sometimes part of the inkprint graphics, like numerical values, can be incorporated in this list of explanations.
Remember that braille characters a-l cannot stand on their own, but need something like a preceding point 6; and be careful about employing mathematics-code characters in math and physical sciences figures.

LINES

In hand-draughting we utilized pens of .25mm, 1.0mm and 2.0mm width, resulting in three clearly different lines. In plotting Autocad, for technical reasons we only use one pen, 0.5mm width, so we lost the very thin line. In some cases, like grid in graphs, we now use a fine dotted line, preferably about 3.5mm interspaced.

HATCHING

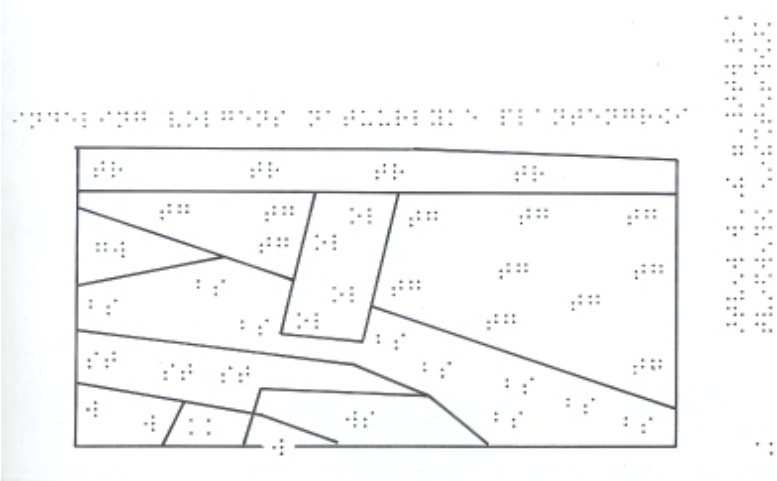
Hatching is what I call filling in areas ...
To use in hatching, I've been looking for patterns that are clearly different from *each* other to the tactile reader. Tests with blind colleagues resulted in this set of eight. I do not object to other types of hatching, but I'm afraid it will be hard to find another clearly different pattern.



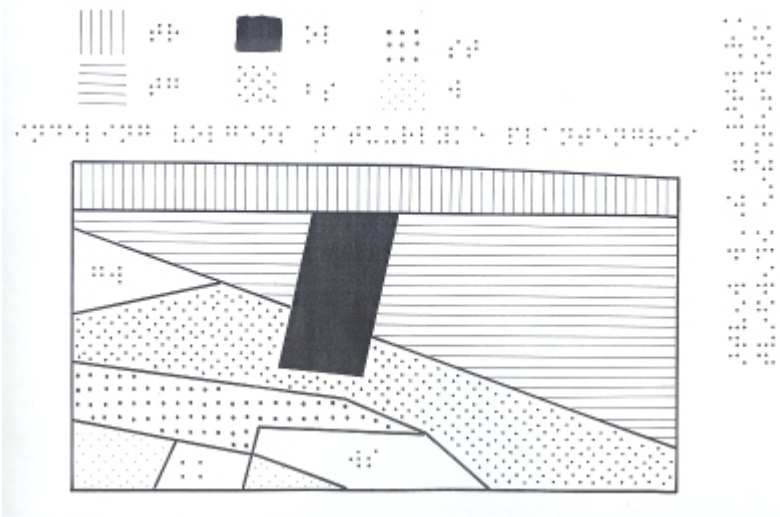
Some patterns might be used at different angles; but only Line is that clear it can be used to indicate different areas. Choose zigzag's and the dashed lines' angle as will fit your drawing best. Line might look like real lines in a drawing, so use this pattern sparingly to avoid confusion, especially in mathematics. The medium dots ('jan') might look like braille.
For larger areas, shading is preferred over filling in with abbreviations.

Shading or Abbreviations?

(Natural vegetation in Russia)



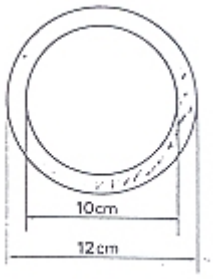
It isn't wrong, but ...



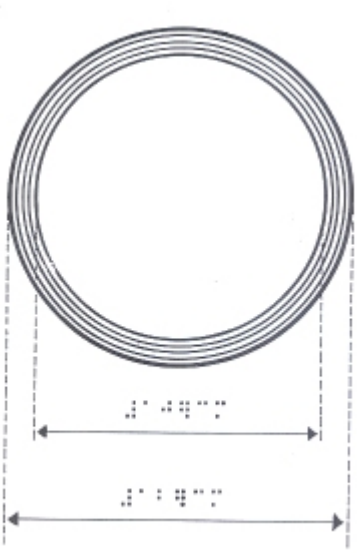
Shading is preferred over abbreviations for filling in larger areas.
Abbreviations are OK for small areas.
(This picture was drawn before I developed the hatching-without-borderlines doctrine.

Lines through hatching will not be very clear, so don't follow the original drawing or leave room around the lines. (See also *Arrows*, below in this chapter.)

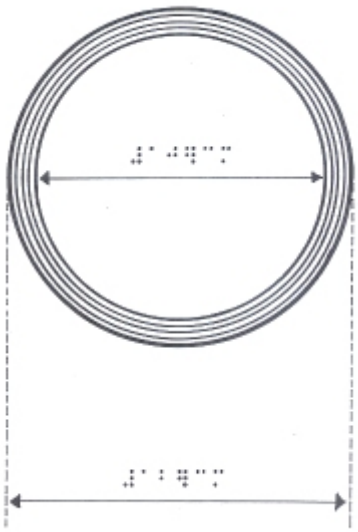
Edit your drawing to avoid lines through a hatching



Original

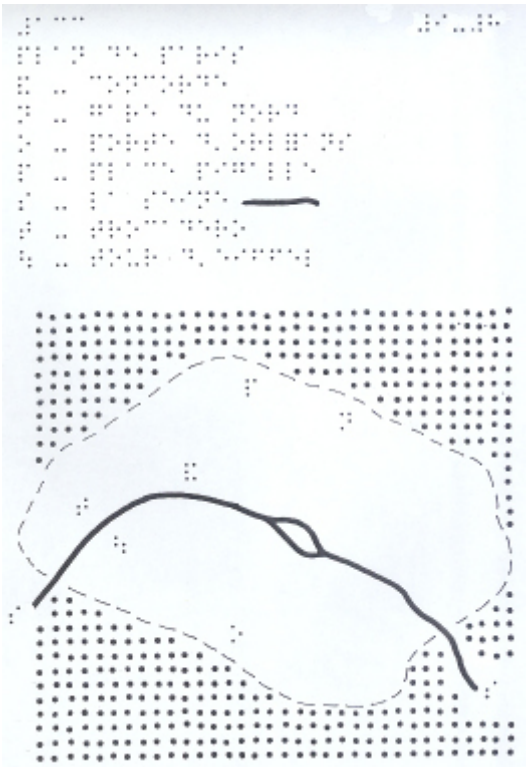


Wrong



Right

Counter-highlighting is what I call putting a hatch around the relevant area, leaving the unshaded area standing out (.. blankly). This also allows for writing text or identifying characters in that area. But usually there is so much more blank space on a page that it doesn't work to identify smaller areas.



A borderline in between two hatches impairs clarity, so ask yourself if you can't do without; also don't put lines around the patterns in your keys. Generally I only put in a bordering line when there's hatching only to one side of it.

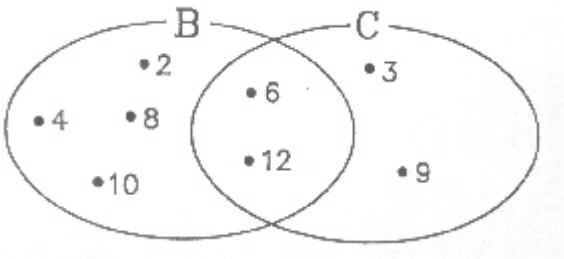
Take care your hatches stand at least the minimum distance (2.5mm) clear of each other and other elements, or they won't be clearly discernible. The small-dots pattern feels a bit like the hatch in the plastic Thermoform maps indicating surface water, so I generally use this one for surface water, and also in fluids, cells, living tissue etc., water interpreted broadly.

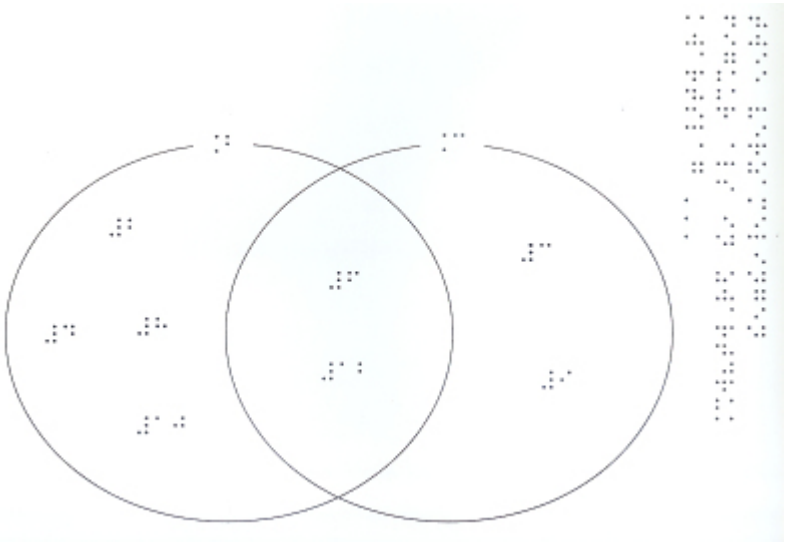
Solid hatching, a completely black area is only a waste of time and ink, as in relief it will feel the same as a crosshatching like net 15. (In hand-draughting we of course filled in the solid areas using brush and ink.) I think small areas are best hatched in this pattern.

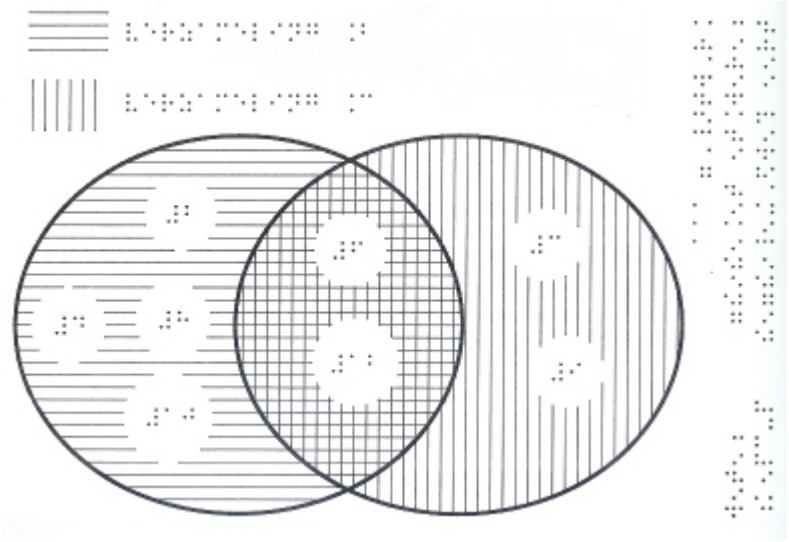
FILLING IN

Sometimes a line in an otherwise clear field in ink print is an edge, an outline: the blind reader on encountering a form like this will only recognize it as a line, not as a form: so I think forms, shapes had best be hatched.
Look for example at the Venn-diagrams below. Ink print shows two ellipses, sets of numbers. Imagine a blind person reading a faithful copy, coming across lines and numbers, but what do they mean? "Ah ... here's a line ... I feel a dot ... and a number ... lines crossing ... a dot and a number ..." The ellipses will just be curved lines, and there appear to be some numbers in the drawing. I think sensible editing can make a drawing like this a lot more meaningful: by hatching the sets in different patterns, explaining these patterns in a key and stating 'Venn- diagram, two sets' in the title, of course.
Also note that in the braille version there are no dots next to the numbers: the numbers 'represent themselves.'

Filling In To Show Sets (Venn Diagrams)

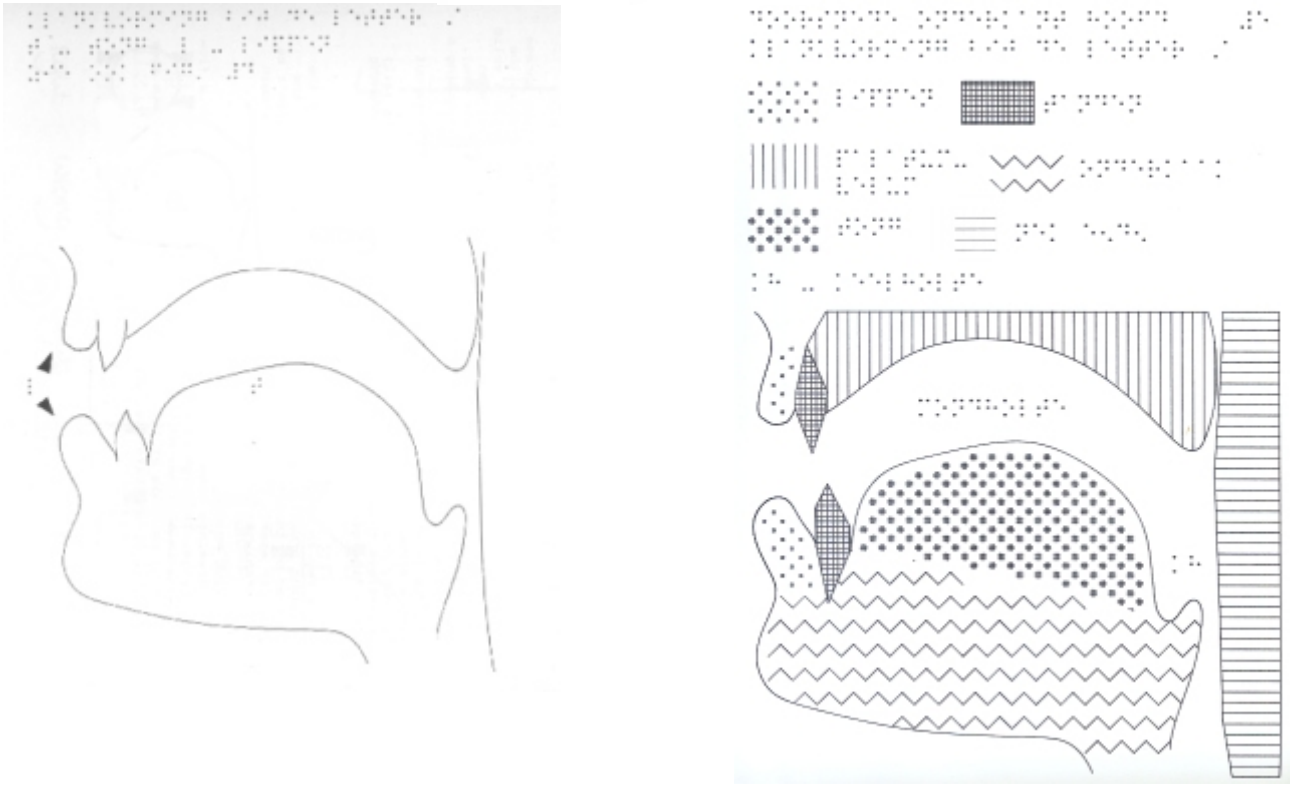






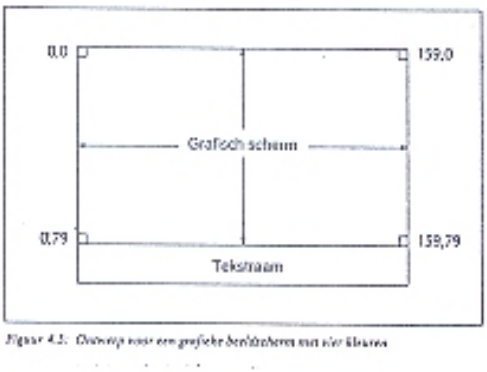
Another example of the need to fill in spaces because the vision impaired reader does not easily recognize lines as indicating shapes is this ugly picture of the shape of the mouth forming letter 'a'.

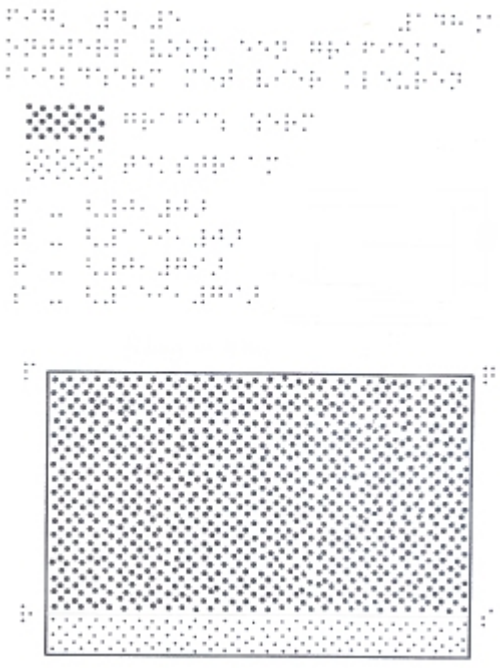
Filling In Shapes



Filling in an area shows its extent much better than arrows indicating an outline.

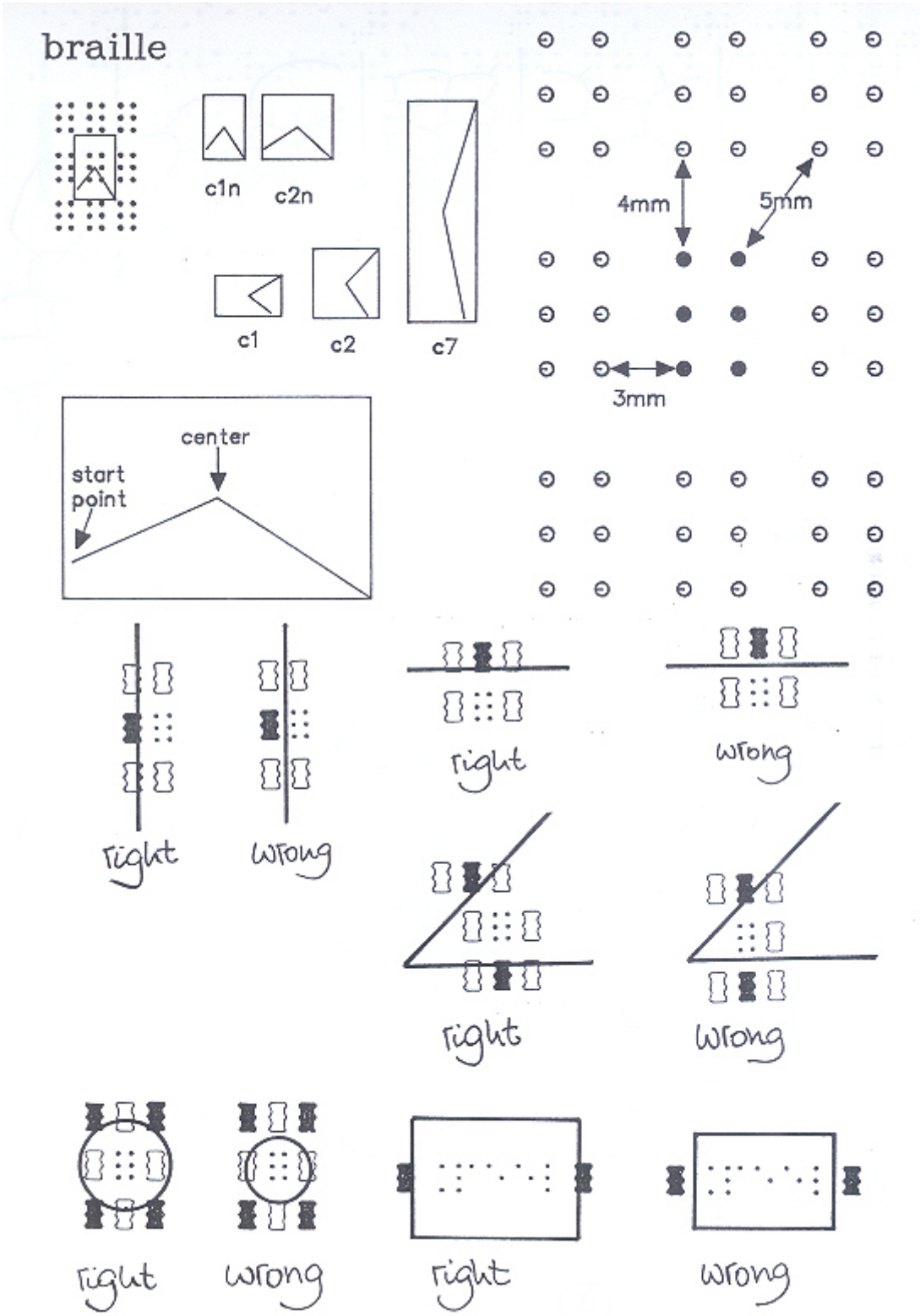
Showing an Outline: Arrows or Filling In?





CLEAR SPACE AROUND BRAILLE CHARACTERS

Braille characters should not be touched by lines and be sufficiently clear of other elements in a drawing.



Imagine some lines of braille text. Single out one or two characters. Draw straight lines around the chosen characters at the nearest points in the surrounding braille characters, left and right, above and below. The rectangle shows the amount of exclusive space a braille character needs. Distance to the lines above or below is about 4mm, to the left or right 3mm, diagonal 5mm.

Take care with initial or final characters that don't have a complete row or column of braille dots, like character l or the capital sign: despite the open space the same area should be cleared as around a full character.

The ASCII Braille Alphabet

As well as being the characters used by an embosser, these characters map to the keys needed to produce the Braille character in a word processor, using the Braille font.

Braille Reference Chart mapping each cell to an ASCII character.

	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

ASCII Braille refers to the codes which have to be sent to a Braille Embosser to correctly print the cells corresponding to the text to be transcribed.

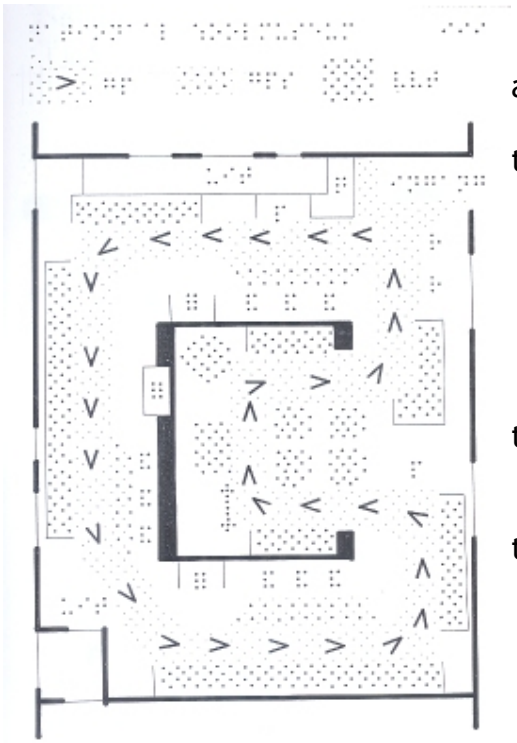
DOTS

Sometimes a graph shows fat dots, points, or in maps cities will be represented by dots or small circles. I prefer to leave out these dots and put the indicating character in its place; except of course when a high degree of precision is called for, but that's rare.

