Map compilation

Educational Material

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Chapter 2

MAP COMPILATION

Ernst Spiess

CONTENTS

2.1 An introduction to map compilation

Map compilation is the process whereby all relevant source materials are assembled for fair drawing. In the case of a *conventional map production process* it normally consists of the following elements:

1. The whole image geometry of the map, including the precise positioning of contained point and line elements and the map grid, but not necessarily exhibiting the high drawing standards expected of the final map.
2. The manuscript with indications of respective areas, but not necessarily their final tones and colours.
3. The lettering manuscript together with a list of all included names and legend texts.
4. The precise specifications for all the map symbols to be used with regard, for example, to their printing colours, form, size, line widths, tones, textures, screen densities, screen angles, type styles, type sizes, overprint and masking priorities.
5. The preliminary layout incorporating the arrangement of all maps and their dimensions, an indication of the folding system to be employed, and the legends and respective texts.
6. An abstract as a specimen of the finished map's desired appearance.

In the *digital map production process* the approach is in some respects different. There is a gradual transition between compilation and fair drafting with the following differences to a traditional compilation:

1. A final symbolisation can and should be easily applied for each map element at the initial stage of compilation. This method is known as WYSIWYG ('What you see is what you get'). This means that a final map image is directly produced with precise positioning of point and line elements.
2. Instead of a coloured manuscript a series of sequential colour proofs is plotted in order to vary point and line symbolisation, and colour tints, until an optimal image is obtained.
3. There is no need for a lettering manuscript as all the names and texts can be placed interactively on the screen in WYSIWYG quality. This process may occasionally profit from a name database, which allows for preselection and provisional positioning.
4. The same kind of precise specifications are needed, although in this case not to direct the fair drawing but rather the final plotting process.
5. Similarly the layout, as far as it is not determined by map use, can easily be modified and changed, especially the placement of frames, legends and texts.
6. The colour proof serves as a specimen of the final map appearance.

Compilations may be produced in different ways which can be categorised according to the graphic techniques employed:

- tracing with ink onto transparent film from source material which is already at the appropriate scale;
- sketching with ink onto a blue copy of the source material which has been reproduced on drawing paper;
- compiling individual symbols on graph paper for subsequent photographic reproduction;
- using templates for similar symbols;
- digitising on a tablet from source maps;
- overlay-digitising on the screen using a base of scanned images;
- computer-assisted editing involving the application of computational and plotting routines to geometrical and statistical data.

Under the following circumstances the preparation of a compilation manuscript can be omitted:

- if clear image geometry is already available and needs only a minor degree of generalisation or retouching;
- if experienced cartographers are to be responsible for the fair drawing; and
- if adequate provision is made to ensure that separate image layers can subsequently be registered one with another.

2.2 Documentation and source materials

The information to be presented in map form may be collected from and based on various sources, but all of the data are related to a specific spatial location. However, other details may also be appended to this primary information.

For the compilation of a new map the following sources may be consulted:

1. *Field surveys* may help in the precise location of detail. Individual points are surveyed using theodolites, distance measuring and GPS instruments in order that their coordinates can be calculated.
2. *Aerial photographs* (preferably consisting of vertical imagery) which can be matched with the help of clearly identified control points or geocoded orthophotos to the map grid.
3. *Statistical sources* comprised primarily of tables containing quantitative details relating to various features. These may be output in map form only if they are connected to a geographic element such as a place, a line or a zone (for example, an administrative area).