ARROWS

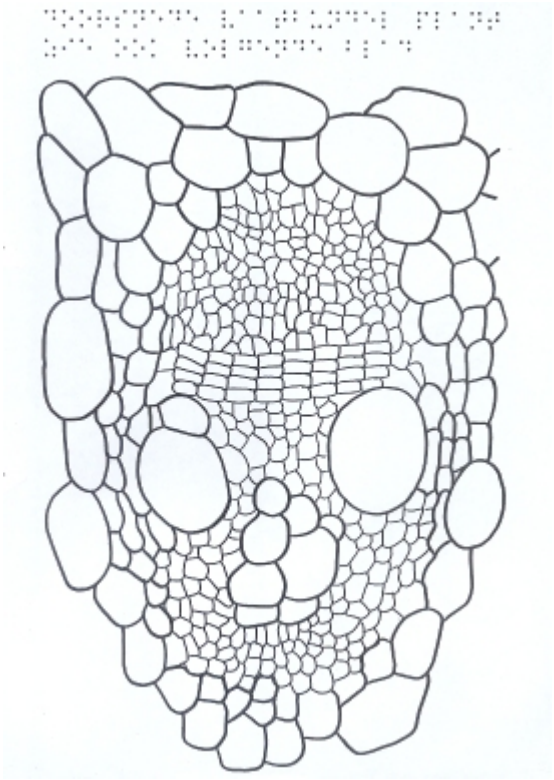
I try to avoid arrows by placing the indicating phrase in or close to the item, or by using key, but sometimes pointing an arrow is the only way to put a name to an element in a drawing. Employ a solid triangle and don't leave out the tail on the short side, the triangle without it doesn't work; when cramped, a V-shape arrow will do.

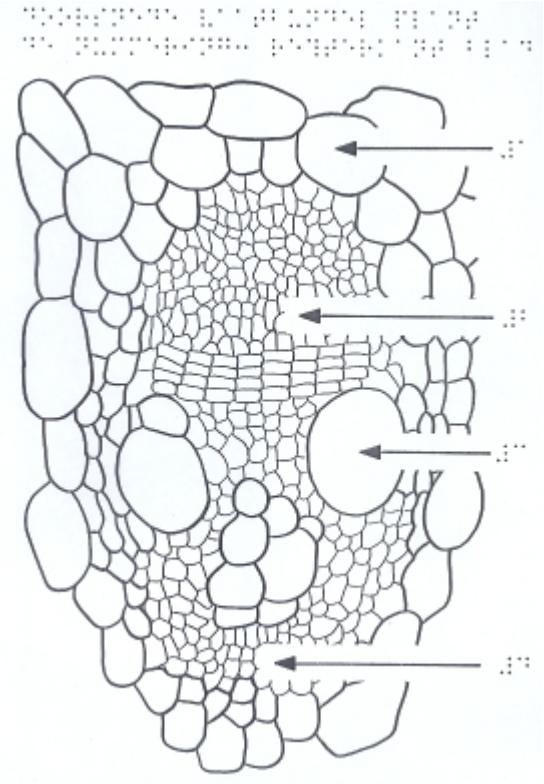
V-shaped arrows:



In very fat lines (over 5mm), having the line gradually taper to a point is better than adding a big arrow shape at the end. In simple graphs that only have arrows at the axes I leave out these arrows and put in a zero or origin sign. In busy drawings, clear a shaft around the arrow and its tail; sometimes this calls for an accompanying unaddled copy drawing (see figures overleaf).

Clearing Shafts for Arrows





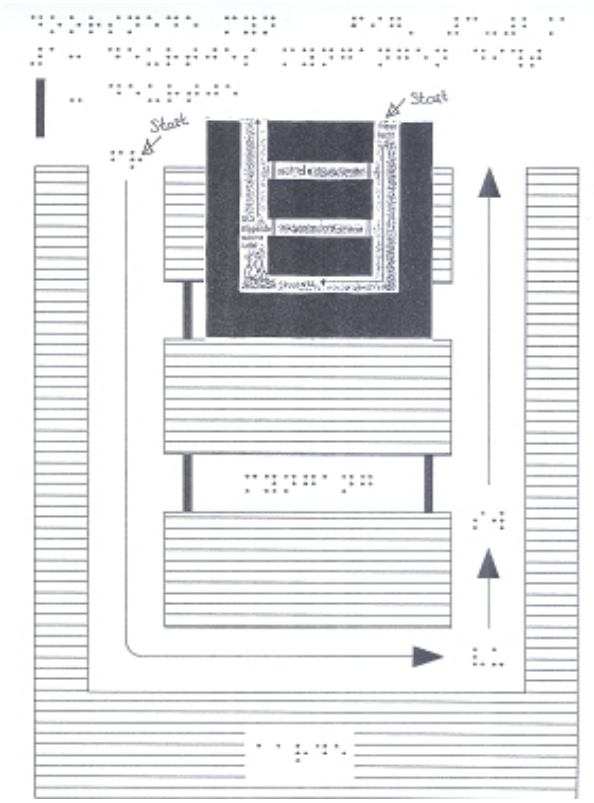
KEY

If a key is needed, put it where it will be read ahead of the drawing proper. If it has to be in another place, notify the reader of this in your title. The columns of a key shouldn't be too far apart. On a page that's to be rotated, the key should preferably be written in the drawing's direction.

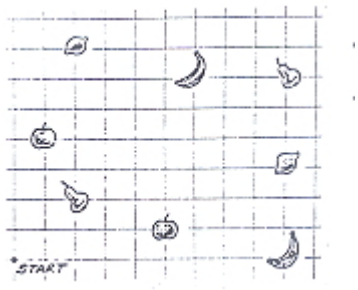
STARTING POINT

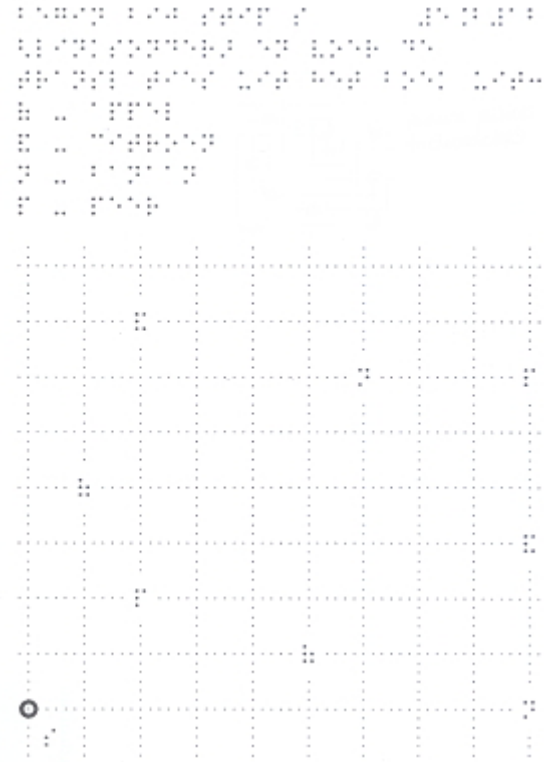
Some drawings show a sequence of events, a progression or a flow of things. The sighted reader will find the place to start reading in no time; not so the blind reader, so either edit your drawing to have this starting point at the top left of your drawing, where the blind reader starts reading, or indicate its location in your title.

Drawing Edited, Starting Point Moved



1. Starting Point Indicated

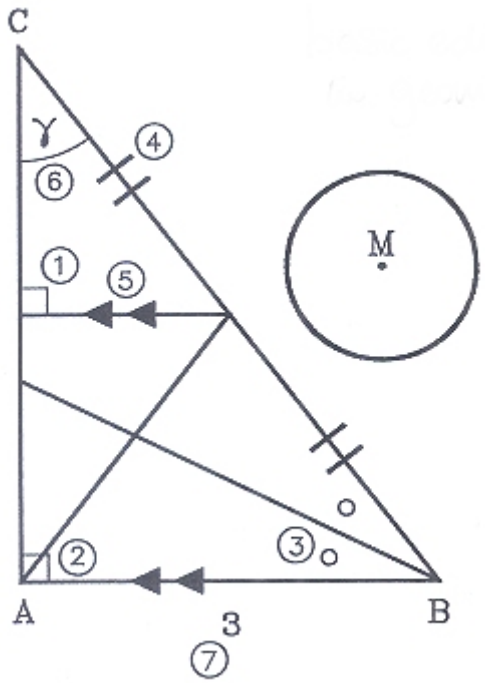


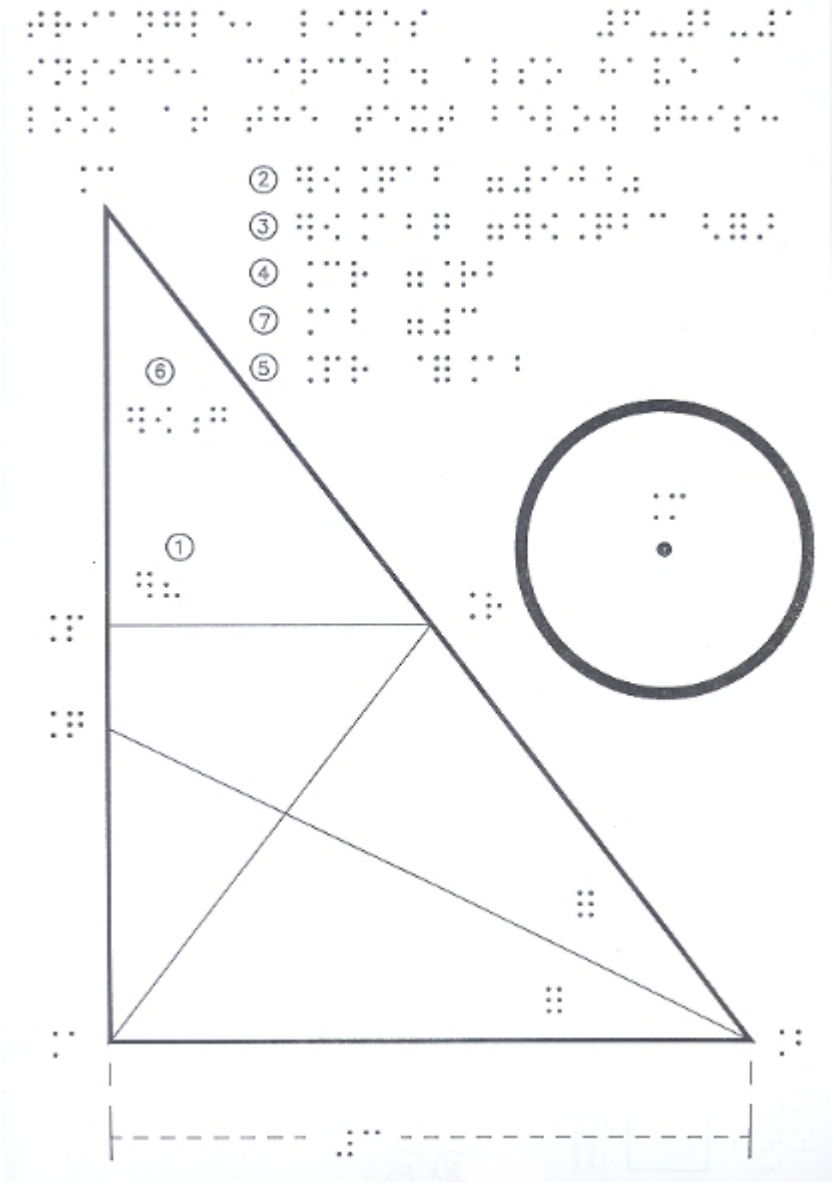


6. GEOMETRY

An inkprint geometrical drawing is a set of dots, lines and shapes: the figure, accompanied by identifiers like characters, and symbols like indicating a 90° angle etc.
Inkprint symbols are often graphical, in relief these might easily be mistaken for 'real' parts of the drawing: so I think they had better be replaced by braille code, or their meaning described, to avoid probably confusing images.
Take care your identifiers are unambiguous, make sure they point at one item only.
For ease in reading, draw lines belonging to different items or of different meaning in different widths, like a triangle fat-lined, the lines inside thin. Take special care of intersecting lines.

Basic Editing in Geometry





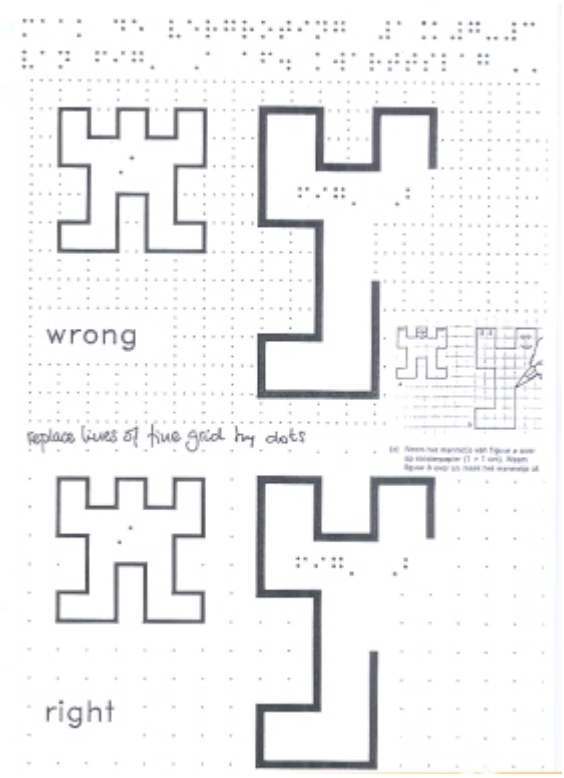
Basic Editing in Geometry

1. Orthogonal sign replaced by braille code.
2. Orthogonal sign replaced by remark in text because there's no fitting palce to put braille code.
3. Equal-angles signs replaced by remark in text.
4. Equal-distances signs replaced by remark in text; to allow for that, characters P, Q and R were added.
5. Parallel-lines signs replaced by remark in text.
6. Arc not copied, Greek character preceded by braille code for 'angle.'
7. Length statement replaced by, or at least repeated in text.

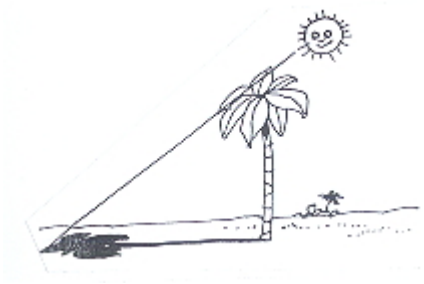
Also note that different kinds of lines have been drawn in various line types and widths.

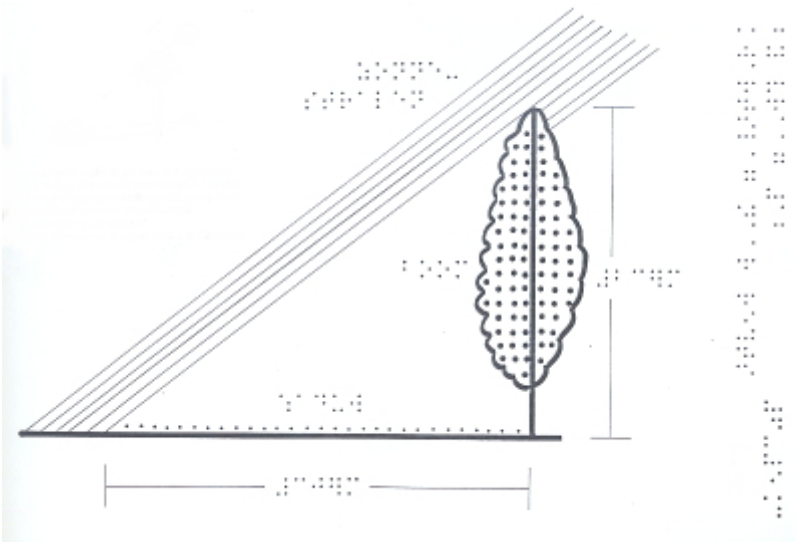
Grids

In general, the grid has to be copied, but don't let it get too fine-meshed, squares with sides smaller than 1½ cm make no sense, preferably go over 2cm. Use very thin or dotted lines for your grid. A very fine grid could either be simplified by rendering only the even lines, have the odd lines represented by a small dash on the axes only, or leave out the lines altogether, and put dots at the (imaginary) intersections.



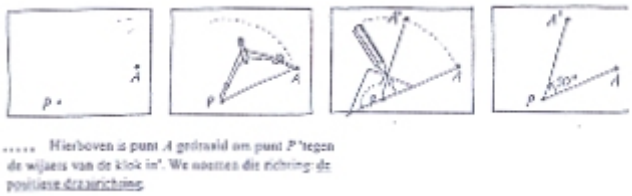
Some figures carry very small details: if necessary zoom in on a separate drawing.
For clarity, or even perceptibility, we sometimes have to make changes, overdoing distances etc.: just as long as we don't change its meaning.
Geometry graphics sometimes sport real-life elements: I prefer to edit those parts, as in general they're just there to brighten up the picture. Occasionally a formalized form with an explanation or a description will be necessary.



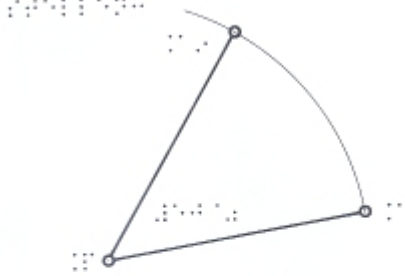


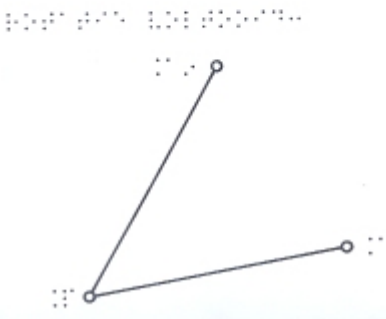
Refer also to the formalising examples in earlier chapters.

This also applies to drawings showing tools like scissors, plastic triangles, rulers etc.: in general just mentioning their presence and describing their use makes more sense than trying to reproduce their outline.

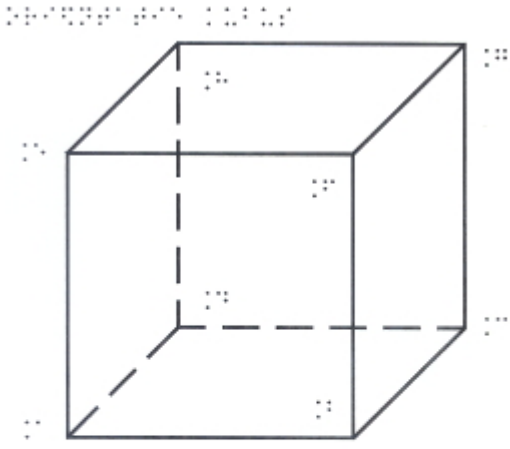


..... Hierboven is punt *A* gedraaid om punt *P* tegen de wijzers van de klok in'. We noemen die richting de positieve draairichting.





Replace ink print colours by our different hatches or line types; don't forget to have the text changed too.
In simple geometry open and filled dots sometimes have a specific meaning, so copy them in a perceptible way.



Spatial geometry, or in fact its two-dimensional renderings, are very hard on the blind student, as a slanting line will not indicate a possible change of plane. I think a cube or pyramid are as far as we can go, and even in these our reader will need help, so I have a figure like these preceded (once in a volume) by a like figure with an explanation as which plane is in front, which on top etc.
The Braille text says: "Introduction to the cube.
"Plane ABCD is the base, ABFE is in front, etc.
"Broken lines are at the figure's back, not visible from the front ... "

7. GRAPHS

A graph consists of axes, and lines or points inside these axes sometimes called functions. Graphs being rather straightforward, they're excellent material for codifying, uniformity. So following the survey of adaptations I have written up a method for graphs.
Very simple graphs sometimes have arrows next to the axes: I think arrows don't mean much to our readers, so I put in a zero at the axes' intersection and leave out the arrows altogether.
Next to, or below the axes their meaning is often written in full: in particular at the y-axis this is often not a very clear indication (as I explained before) and besides it takes too much space, so I prefer to use an x and y at the axes in any graph, explaining their meaning in a key (years under the x-axis are fine). Only where ink print already has a one- or two-character identifier do I copy those.
Basic Graph

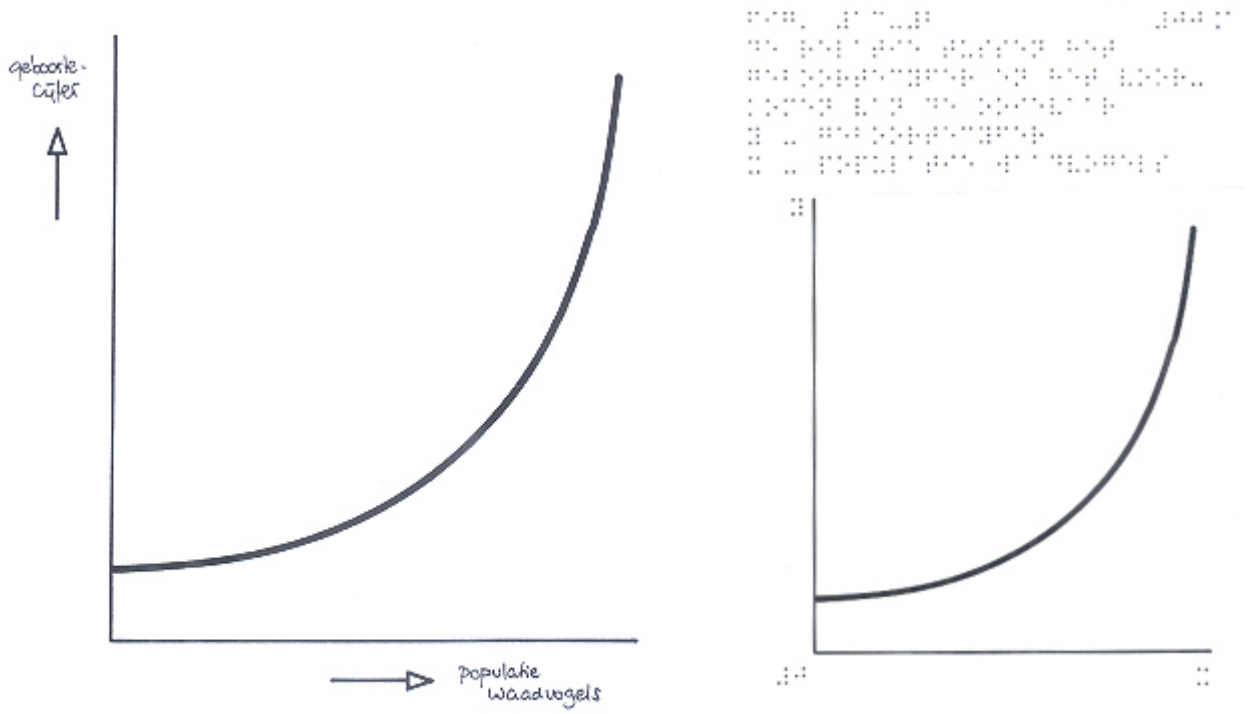
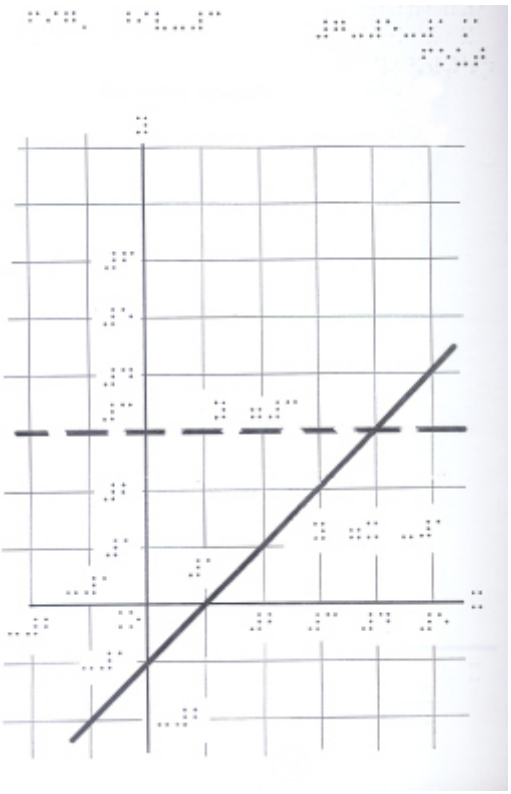


fig. 13-2
De relatie tussen het geboortecijfer en het voorkomen van de grote waadvogel

The small circle at the axes' intersection poses a Braille problem: is it number zero or capital letter O? In mathematics, to be recognized in ink print by x and y at the axes, it's capital letter O; in all other graphs, showing real units at the axes, it's number zero. Preferably put y and y-numbers left of the y-axis, x and x-numbers below the x- axis; but if this should impair the clarity of your drawing put them somewhere else. In mathematics generally only the O and two 1's are shown: if possible, copy; otherwise put in some other number. Sometimes a graph gets clearer by pruning axis numbers, there's often no need for the reader to go over a profusion of numbers.

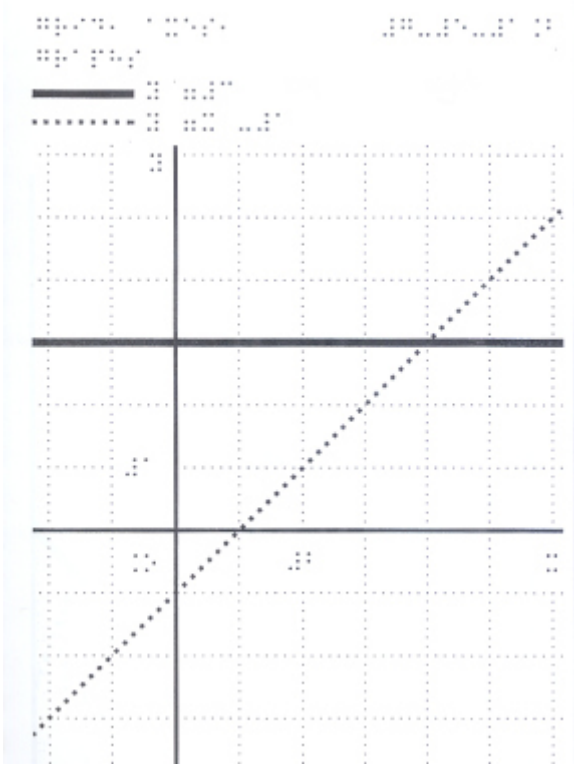
In my opinion putting an identifying text or word next to a curve or function line is not very clear: you'd better choose different line types and explain their meaning in a key.

Basic Math Graph



Wrong:

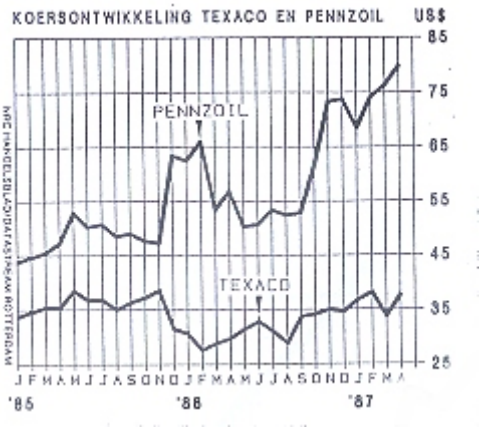
1. Too any numbers
2. Grid is solid line, too similar to other lines
3. Functions are given next to lines: is that unambiguously clear?



Better :

1. A few numbers suffice
   (Note #2 on x-axis: there is no room for #1)
2. Grid is a dotted line, clearly different from other lines
3. Functions are explained in key

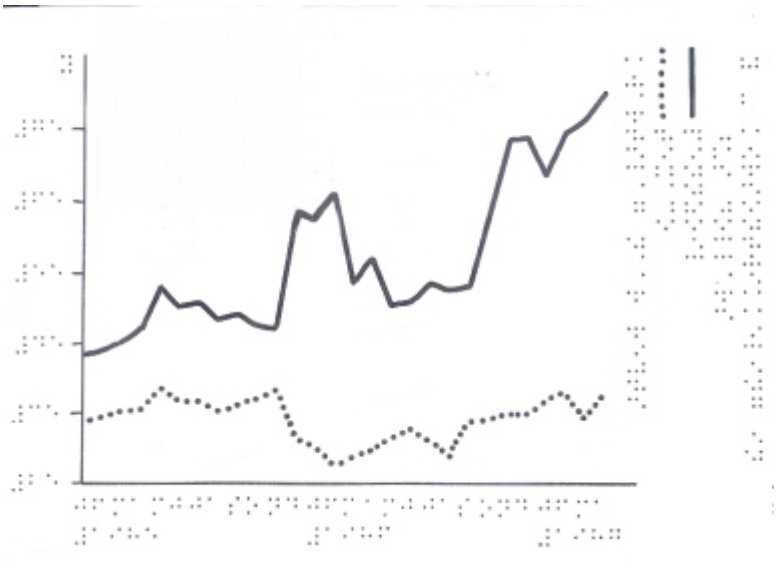
Use A Key



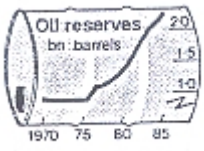
The grid will make a Braille graph hard to read, and identification next to the lines is not clear

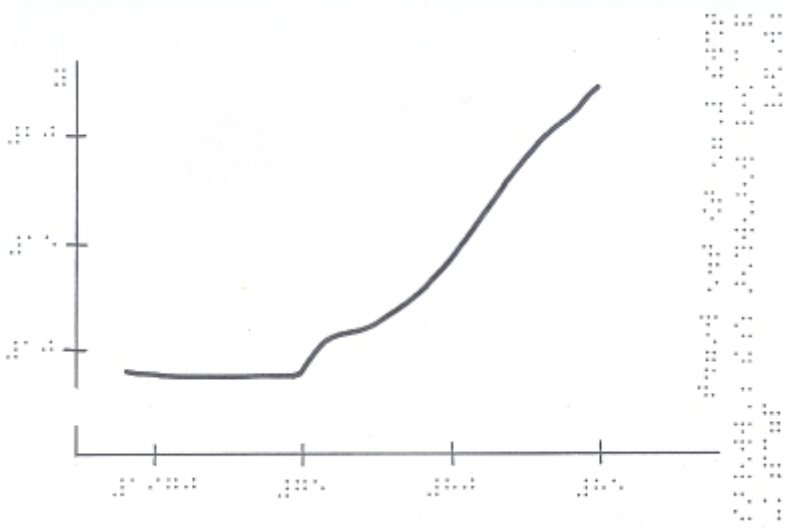
Remove the grid for clarity, and identify the lines in the key;

Note that the line explaining the y is the title;
The key might have been placed in line with the graph.



The zeroes in the thousands or millions of the units at the axes take unnecessary space: cut down by explaining in the key (e.g. "y - cars manufactured x1000").
In rare cases one of the rows of numbers might be written in a deviant direction. Preferably make a remark about this.
Draw the axes in a standard width, for instance 1mm.
Don't copy the zigzag indicating an axis interruption: a short break in the axis line (about 7mm, within the fingertip window) is clearer.





The jagged line has been replaced by a short break in the axis ;

The y explanation is the title;
The y-axis has moved to its usual position on the left; and
of course no attempt has been made to copy the oil drum.

In rendering the grid, think of the reader who has to go over all these lines to take in your drawing. Ask yourself if grid is really necessary, is that much precision asked for? Sometimes one might just as well only draw lines from important points in the graph to the axes, so these values can be read accurately; in other cases just putting grid below or above the curve will do nicely.

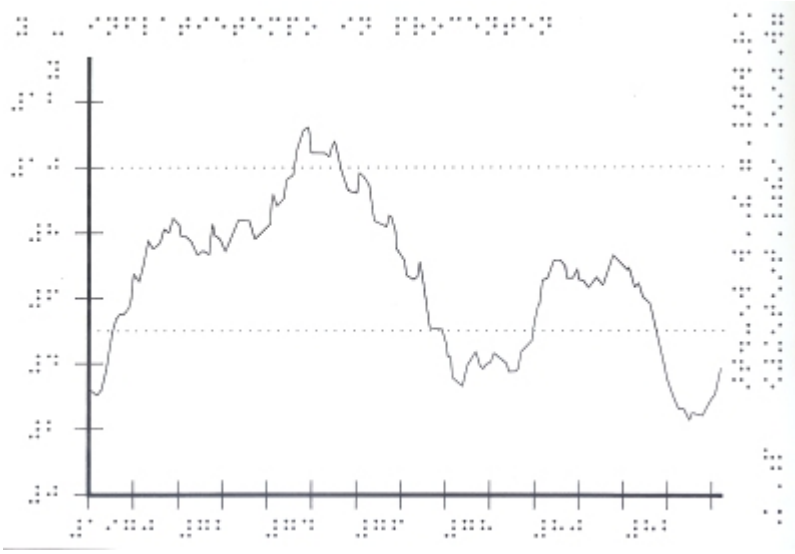
Remove Grid

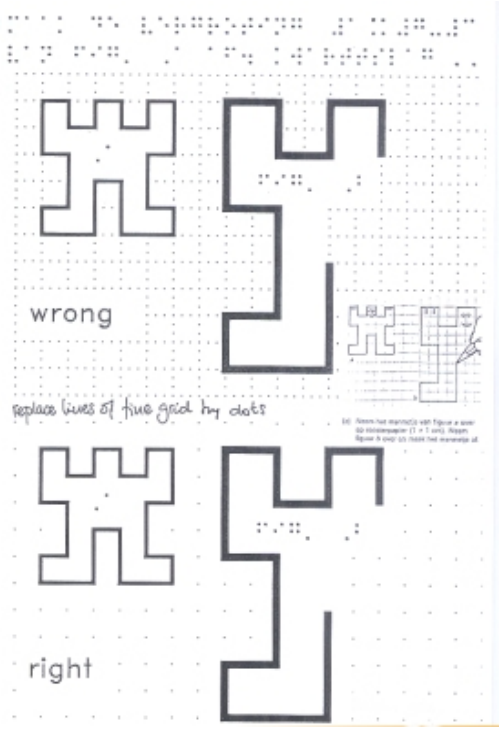
The blind reader will have to spend a lot of time searching for the curve in a grid like this.

The grid and the broken lines (yearly averages) clutter up the curve too.

Did we really need that grid?

The yearly averages are given in a table.
Usually, we draw the curve as a fat line, but in this particular case that would not show the wriggliness well.



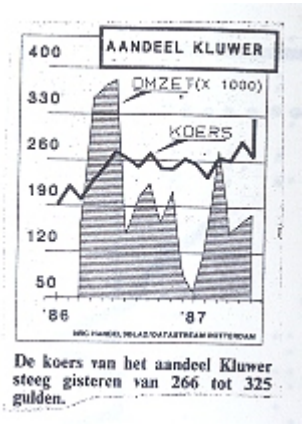


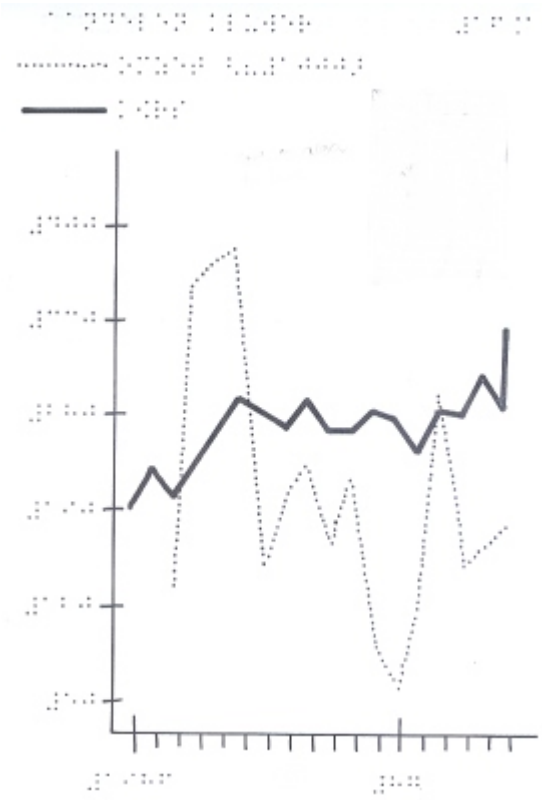
Replacing lines of fine grid by dots on the intersections, as already discussed in geometry, may clear up your drawing.

A graph that has more than three or four function lines will generally have to be made into a series of graphs when the lines are too close together. Separate the close lines and try to have one of the lines, preferably a mean or reference line, in each graph of the series.
The function lines are the most important part of a graph, so have them stand out, draw them fat so they're easy to find.

If a graph has shadings between the lines we'll have to look for their meaning: sometimes it's just for decoration or sighted clarity and we can leave it out; in other cases the graph is all about the hatches' proportions, the shadings indicate volume, and we had better leave out the lines as they impair clarity.

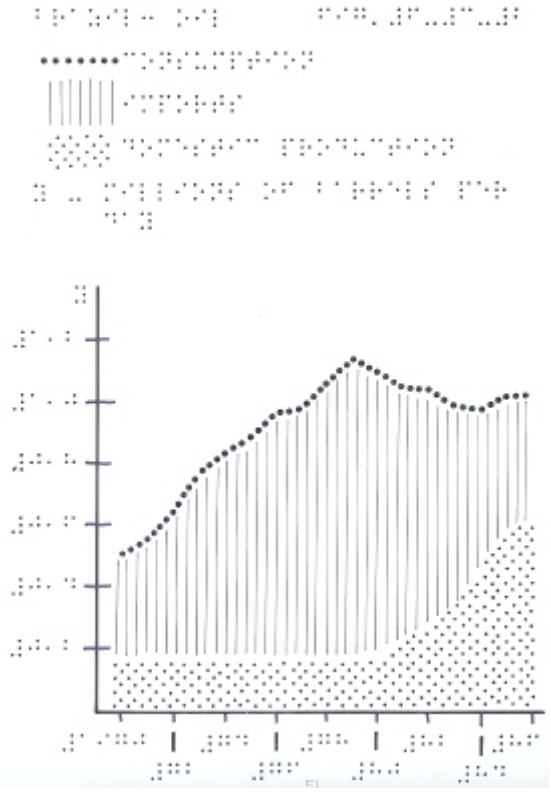
Shading in Graphs

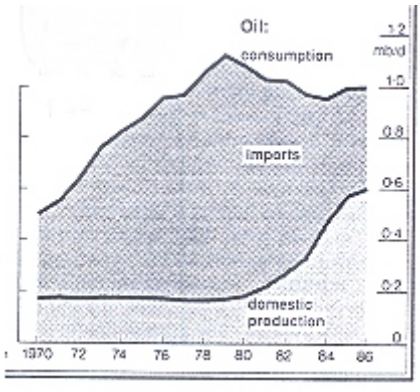




The shading has no meaning, so it is left out.

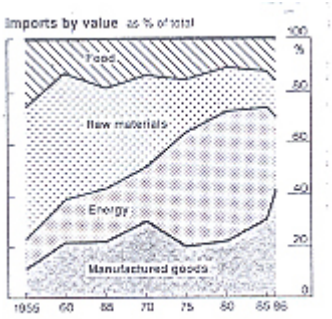
Note use of key instead of arrows.
Also note that the reference lines have been replaced by a standard y-axis.

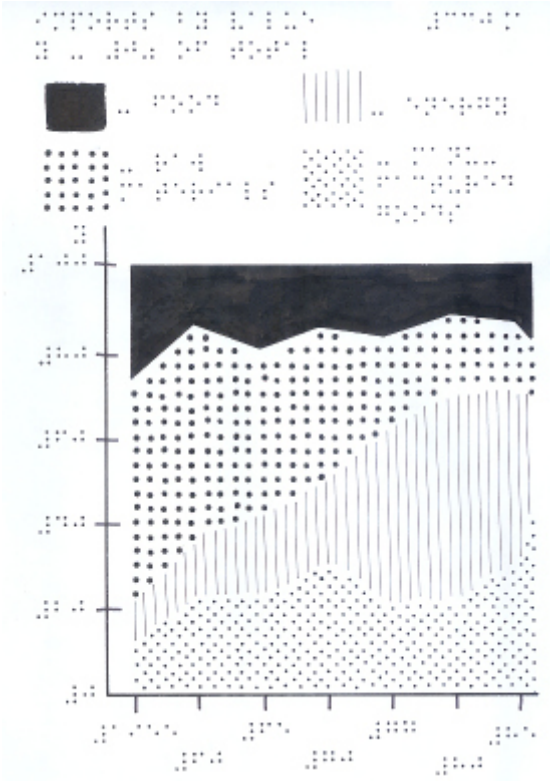




The size of the shadings indicates volume

Note the line type used on top; the other line has been removed for clarity.
Also note use of key, and y-axis move to standard left.



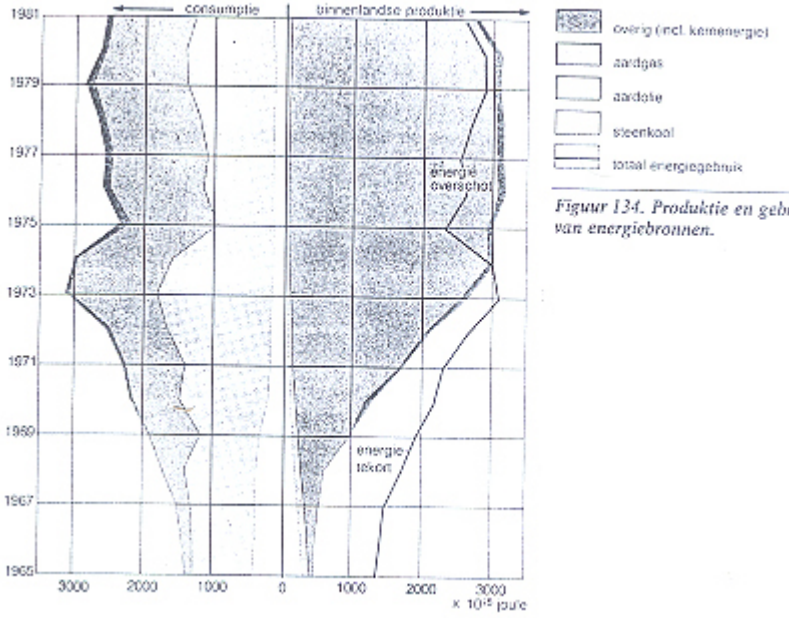


The size of the shadings indicates volume.

Note that lines between hatches have been removed for clarity.
Also note use of key, and y-axis to standard location on the left.
The first year on the x-axis is given in full, after that the '19' is left out.

Except in mathematics there's no reason not to juggle x- and y-scales separately if the lines in your graph are close together.
Look out for possibly confusing graphic elements, and simplify or relegate them to text. Estimates into the future are often dashed, in an otherwise continuous-line graph: copying this will unnecessarily complicate your drawing.
Reduce unusual graphs to the standard model.

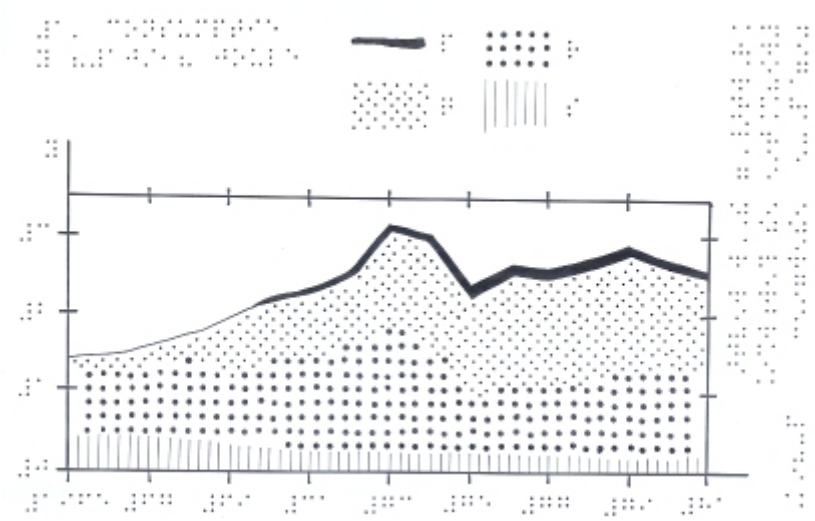
Split Up Complicated Graphs

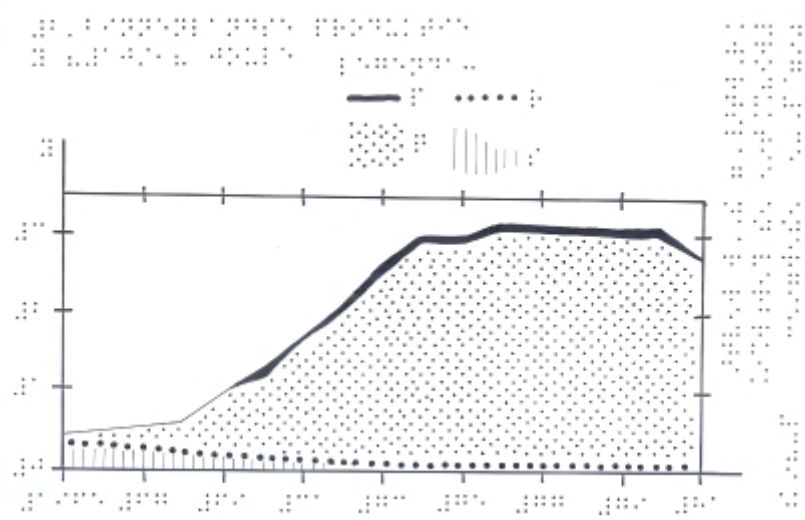


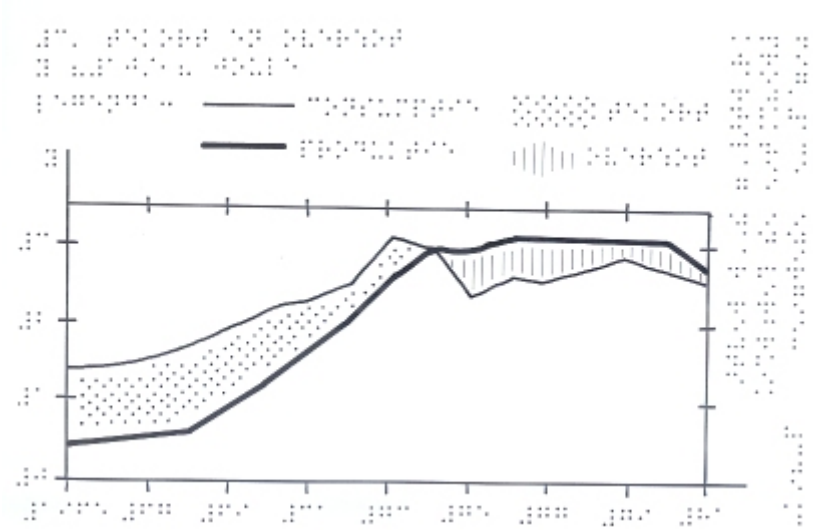
Figuur 134. Produktie en gebruik van energiebronnen.

This complicated graph has to be split up, into three standard graphs.

It shows production and consumption of energy by type (oil, gas, coal etc.) and the resulting shortage and surplus.







The first two graphs show energy production and consumption over the years by type (coal, oil etc.), the third shows the resulting shortage and surplus.

METHOD

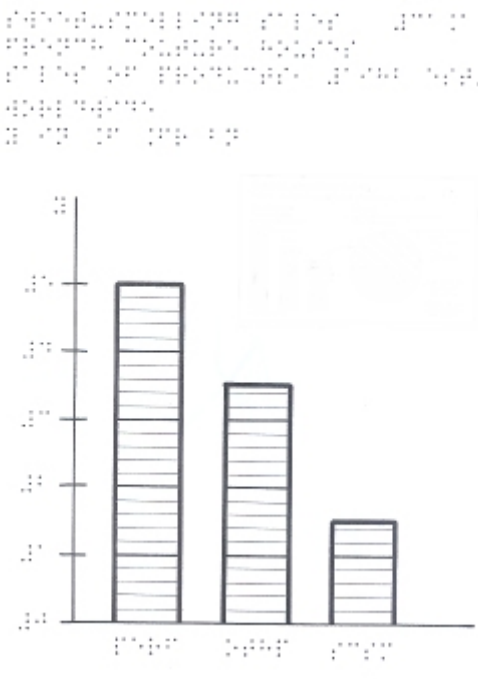
1. Enlarge your original to desired size; if need be change x:y ratio
2. Decide on the direction of your drawing: length- or widthwise?
3. Will the graph leave enough space for your title (including key)? If so, put in page number and title; otherwise draw the graph first.
4. Draw axes, 1mm width; put in x, y and 0, and dashes and numbers for units.
5. Put in grid, possibly reduced.
6. Put in function line or lines, curves. Decide on linetype by expediency (e.g. wriggling line thin, straight line fat).
7. If so desired, put in referencing lines from important points in your lines to the axes (if no grid was applied).
8. Reduce confusing elements.

8. CHARTS

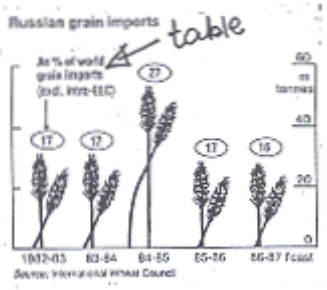
PICTURE OR DESCRIPTION?

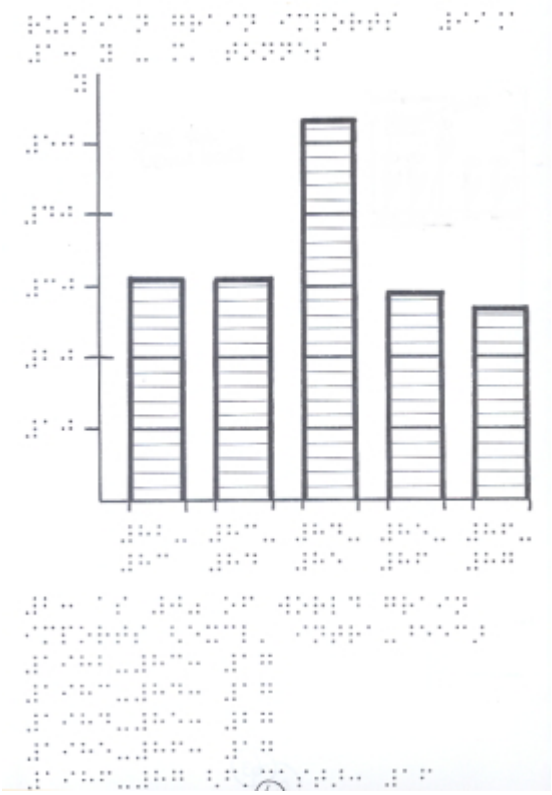
Charts are a way of representation that's very clear to a sighted person, to take in at a glance, the best way of showing certain data; to a blind reader, however, a list of numbers is far easier to read and understand. So should we transform all charts into tables? Firstly, the blind reader then will never learn how to read charts, so all braille producers should agree on their transformation into text. Secondly, some indescribable charts are left, hard to understand as the reader is not familiar with the basic type. And thirdly, isn't reading charts part of the secondary school's curriculum?
We should cut down in drawing charts, especially in non-educational or post-secondary school texts, but that still leaves a lot of charts to be drawn.
I am aware of this discussion contradicting my argument in the introduction about editing for the blind. Still waiting for a unified theory.
In general, the information in a bar is in its length, width doesn't matter: so go for a comfortable width like 2cm, if space allows. On the other hand, a bar chart intends to compare, so if possible keep it to one page. Sometimes it's best to make a line chart out of a bar chart.
A simple bar chart just has some bars in a coordinate system like axes in graphs: in many ways, bar charts are like graphs. Draw axes at 1mm width; draw the bars' outlines in a fat line, like 2.5mm. Now the chart is still just a collection of lines, but filling in the bars with thin lines that also work as reference lines (horizontal in vertical bars, vertical in horizontal bars), and ideally at a distance from each other within the fingertip window is a beautiful solution. It suggests a numerical value. If possible, have an axis-width line at axis-numbers height or width.
Don't put grid at the outside.

Filling in the bars with lines that also work as reference lines; note the fine lines that fill in the bars, and the bigger lines referencing to the numbers on the y-axis.



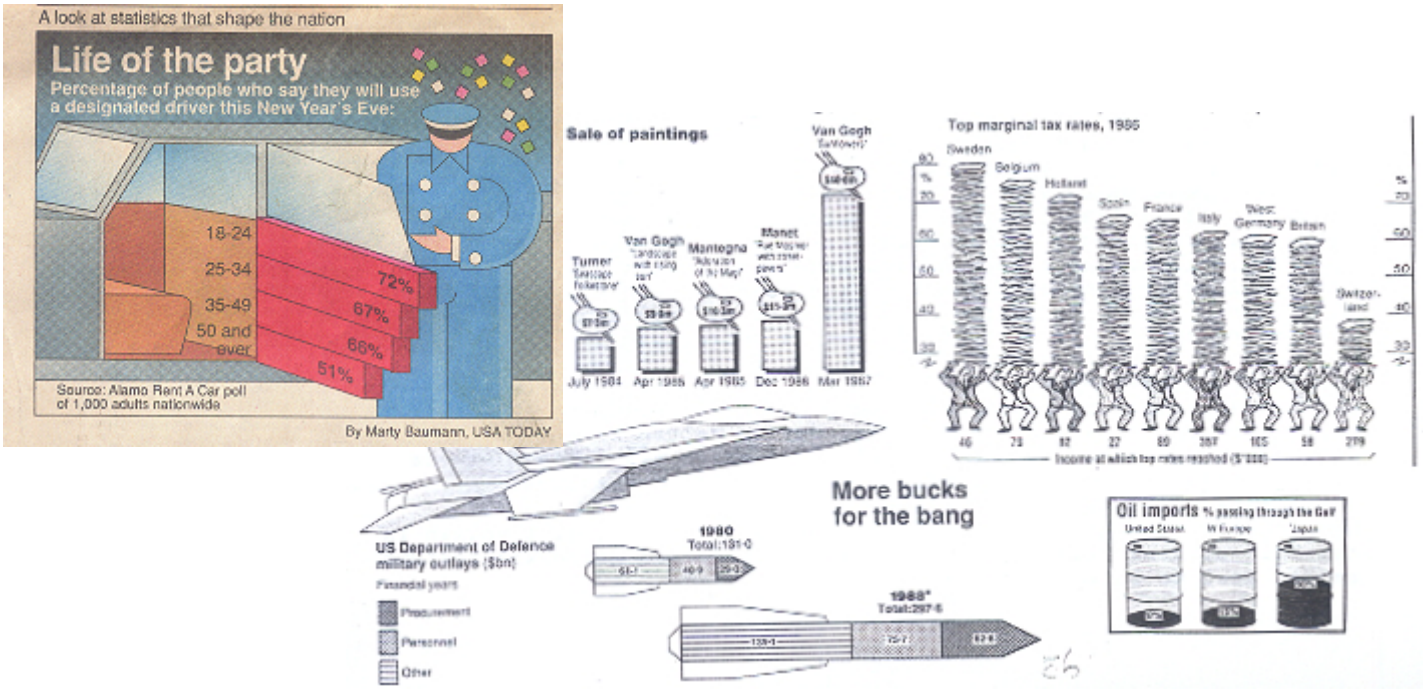
Charts are often decorated by lifelike elements, or drawn in emblems of their subject matter: to the blind these are not amusing. Again we'd best render them in a uniform way.
Edit Fancy Picture to Standard Chart





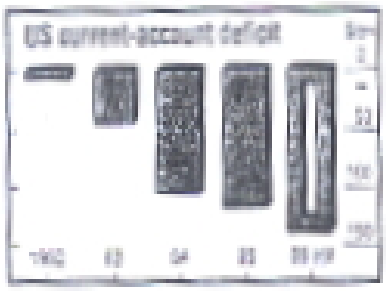
The ears of grain would not make sense. The numbers in the circles are given in a list; note the fine lines that fill in the bars, and the bigger lines referencing to the numbers on the y-axis.

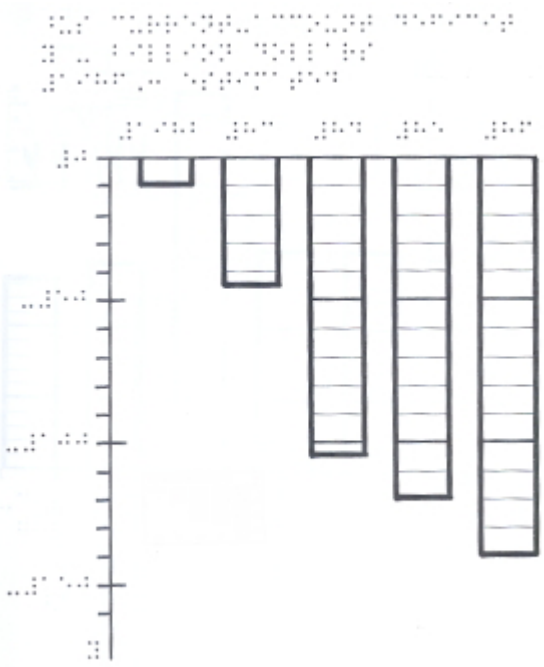
Funny Charts for The Sighted (Inkprint Only)



Of course we're not going to copy the embellishments.

Estimates or projections may not look like the other bars in a chart: for us a uniform rendering is better.

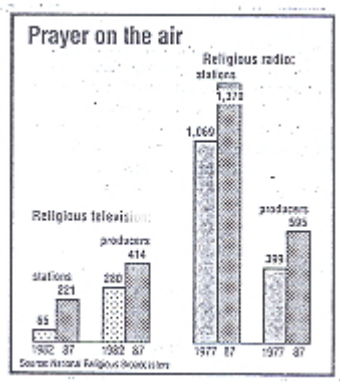


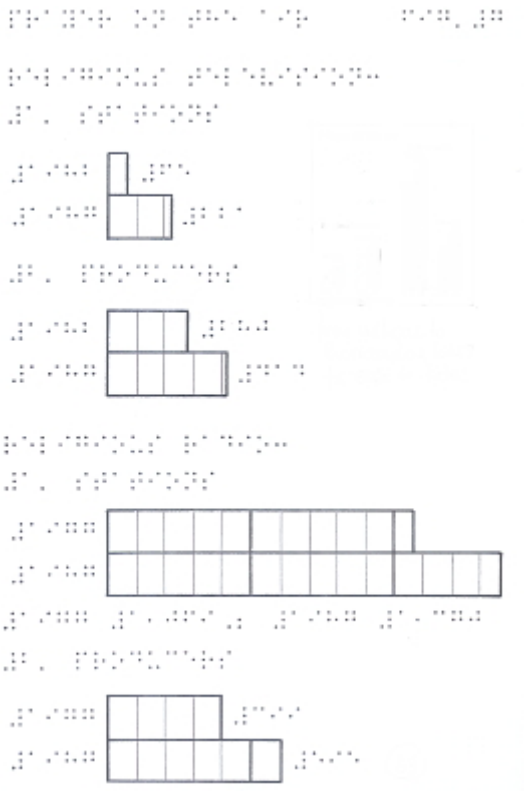


Do not draw the last bar in a different way – the Braille version has a line: "1986: estimated".

Vertical bars make writing, identification easier, for there is usually only room for two or three Braille characters under a bar, so rotating vertical bars might make the chart easier to read.

Move bars from vertical to horizontal

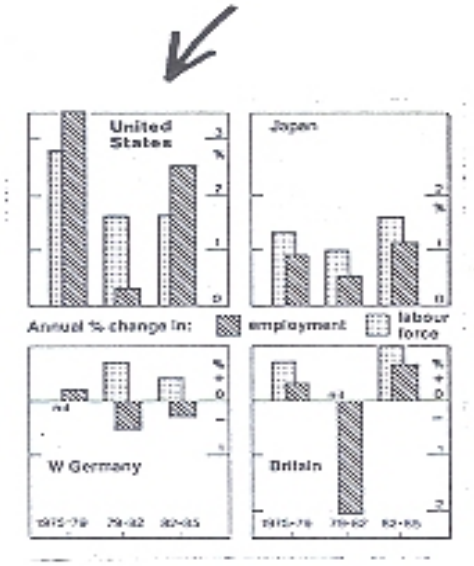


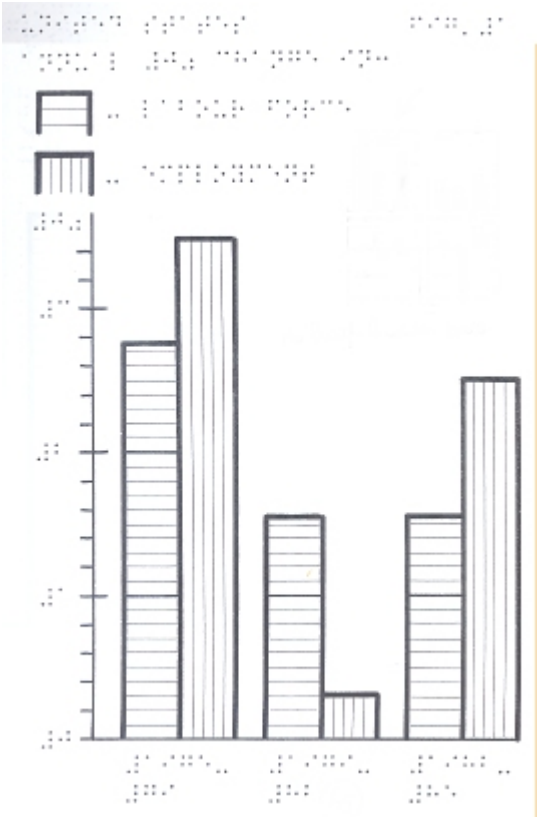


This chart is a prime candidate for a full description instead of a picture. Nothing would have been

lost had this chart been rendered as a simple table. (Where are the axes Eugene?)

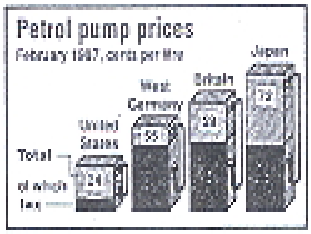
Some bar charts have clusters of different bars: try to hatch the largest bar in reference lines. This kind of chart often has half-hidden bars: bring these out in the open like all other bars.
Edit to Uniformity



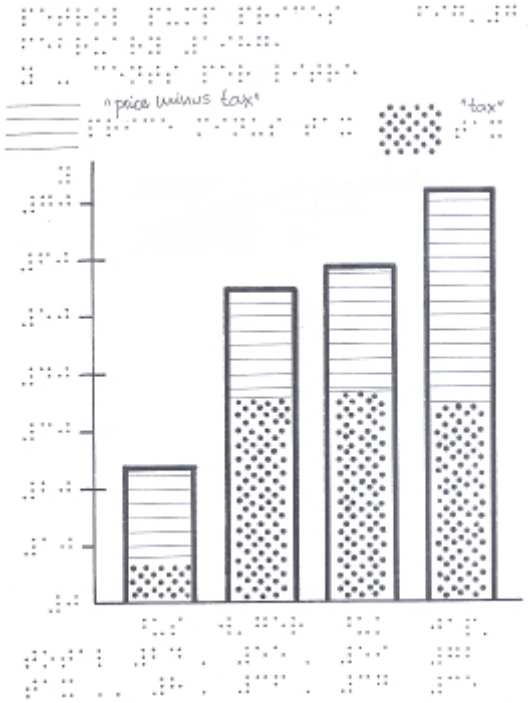


Bring the half-hidden bars out into the open – also note the standard axes.

Other complicated bar charts have bars divided in sections: choose hatch- type by expediency, like small sections solid black. In this kind of chart it's often better not to have a fat outline, as its top might look like a bar section. Enlarging details on a separate page is a possibility here; mark clearly which part you're going to show in detail.
Two-variables bars



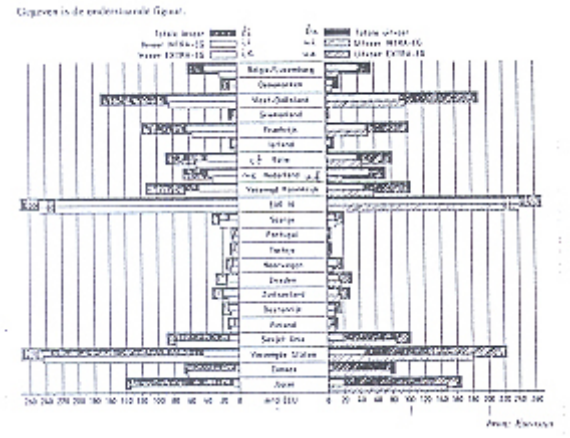
Would our readers appreciate an artistic rendering of those gas pumps?



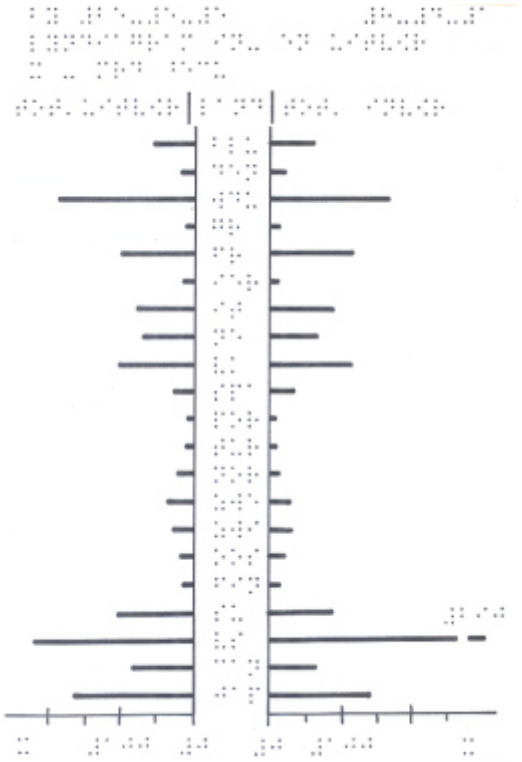
Prepare a standard bar graph, axes, key, etc. Key says: "Price minus tax" and "Tax"; the numbers that were written in the pumps are given below the chart in the Braille version.

Again sometimes we'll have to juggle: rotate, mirror etc. to get a clearer picture; sometimes go for a description of a complicated chart, but in those cases it might be nice still to draw a part of the chart and an overview, or a simplified version, so as to give the blind reader a notion of its inkprint graphic representation..

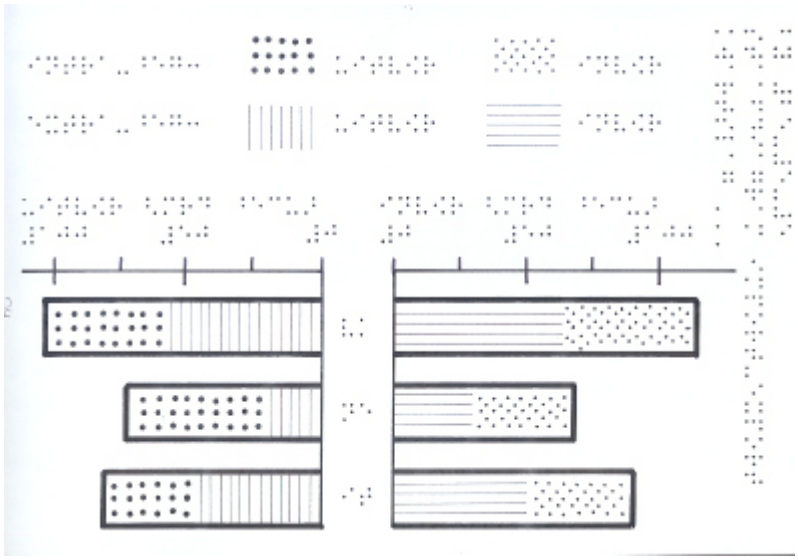
A Complicated Chart



I think it's best to go for a full table description,
the basic bars and a few of the full bars as an example.



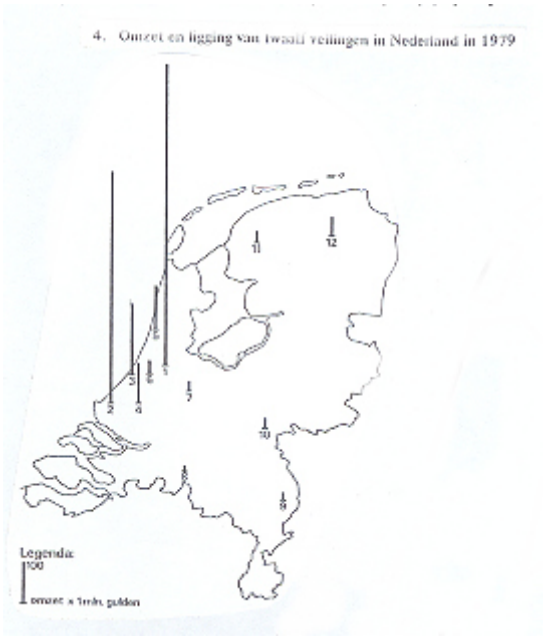
Part 1



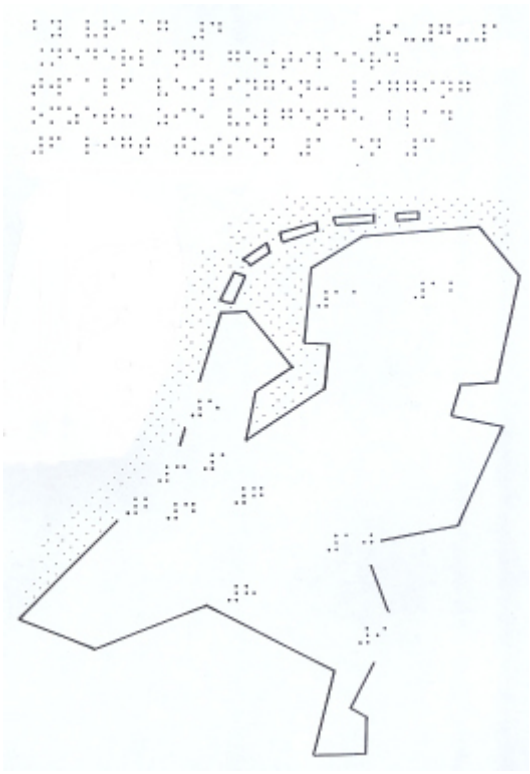
Part 2

Maps containing charts are usually for decoration, but occasionally show locations relevant to the bars: in that case we split up in a separate map and chart.

Chart in A Serious Map

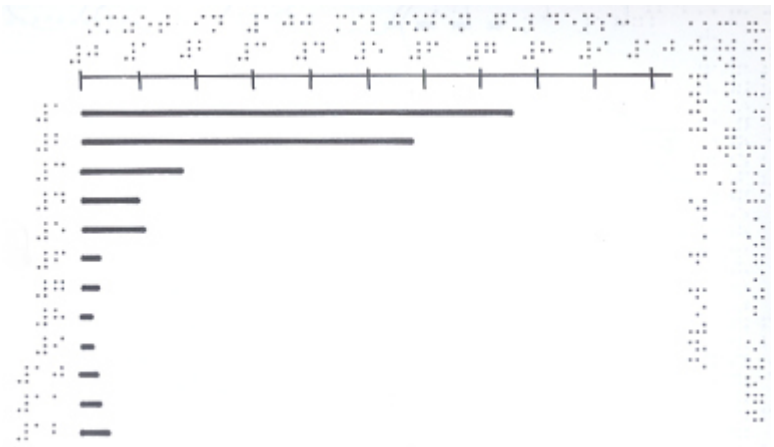


Produce Auction Sites in Holland
with Volume of Sales



Locations map: Produce Auction Sites in Holland
with Volume of Sales
Locations, Chart on Next Page

Also note that braille says: "#6 is in between #1 and #3" for there is no room in the map to print #6.

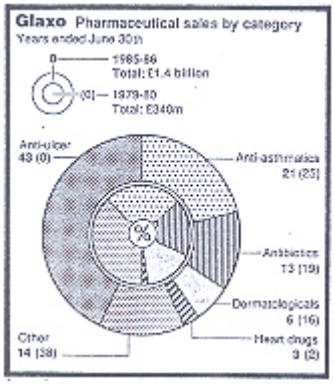


Produce Auction Sites in Holland
with Volume of Sales

Also note that the chart has been rotated to allow writing the twelve identifying numbers that wouldn't have fit below an x-axis.

Pie charts follow the general chart guidelines, but allow for more writing in the sections, which may be useful.

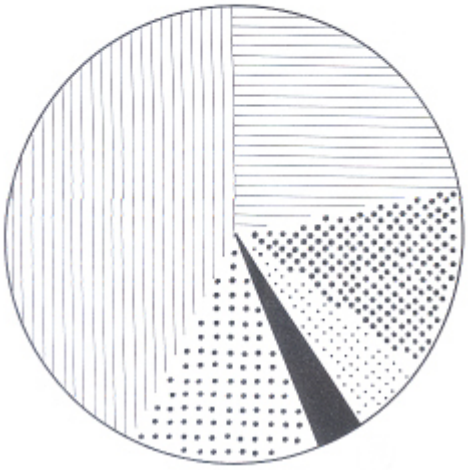
A Pie Chart Example



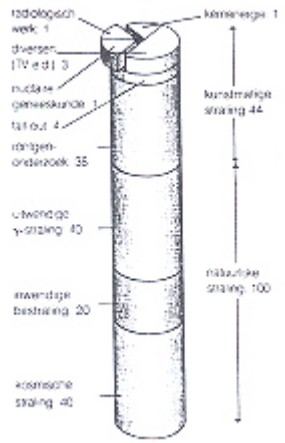
I don't think the key in inkprint that explains the two circles is going to work for blind readers.

So draw two separate pie charts, and give the numbers at the key in text.

Also note that there are no lines between the various shadings.

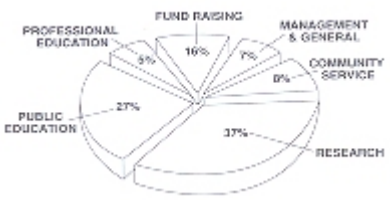


Braille Part 2.

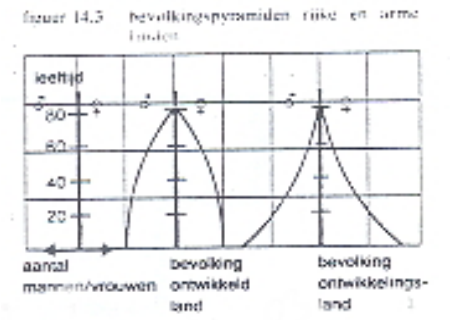


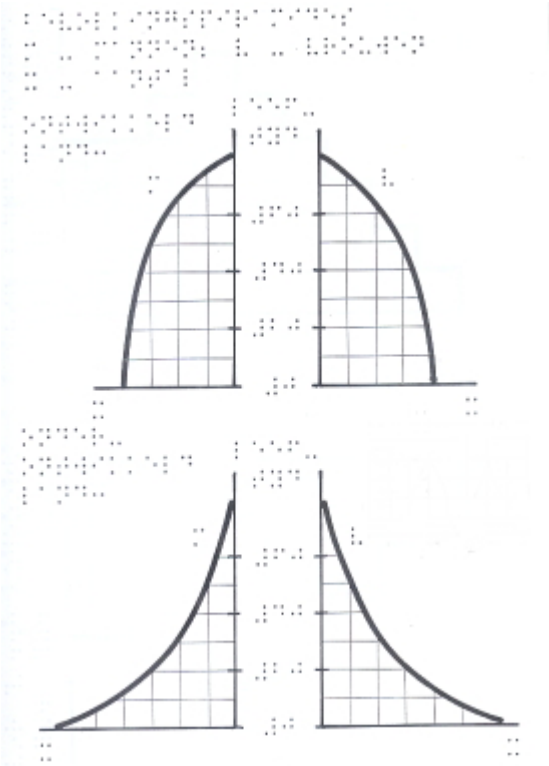
Fractured pies cause unnecessary difficulties in reading

I would give a full description of the second chart, maybe the top as a picture.

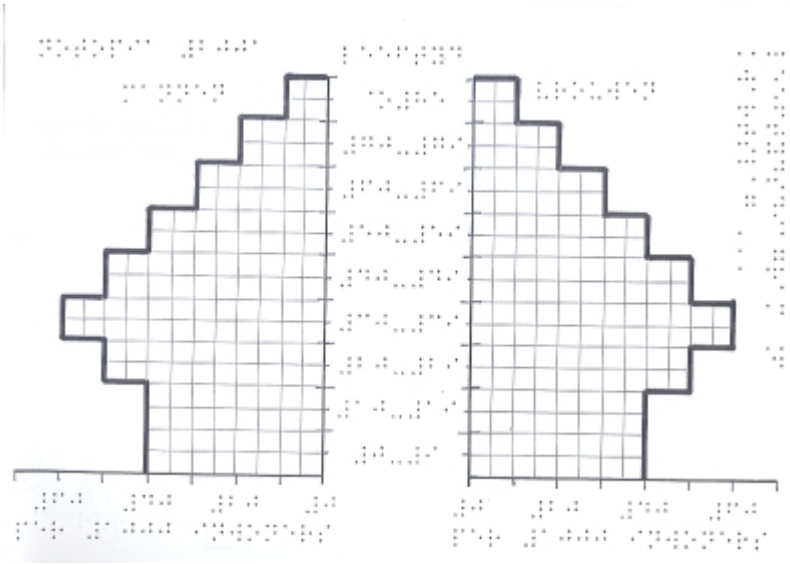


Population pyramids can't be described satisfactorily, as it will take a lot of imagination to relate a group of numbers to a shape; so we'll have to draw them, and in a standard way.
Population Pyramids





The "m" and "v" next to the curves are not ideal.

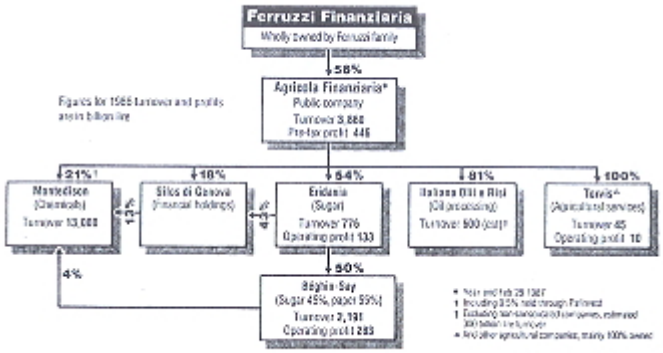


A line in text like "men:left, women:right" would have been better than that identification next to the sides.

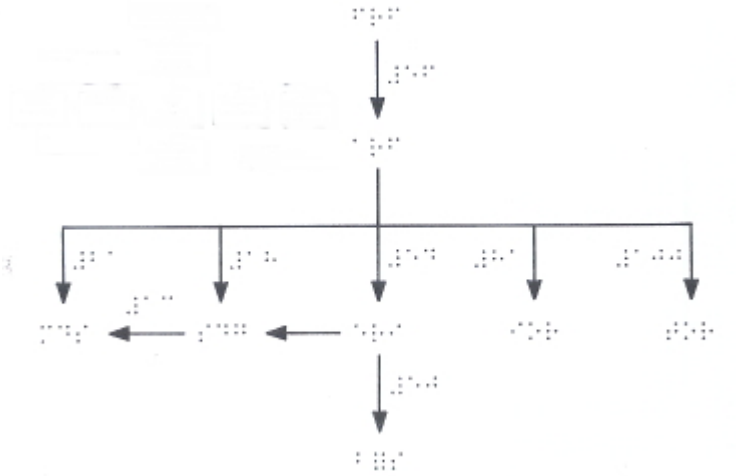
9. DIAGRAMS

Draw rectangles and connecting lines in different widths, connecting lines must be thick as they are the most important part of your drawing; quite often the rectangles around text might just as well be left out.

Simplify A Diagram



There's too much text in the boxes, and who needs those boxes anyway?



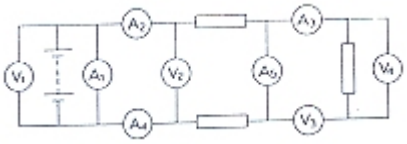
The braille drawing only gives names and numbers ("numbers in the diagram indicate percentages'); all other information from inkprint is rendered as text, like this:

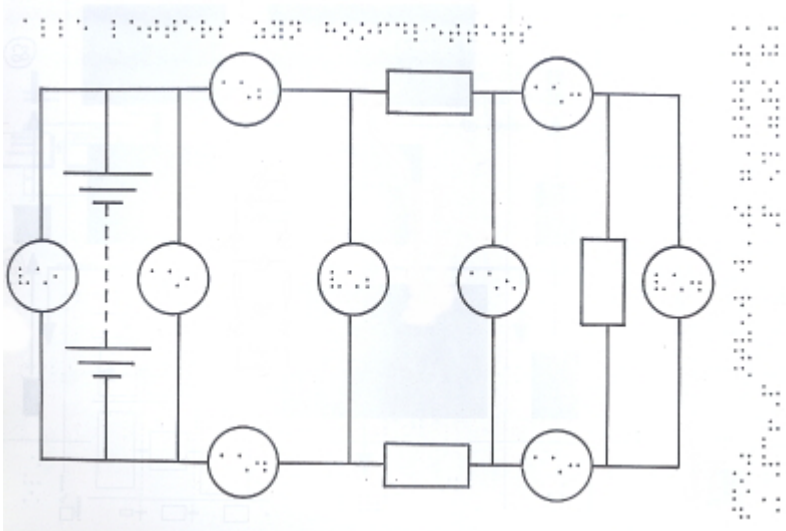
Figures for 1986 turnover and profits are in billion lire

frf - Ferruzzi Finanziaria
Wholly owned by Ferruzzi family
mds - Montedison (Chemicals)
Turnover 13.000

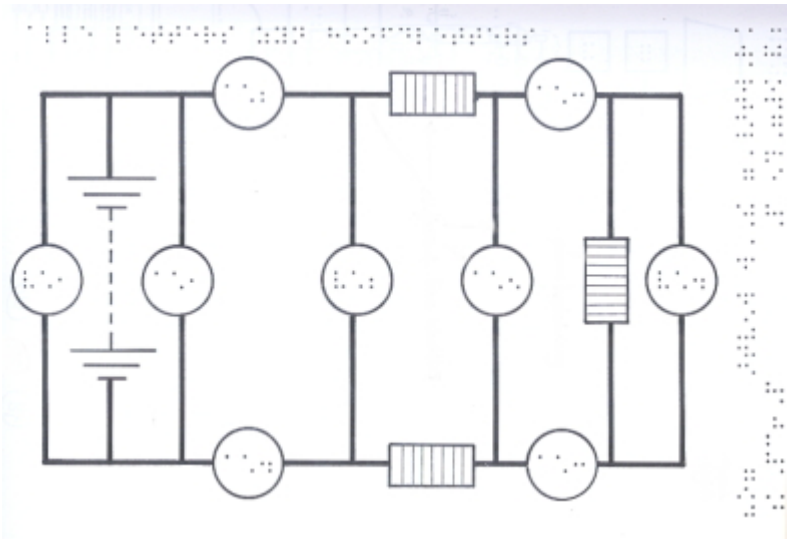
Do not copy complicated graphical elements in your schemes: just a rectangle and its name will do. A word like 'battery' makes sense to our readers, representing it by a series of straight and curved lines will probably have no meaning. Often abbreviations will have to be used, choose them sensibly; do not change existing codes. In schematic representations like electrical diagrams, the current passes through a wire that should look different from the gauges and apparatus attached, as those might otherwise look like the wire branching out.

Line Widths: Electrical Diagram





In the 'wrong' rendering, the blind reader tracing the cable, arriving at an object might get the impression it's the wire branching out; different line widths make the picture clearer.

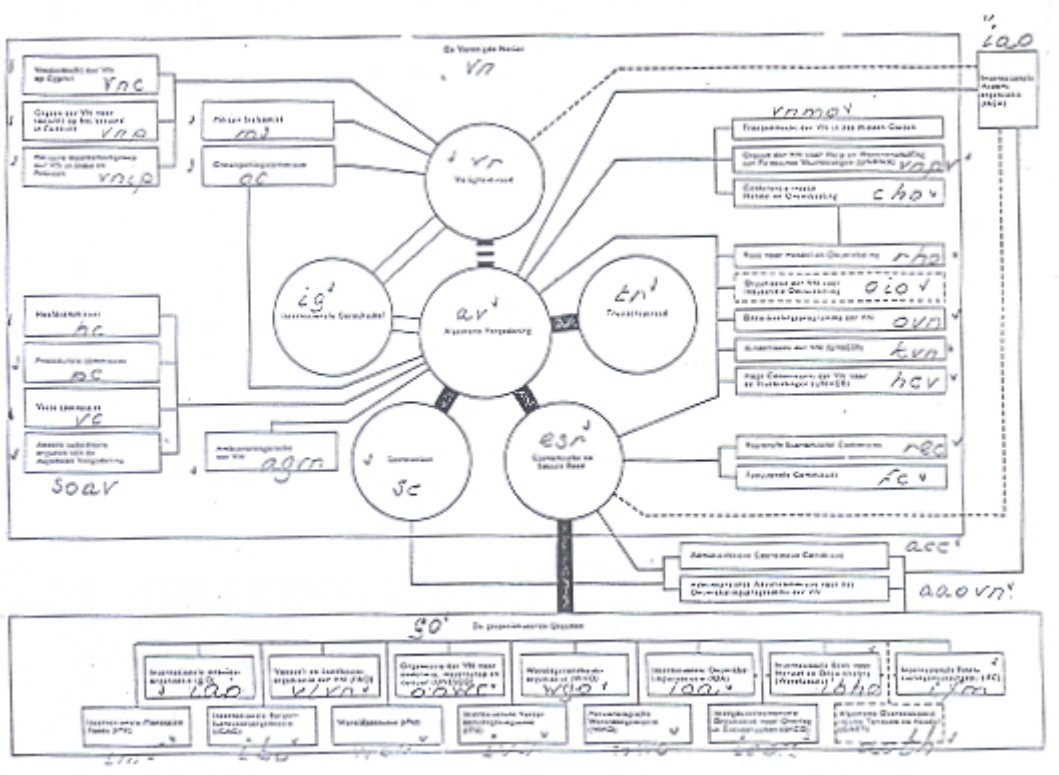


Right

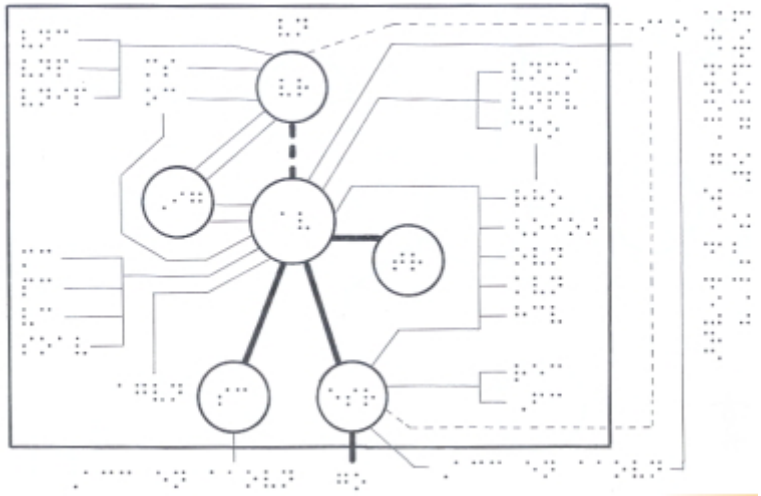
Keep arrowheads some distance from lines they point at. Take care at intersections: maybe change one of the lines' width for some distance to stay in the clear about which line continues where.

Generally a partial or complete description is to be preferred over copying a complicated diagram. It makes no sense if our readers have to go through a drawing with a lot of lines and abbreviations accompanied by a long list explaining those codes.

Editing A Very Complicated Diagram



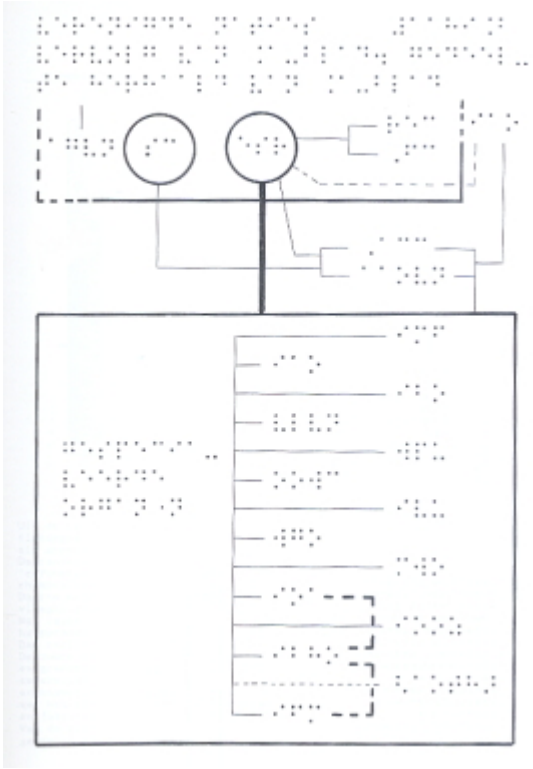
This is a diagram of the United Nations' organisational structure. Imagine the blind reader having to go through the long list of abbreviations. Reading a good description would take about as much time, and make much more sense than the drawings.

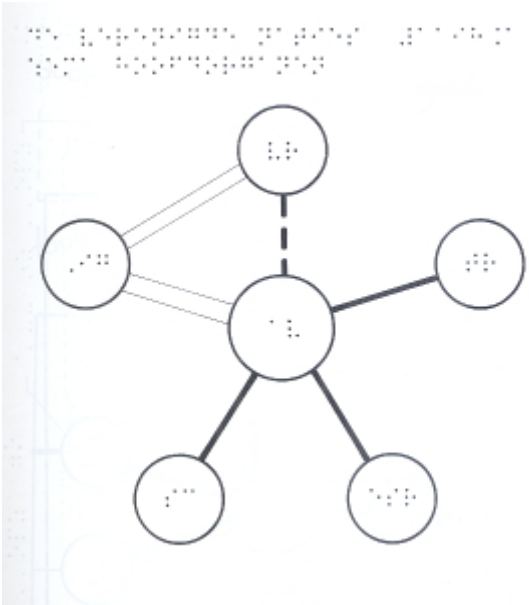


wrong, part 1

Imagine the blind reader having to go through the long list of abbreviations, and then take on this picture (which is only the first part).
Reading a good description would take about as much time, and make much more sense than the drawings.

Wrong, part 2



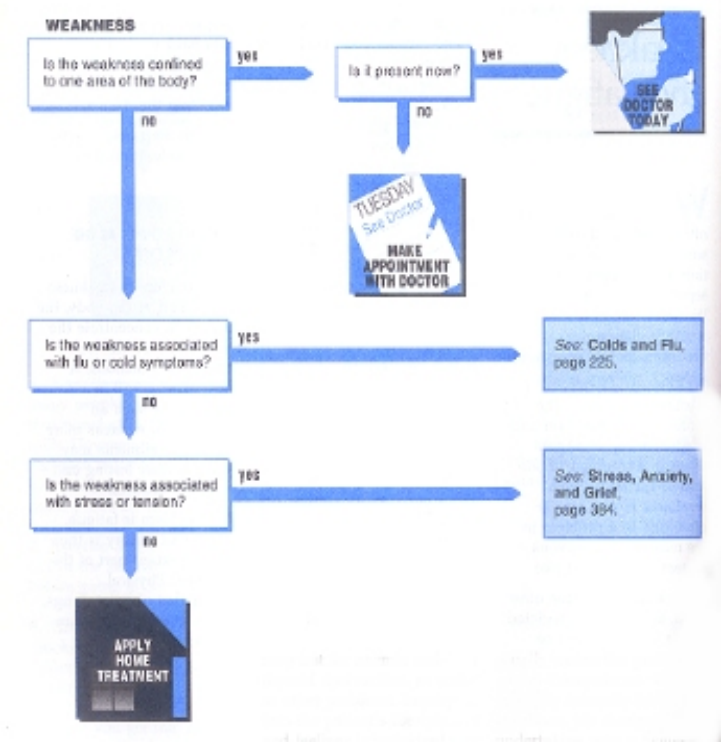


better

A diagram of the basic structure, most important part, and having the other parts described, makes much more sense, and takes much less time to read.

The data from most complicated diagrams can be given in an easy-to-read descriptions or tables. Even if the blind reader would eventually be able to make sense of these diagrams as pictures that time could be spent much more profitably elsewhere.

Diagrams That Are Better Fully Described



It is entirely possible to draw a clear Braille picture of this decision chart, but a description is way easier to read. Number the question boxes. Then make a table like:

Weakness

1. Is the weakness confined to one area of the body?

   yes: go to 2.

   no: go to 3.
2. Is it present now?

   yes: See doctor today

   no: Make appointment with doctor
3. Is the weakness associated with flu or cold symptoms?

   yes: See: Colds and Flu, page 225.

   no: go to 4
4. Is the weakness associated with stress of tension?

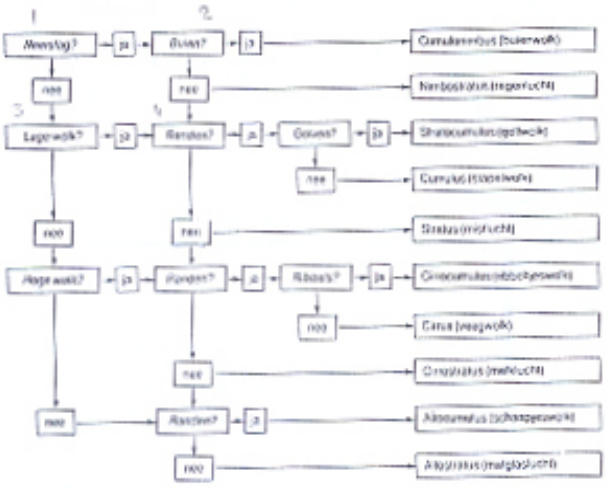
   yes: See: Stress, Anxiety and Grief, Page 384.

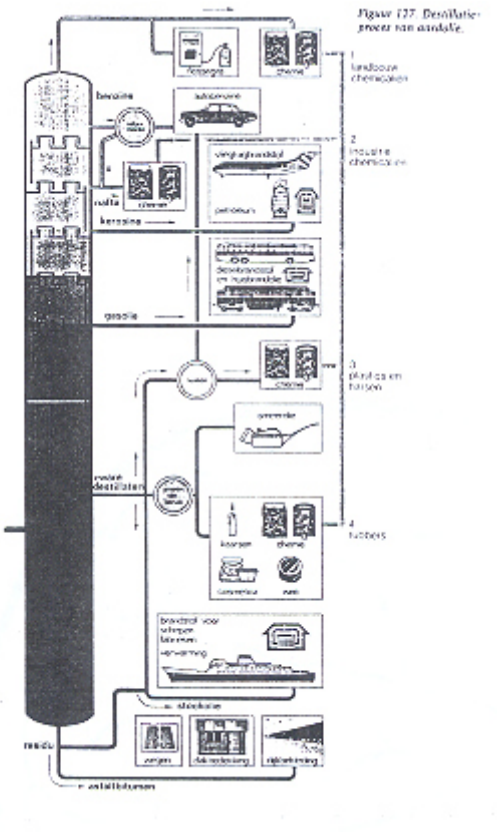
   no: Apply home treatment.

The blind people I worked with never *liked* graphics, the unfamiliarity, and the material is not pleasant to the touch; that's why I would choose to translate this one to text, also taking into account that it will be read under less-than-ideal circumstances.

Numbering the boxes on the left allows for a description like:

1. Rain?
   yes: go to 2
   no: go to 3
2. Showers?
   yes: *Cumulonimbus*
   No:
   A: go to 4
   B: *Nimbostratus*
3. Low clouds?
   yes: go to 4
   no: go to 5
4. etc. etc.





"From the top of the distillation column, the lightest fractions, etc. etc."

Look for original solutions to rendering colors etc. Again the main thing is to understand what the diagram is about.

Diagram Solutions

Row and Column Headers (Periodic Table, first 20 elements)

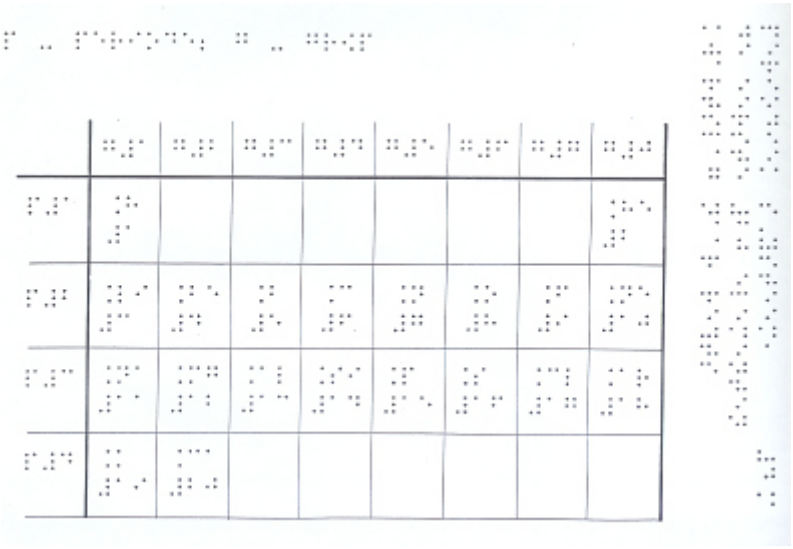
Where will you put the "Group" and "Period"?

1. *Periodiek systeem, de eerste 20 elementen*

Groep

Periode

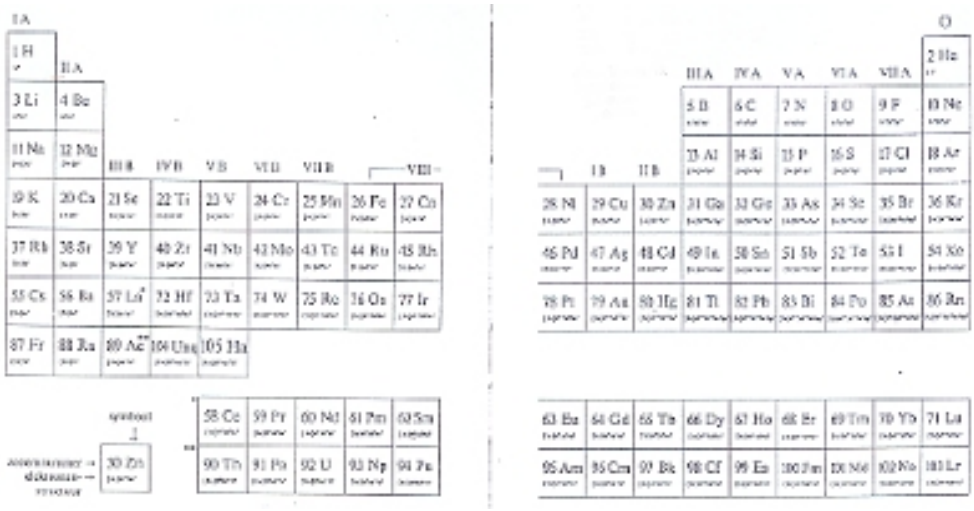
	1	2	3	4	5	6	7	0
1	H 1							He 2
2	Li 3	Be 4	B 5	C 6	N 7	O 8	F 9	Ne 10
3	Na 11	Mg 12	Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
4	K 19	Ca 20						



The table column and row headers each have a 'g' for 'group' or a 'p' for 'period' with the number.

This may look like a minor thing, but there is no other way to clearly indicate groups and periods.
In a real Braille picture the top left 'p' would be too close to the edge.

Splitting Up (Full Periodic Table)



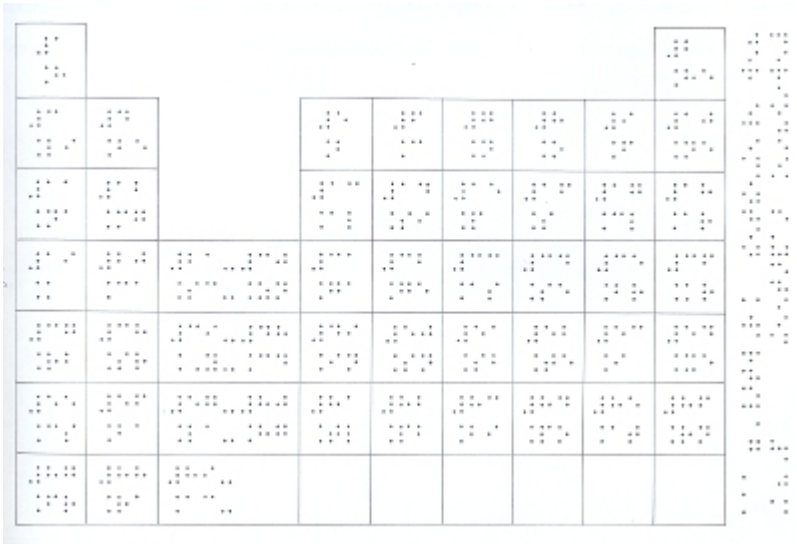
The Periodic Table itself already provides a model for splitting up,
which we will take one step further

This Periodic Table gives an electron structure below the atom number and symbol, other Periodic Tables carry other information like atom weight etc.: I would ask the Braille text people to put that in a regular table like this (maybe by now these tables are already on file):

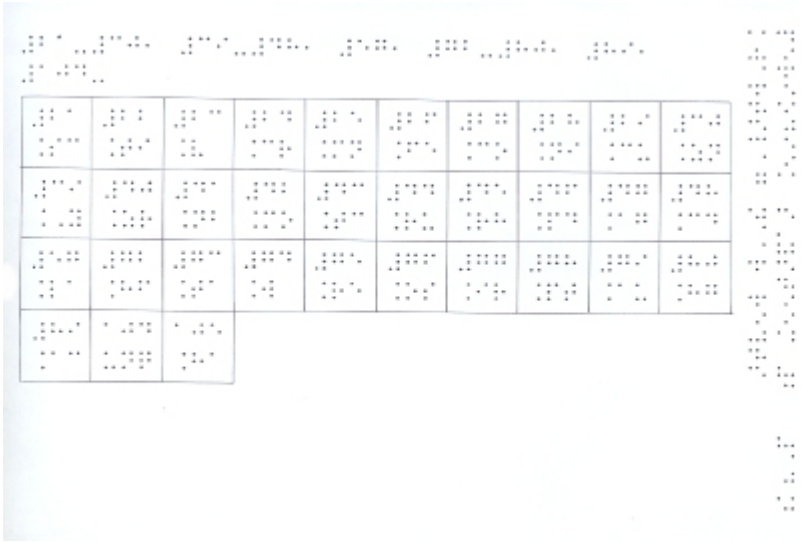
The Periodic Table's elements listed:

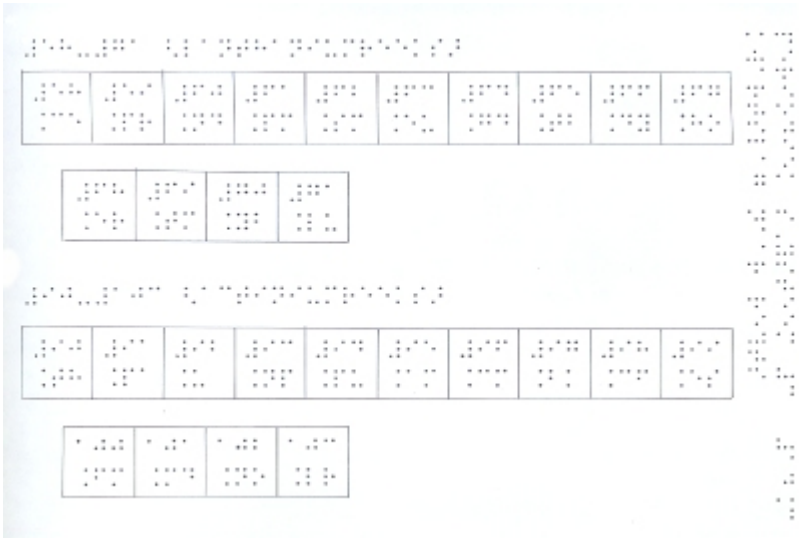
group	atom number	symbol	electron structure
IA	1	H	$1s^1$
0	2	He	$1s^2$
IA	3	Li	$1s^2 2s^1$
IIA	4	Be	etc.

This table will be a guide to understanding the Periodic Table.
Other editions of the Periodic Table may give other data, that also could go in a list like this.

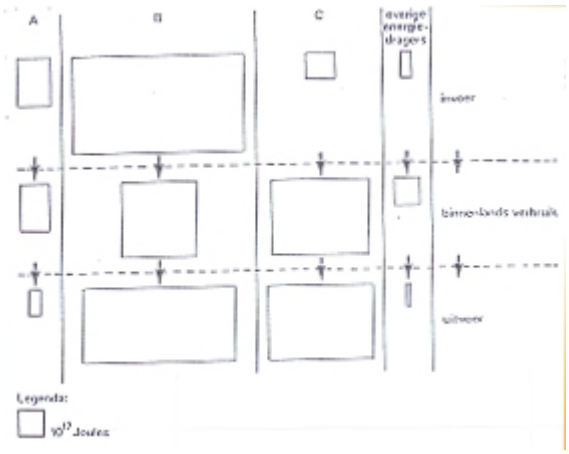


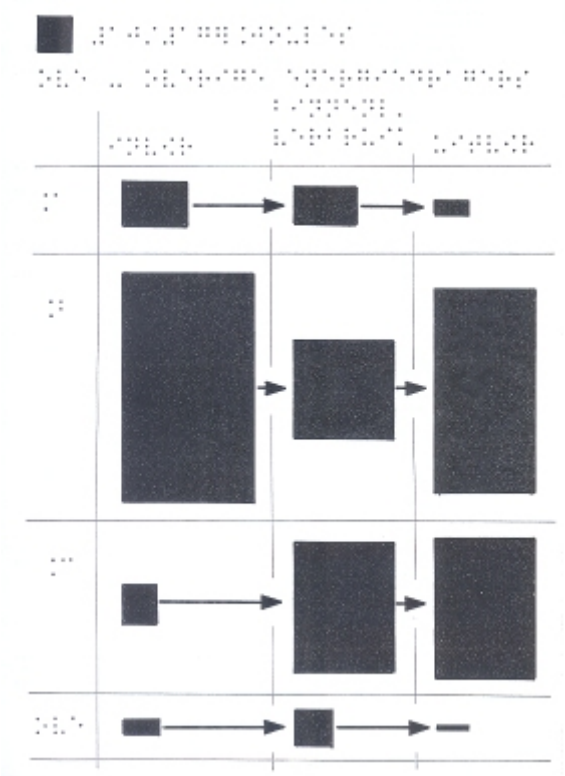
The Periodic Table itself already provides
a model for splitting up
which we take one step further.





Change Direction

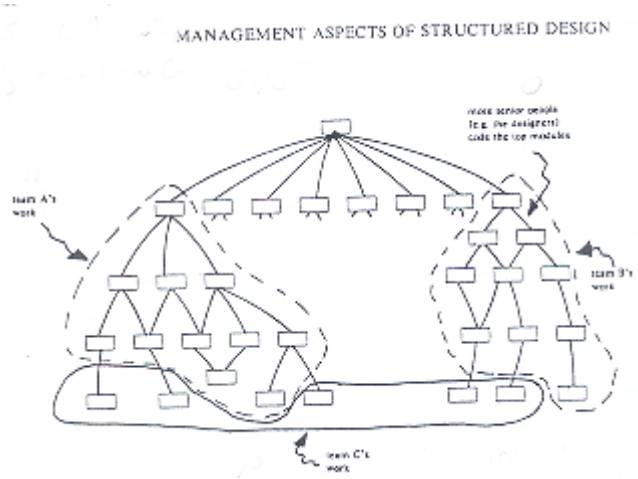


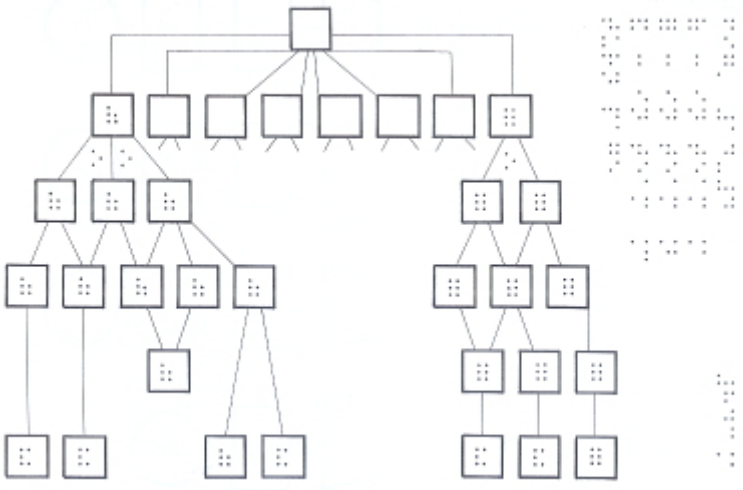


An empty box would be just a square to our readers, so they have been filled in.

Line Demarcations

Copying the lines demarcating the teams is going to be messy.

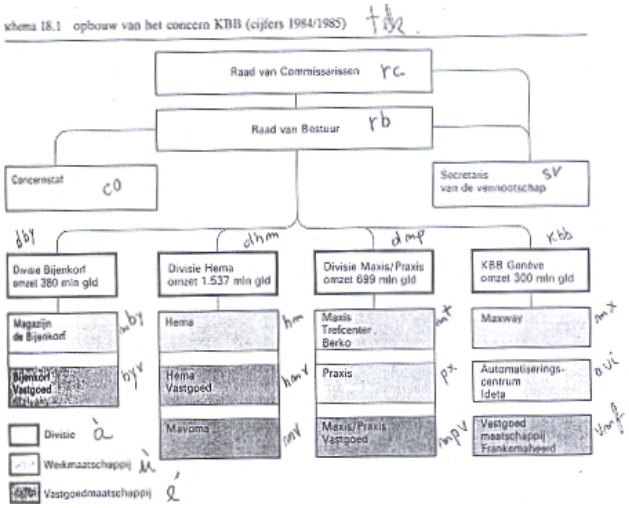


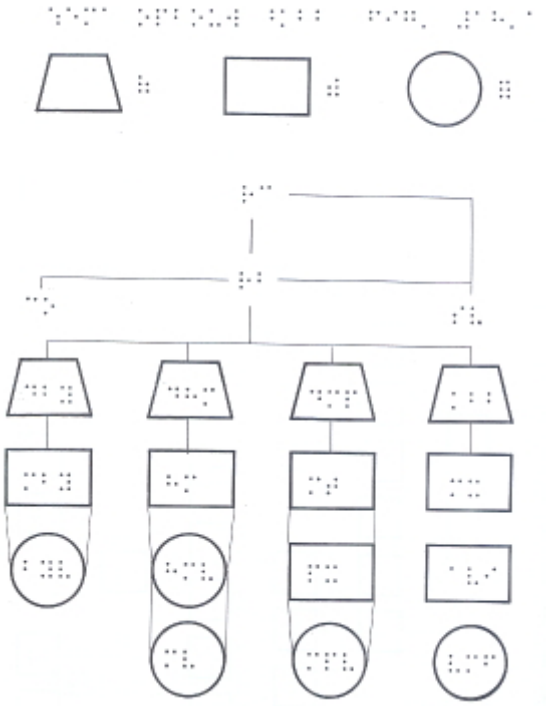


The teams are identified by letters.

The boxes around the letters are not necessary, maybe should not have been copied.

Colored Boxes





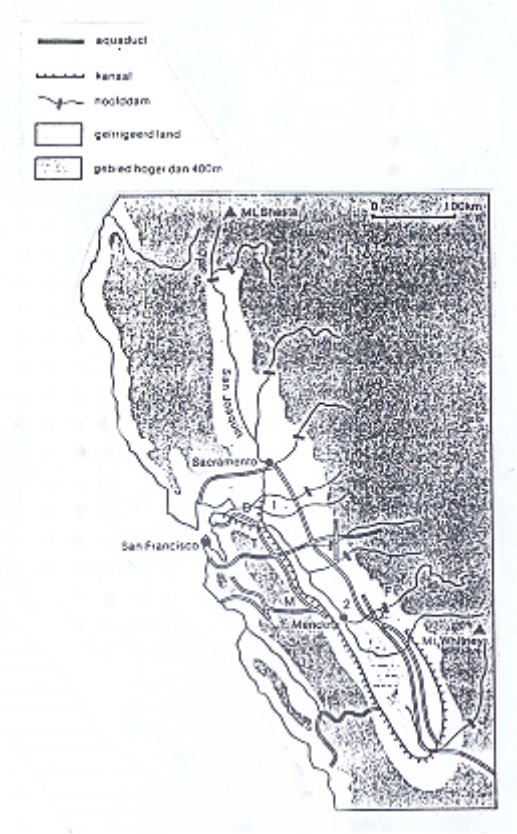
Colored Boxes, Replaced by Shapes

Viewing the large number of abbreviations, a diagram like this might as well, maybe better be fully described, instead of offering a picture like this.

10. GEOGRAPHY, MAPS

In maps the main problem is lack of space: the scale we have to work in is so much larger, braille needs more space than inkprint lettering and exclusive space at that, and of course our drawings are limited to A4- size.
Basically there are two ways of solving this problem: either enlarge the map and show the parts over several pages, or split up your map into subjects that are treated on different pages. We expect our readers to piece together ("synthesise") the information into a complete map in their mind.

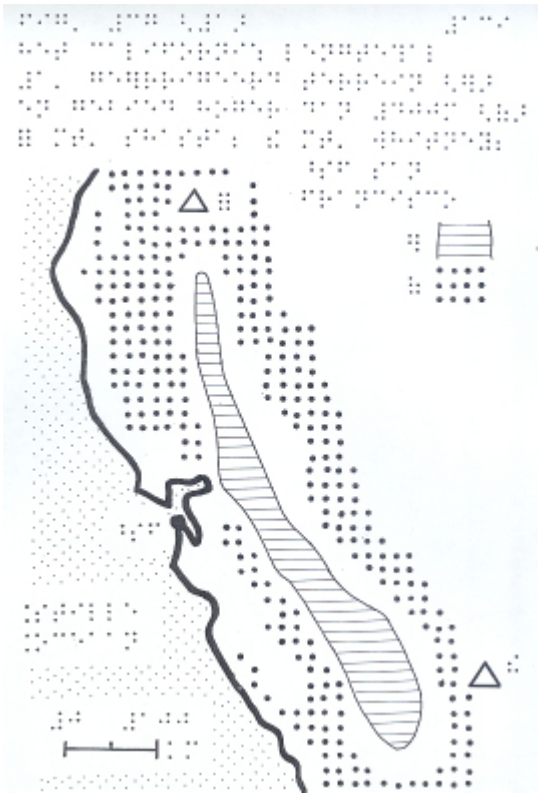
Thematic split-up: (The San Joaquin Valley, California)



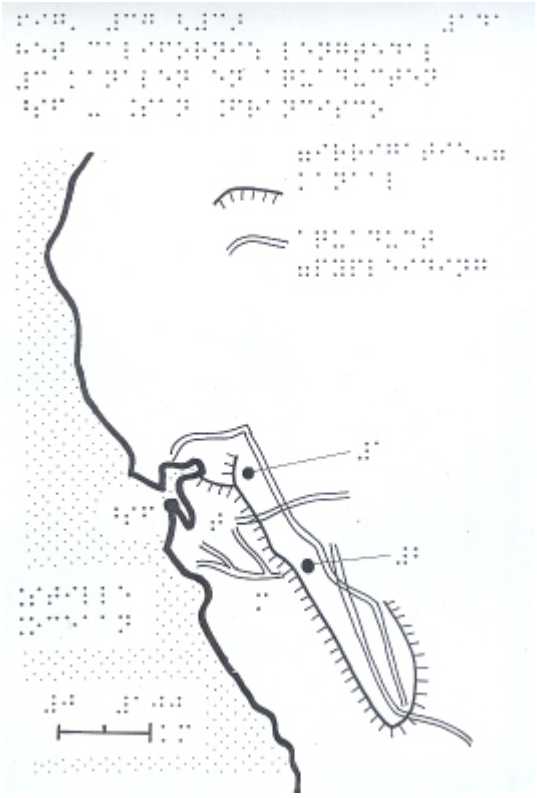
It's not all going to fit on one page. It will be split into:

- the terrain: mountains and irrigated areas
- rivers and dams
- canals and aquaducts.

1



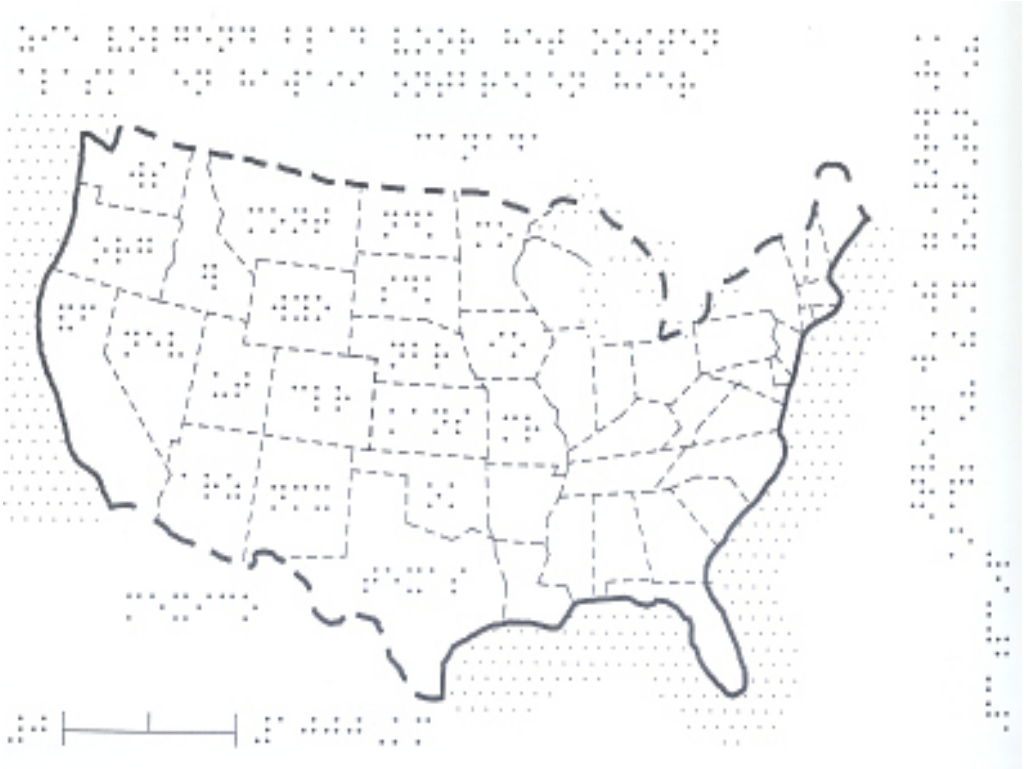
2

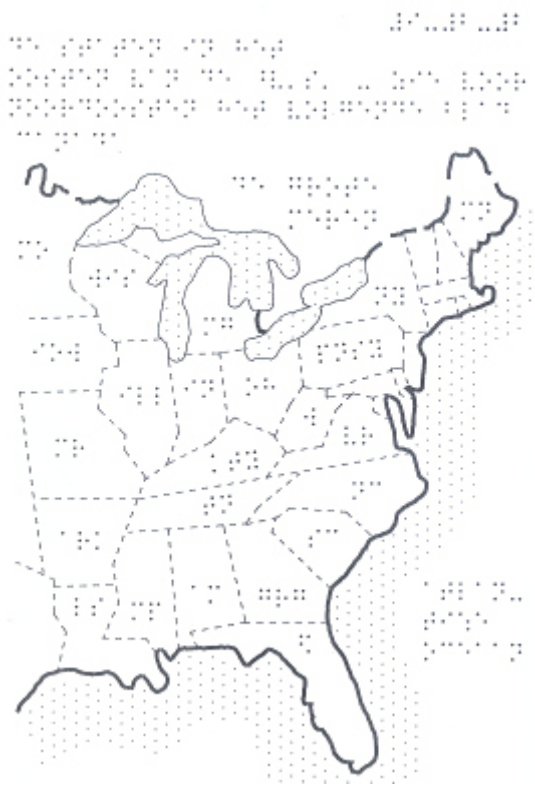


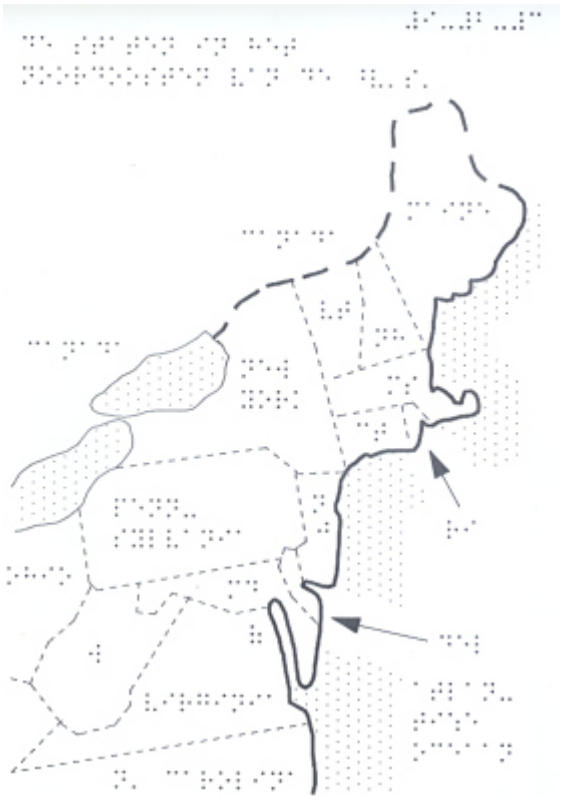
If a map is to be enlarged, always have a full area survey first. Indicate the sector map's position clearly, either in your survey, on a map dedicated to this purpose, or on the detailed maps themselves: use compass directions and 'centre'.

Split Up to Enlarge Details (The United States)

Overview, large states identified; the East; the Northeast



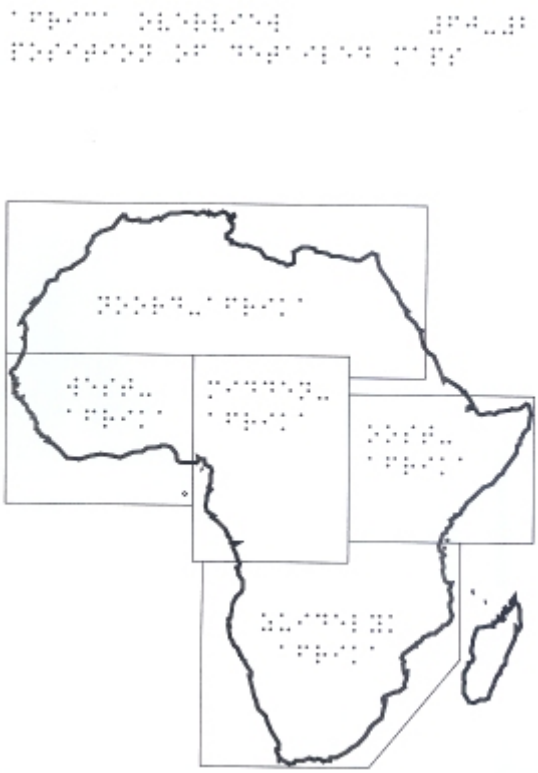




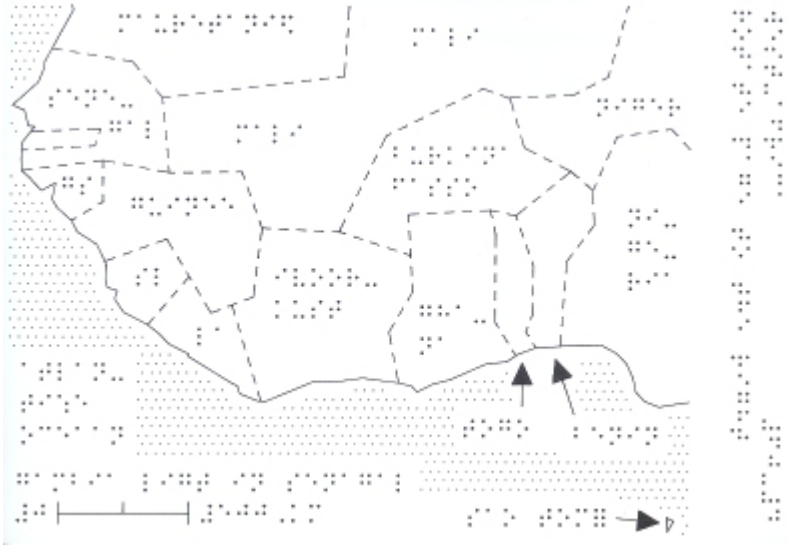
When you have a large number of maps an index map may be useful, showing the location of the detailed maps on the overview map.

Use of Index Map (Africa). Overview; index map; North; West; Thematic Map

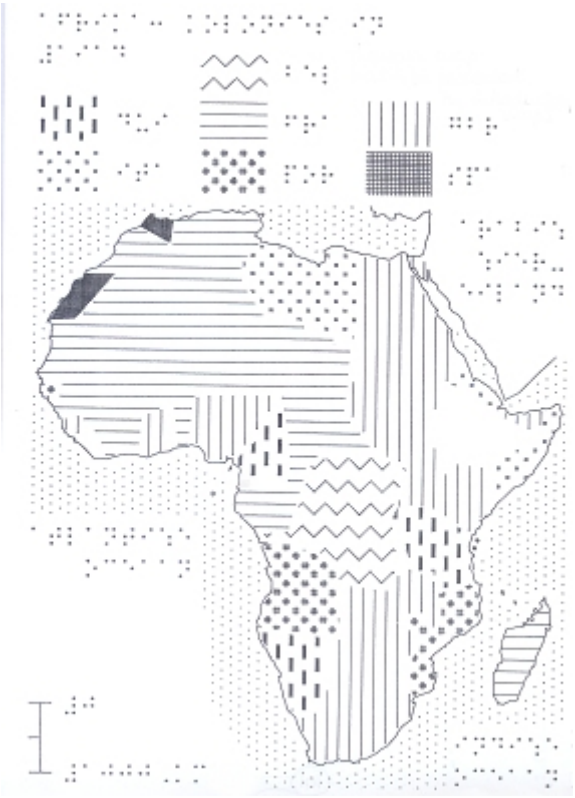
Unfortunately the other maps in the series are not available.



North



West

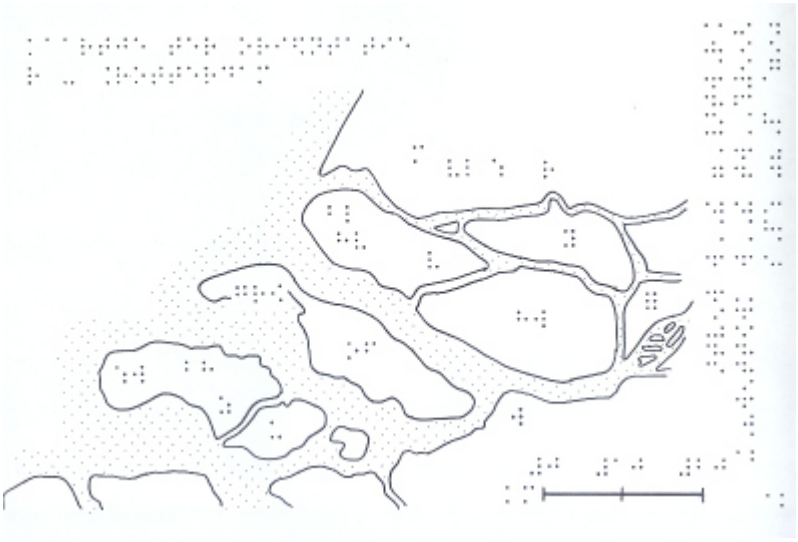


European Colonies in 1914

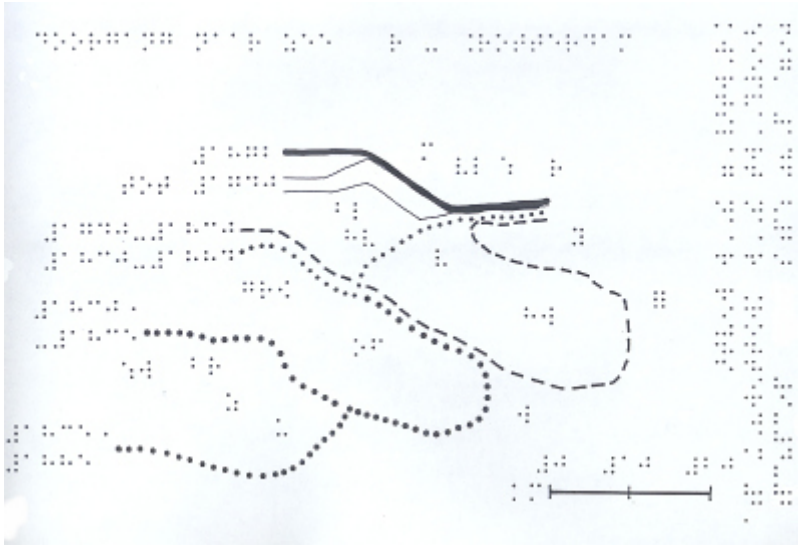
Only after the orientation maps can we present a map like this.

In some maps it's better to split up in subjects: start with an orientation map, carry over some orientation points or the outline to the complete series, then put in the various matters on individual maps. Often it's virtually impossible to cram all the information in just one drawing, sometimes clarity is improved by splitting up. On the other hand, drawing comparisons might get harder.

Split Up in Orientation and Thematic Map: (Sea Routes to Rotterdam)



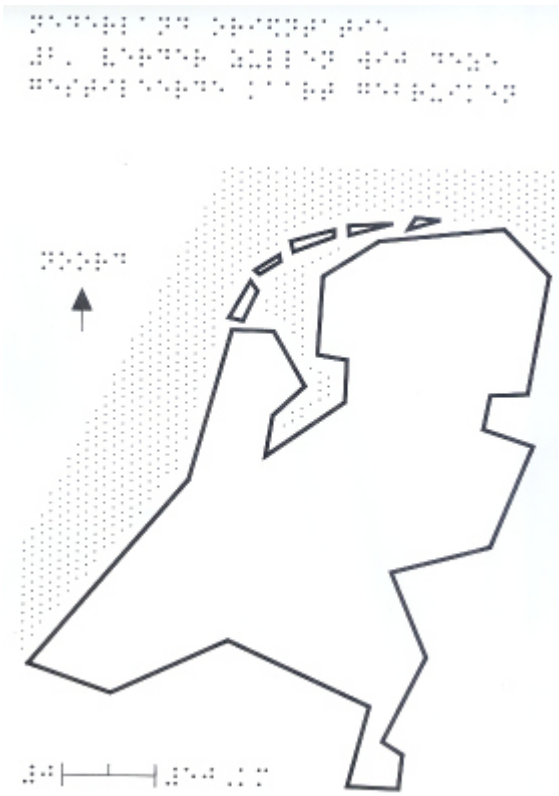
1. orientation
2. thematic map

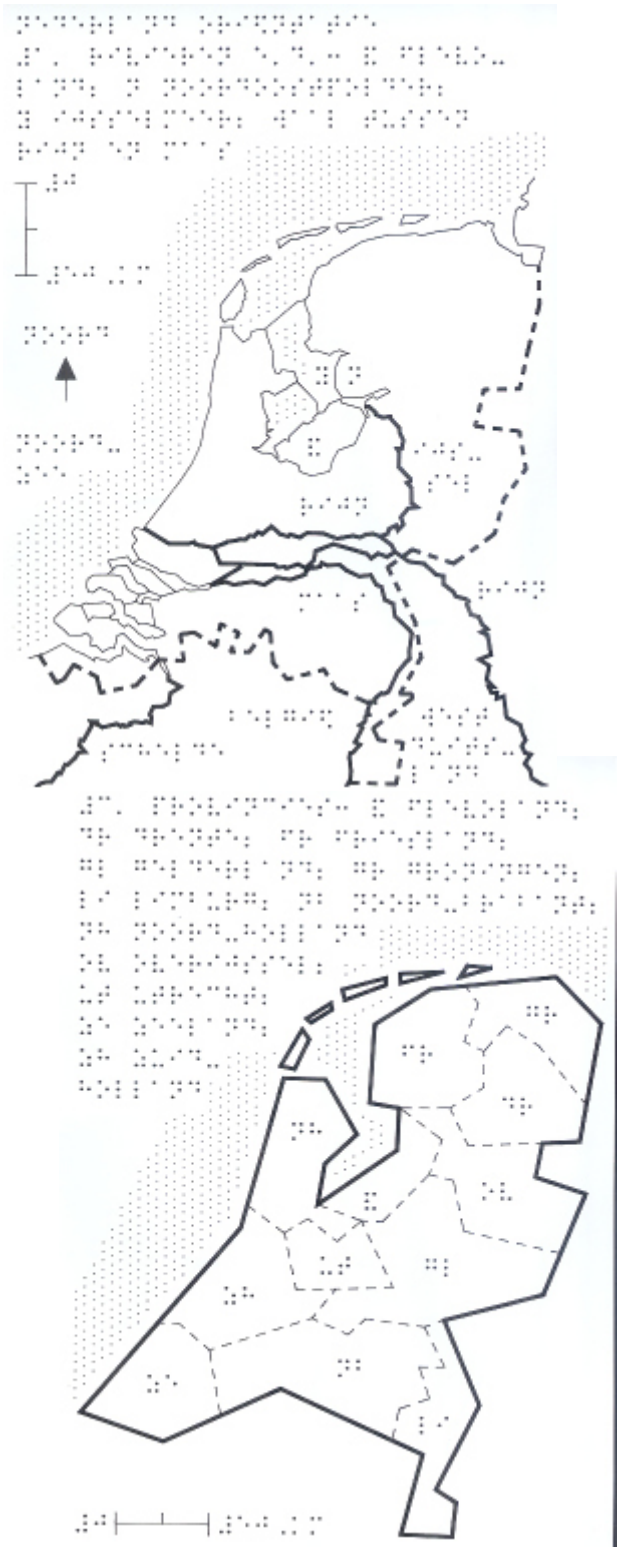


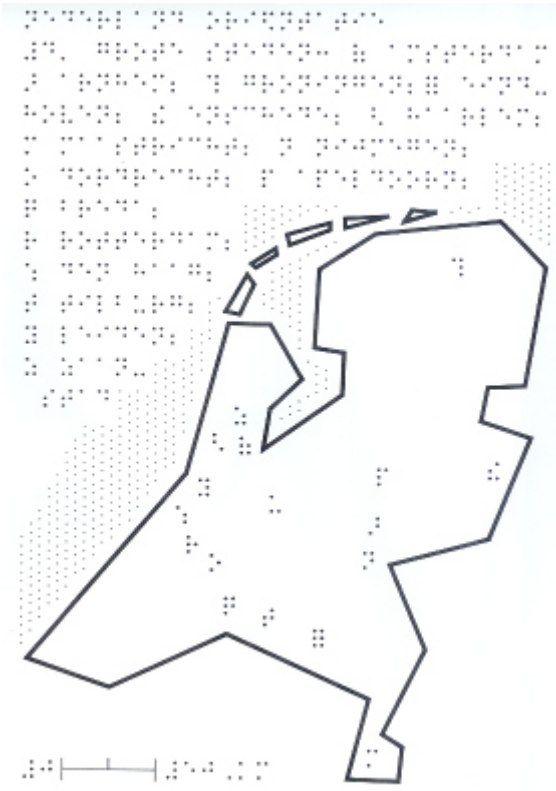
In this same vein I will open a book that has a number of maps on a few areas by an introductory series of maps on that or those areas, showing important features like main cities, rivers etc., and if need be introduces a formalized outline.

A Series of Orientation Maps: (Holland)

1. realistic outline and waterways
2. formalized map (Braille says: from now on we'll be using this map)
3. provinces
4. main cities

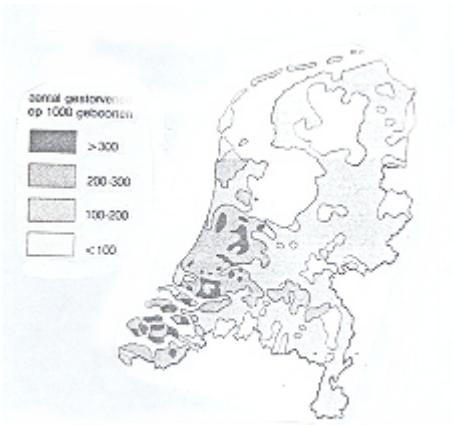




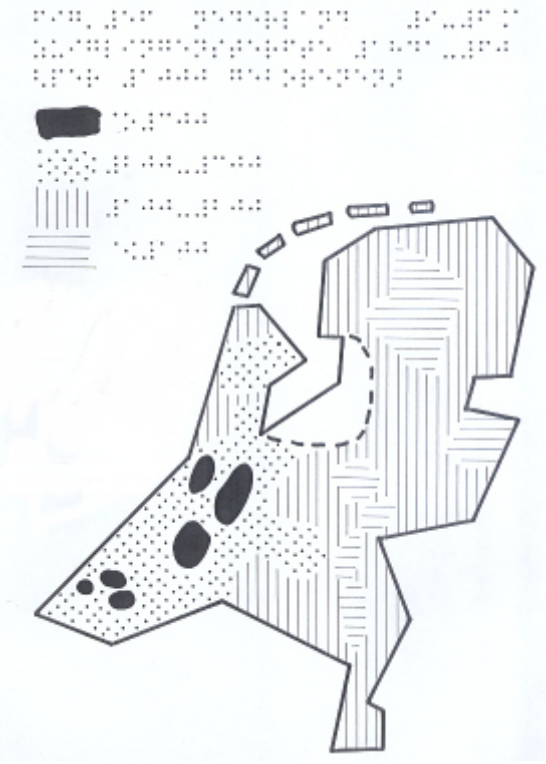


After the area introduction, later maps will be uncluttered, dedicated solely to the subject in hand. The later, thematic maps have to be in exactly the same outline, of course.

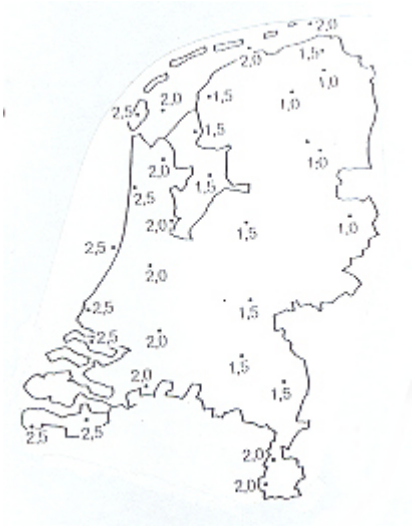
Infant Mortality, Holland 1841-60

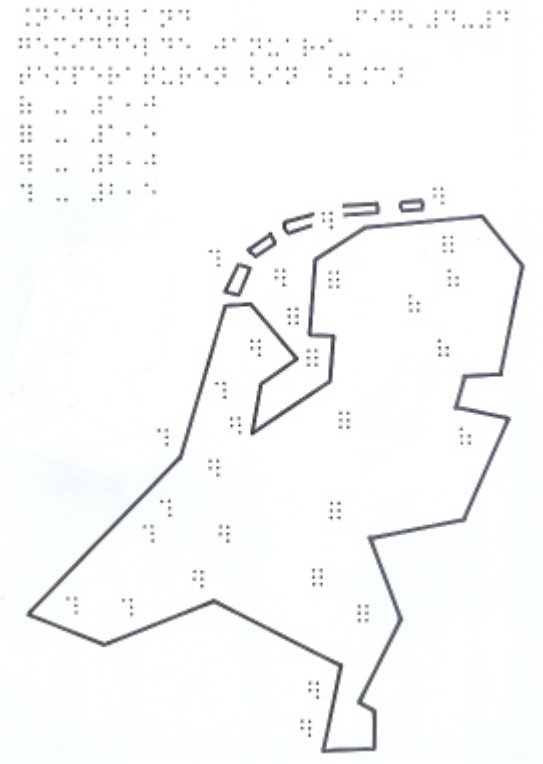


Zuigelingensterfte 1841-1860



Average January Temperatures in Holland (°C)

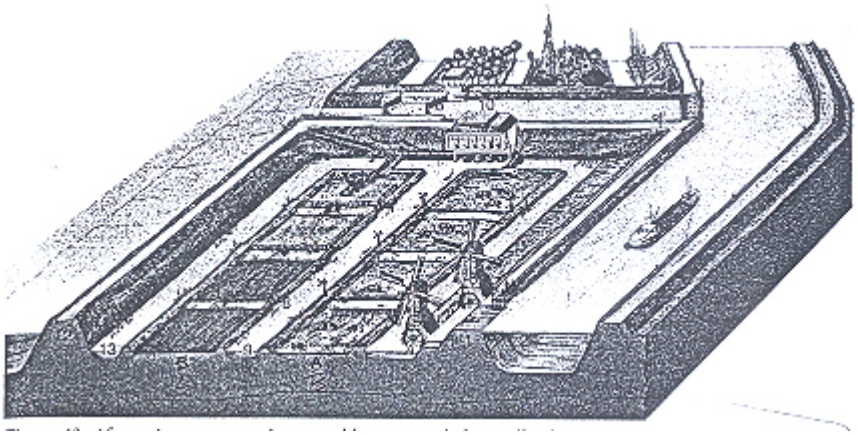




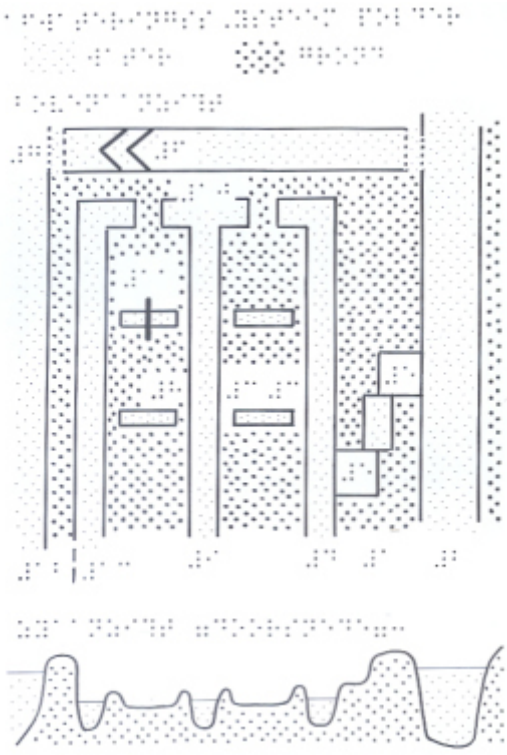
When a graph or a chart is superimposed over a map these are to be separated in a clean map and a clean chart; unless the map is for decoration only, then it may be left out. See the "Produce in Holland" charts in the Charts chapter.

Three-dimensional drawings have to be edited. The following example is split up in two views (on one page).

Split Up Three dimensional in Two Views



This is not a very good Braille picture.
The ditches are too narrow to show their watery content, there shouldn't be a line on top, and many items are too small for clarity.



In drawing a jagged coastline, keep the minimum distance in mind: a number of narrow inlets close together will just be a blur to our readers. It's nice to show a somewhat jagged coastline once, but then its information is spent; our readers had better spend their time on new features.
Islands and peninsula of a somewhat larger size also tend to pose a problem: we cannot discernibly hatch a small outlined area. Like in the map of Holland the south-west corner's largish (Dutch-scale) islands and sea-arms leave no room for other information, so in the map I generally use I have reduced the coastline there to one straight line.
One might also shift information concerning islands that are small in your map to text, like 'Japan is a first-world country'.

It is rather improbable that the blind reader will recognize an area by its form, so it is essential to put the area's name in the title, or add an orientation map. In case names of neighbouring areas are not given in inkprint, add those in your map, so the reader will be given more clues as to an area's location. For illustration look at the maps of King Darius' Empire in the Introduction.

It's not easy to find text or special items in a hatched area, especially if the hatch is dots; so sometimes what I call counter-highlighting, shading the surroundings of the relevant area, might be useful. For illustration, check the counter-highlighting example in Chapter 5.

Another kind of map shows a recommended walk through an exhibition using V-shaped arrows; check the example in an earlier chapter.

Remember the main points:
- No outlining of hatches, neither in your key;
- Areas might be filled up by relevant text also;
- Draw borders dashed, being imaginary lines;
- Hatch surface water in very fine dots.

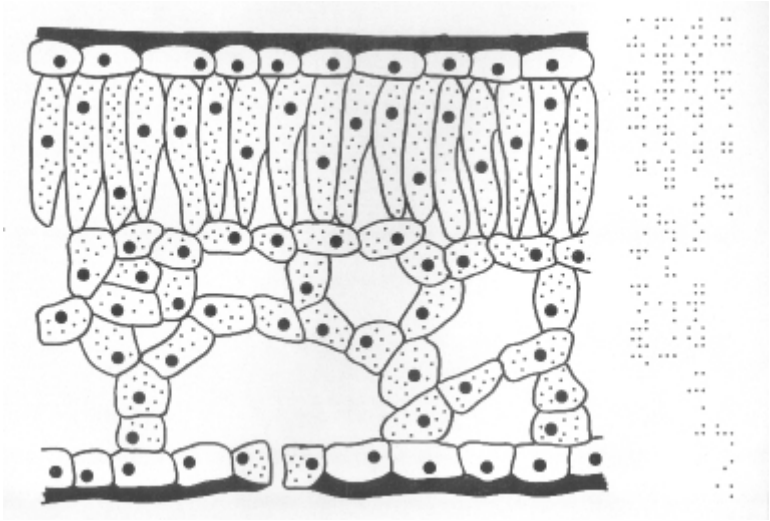
11. BIOLOGY

Like in maps, it's most important to have good titles, and we should also help the reader in recognizing and locating the subject by identifying most or all of the items in the drawing, and naming its surroundings.

Identifying might be done by copying the item, or one of its kind in your key. Also remember the clearing of a shaft to the sides of an arrow as described in the General chapter.
Keep in mind that an outline is not enough to indicate an area: it has to be hatched too.

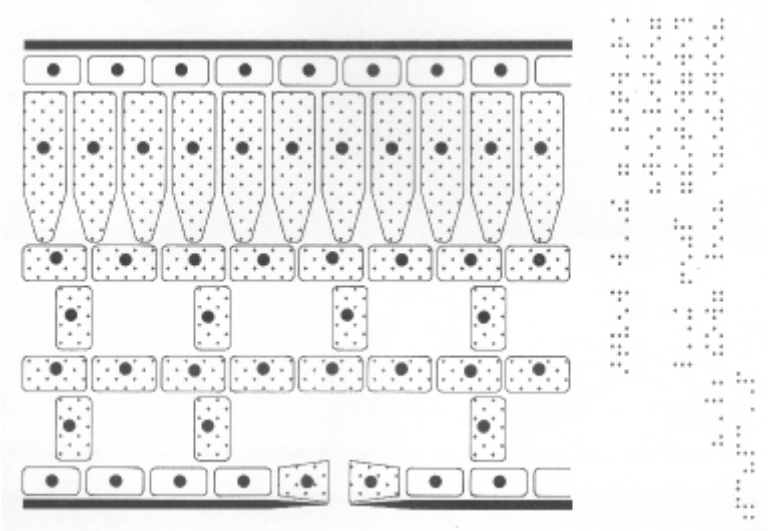
A biology picture often has many small items, like cells. These items are generally of a few kinds, but differentiation within a type might be considerable: to a sighted reader this will not pose a problem, but to a blind reader the individual differences will loom large, and I think he will not recognize the types but just discern a lot of different, individual items. So I will draw all cells of one kind in exactly the same manner (which is very easily done in computer-aided draughting, of course). To the sighted this formalized picture may look rather funny, but it will greatly help our readers understand. As I've said before, this kind of editing aks for some knowledge and understanding of the subject matter in hand.

Realistic or Formalized? Cross-section of a leaf:



The individual cells have too much identity of their own, i.e. within a type there is too much variety for the blind reader.

The various types of cells are easy to recognize.

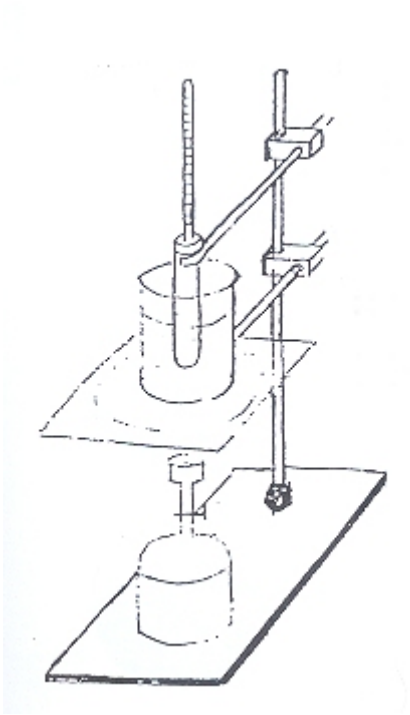


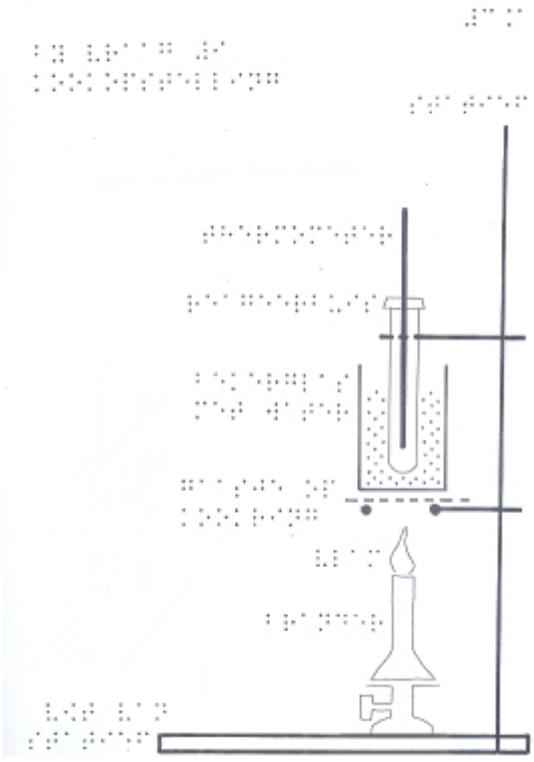
Check also the stomach pictures in an earlier chapter. No Threedimensional Drawings, such as the one of the fanned-out tree or the cell mitosis; and fill in shapes, like in the picture of a mouth saying "a" in an earlier chapter. Also, clear paths for arrows, as in the vascular bundle of a plant picture in an earlier chapter.

12. THE SCIENCES

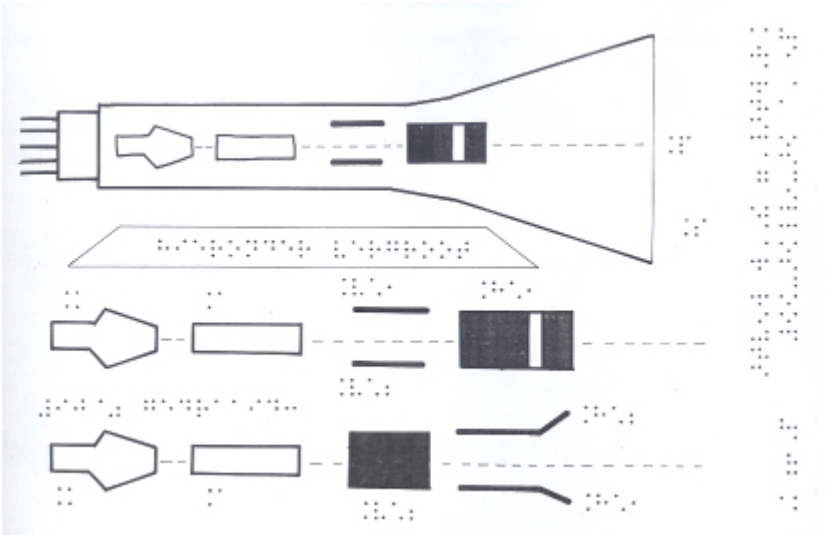
In physics we often come across apparatus and machinery: represent essentials only, basic principles, try to show how it 'works', simplify or split up in component parts.
Pictures are generally three-dimensional: represent by a kind of schematic cross-section; and identify all items in your drawing: to the sighted these may look pretty obvious, but the blind reader generally will not recognize these shapes.
Adding explanations or comment will also help.

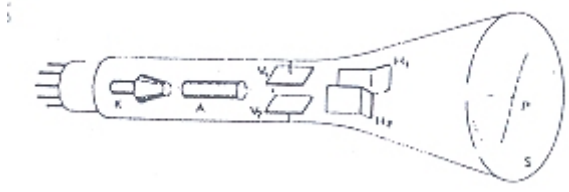
Schematic Cross-sections; Identify All Parts, Explain



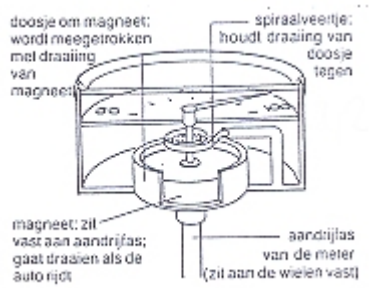


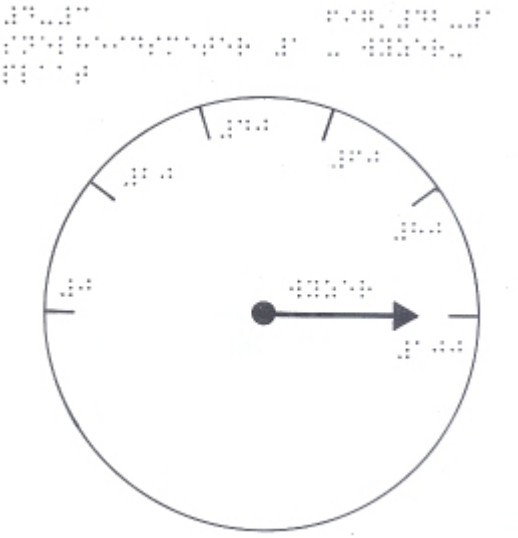
Laboratory equipment and Oscilloscope





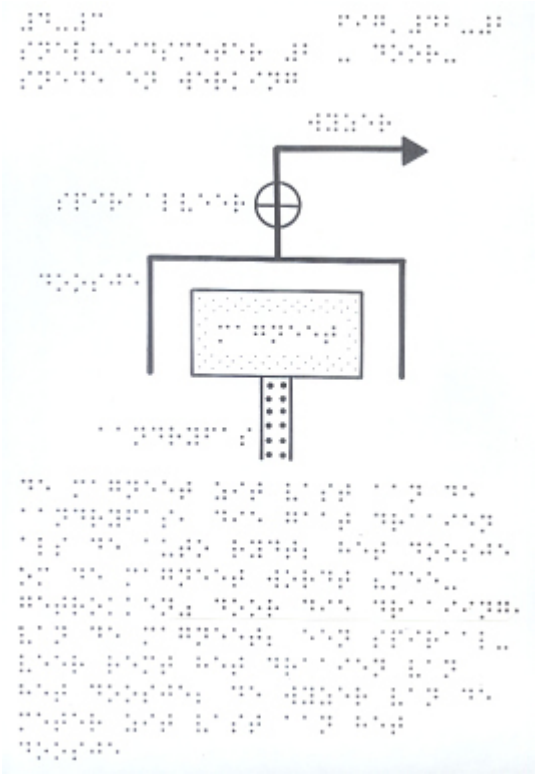
Speedometer



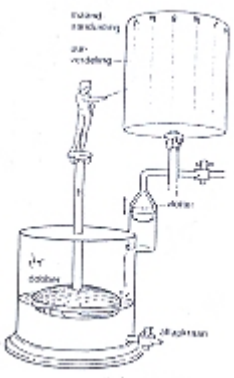


1 - top view: the gauge

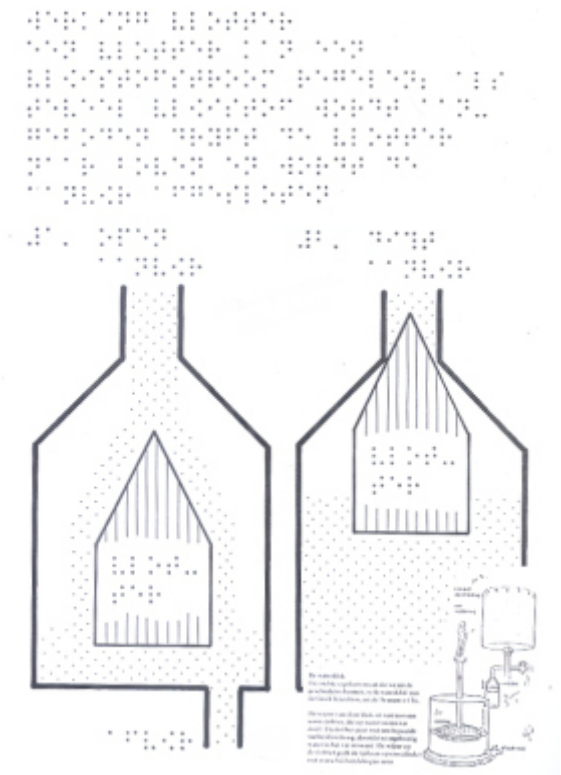
2 - the works explained



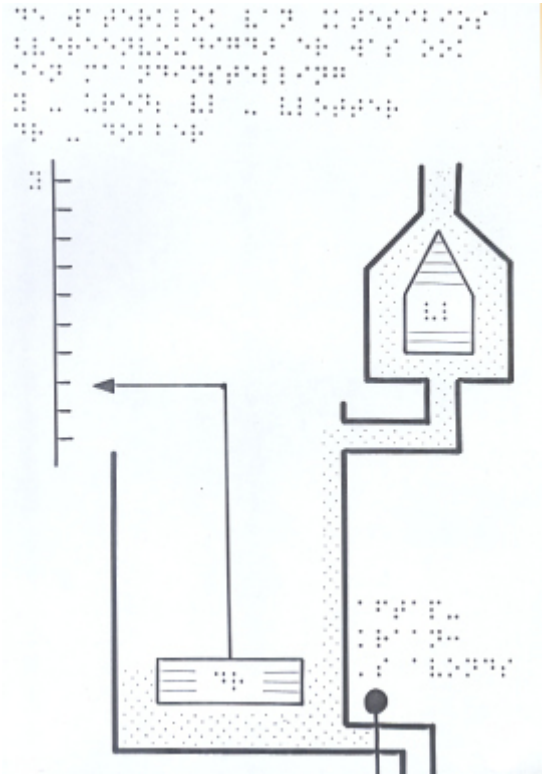
Water Clock (Clepsydra)



Detail enlarged and explained



complete apparatus (ca 50K)



You have already seen the periodic tables in the Diagrams chapter.