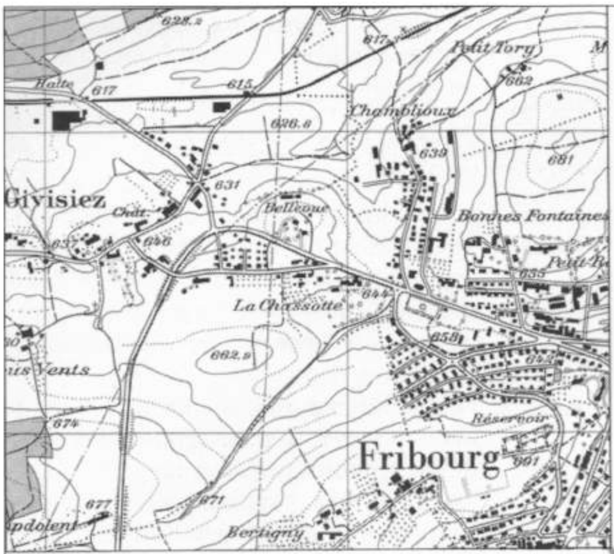


Fig. 2.1 Topographic map, an important source for every new map

Fig. 2.2 Aerial photograph showing the latest changes

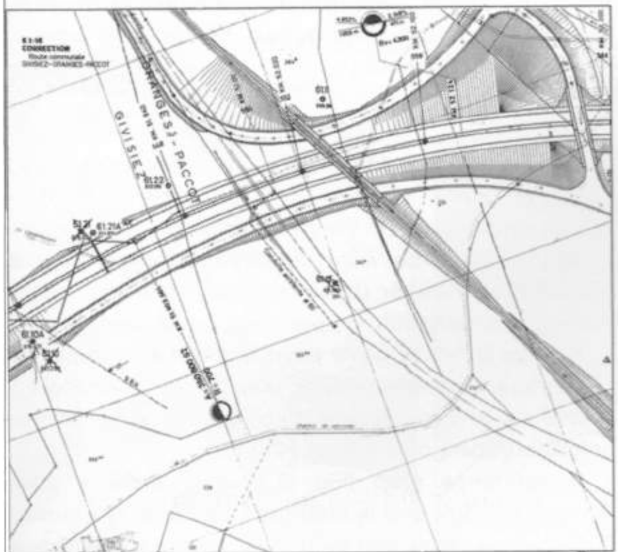


Fig. 2.3 Highway construction plan for final updates

Gemeindenamen mit gebräuchlichen Uebersetzungen nach Kantonen[1]
Noms de communes dont la traduction est usuelle, par cantons[1]
Nomi di comuni per cantone, la cui traduzione in uso[1]

Amtliche Namen Appellations officielles Denominazioni ufficiali	Bezeichnungen in anderen Amtssprachen / Appellations dans les autres langues officielles / Denominazioni nelle altre lingue ufficiali Deutsch Allemand Tedesco	Français Französisch Francese	Italiano Italienisch Italien
Zug			
Zug		Zoug	Zugo
Fribourg / Freiburg			
Agriswil		Agrimoine	
Büchslen		Buchillon	
Courgevaux	Gurwolf		
Düdingen		Guin	
Fribourg	Freiburg		Friburgo
Gempenach		Champagny	
Giffers		Chevrilles	
Gruyères	Greyerz		
Gurmels		Cormondes	
Jaun		Bellegarde	
Kerzers		Chiètres (FR)	
Lurtigen		Lourtens	
Meyriez	Merlach		

Fig. 2.4 Gazetteer as a source for toponymic detail

2183	CORMINBOEUF	421	364
2184	CORPATAUX	262	255
2185	CORSEREY	94	93
2186	COTTENS (FR)	320	309
2188	ECUVILLENS	274	261
2189	EPENDES (FR)	408	380
2190	ESSERT (FR)	115	101
2191	ESTAVAYER-LE-GIBLOUX	66	64
2192	FARVAGNY-LE-GRAND	310	303
2193	FARVAGNY-LE-PETIT	125	91
2194	FERPICLOZ	74	67
2195	FORMANGUEIRES	29	25
2196	FRIBOURG	17699	19701
2197	GIVISIEZ	438	571
2198	GRANGES-PACCOT	601	542
2199	GRENILLES	42	39
2200	GROLLEY	379	382
2202	LENTIGNY	229	239
2203	LOSSY	96	88
2204	LOVENS	87	73
2205	MAGNEDENS	45	35
2206	MARLY	2662	2573
2208	MATRAN	336	267
2209	MONTECU	69	73

Fig. 2.5 Statistical data on population

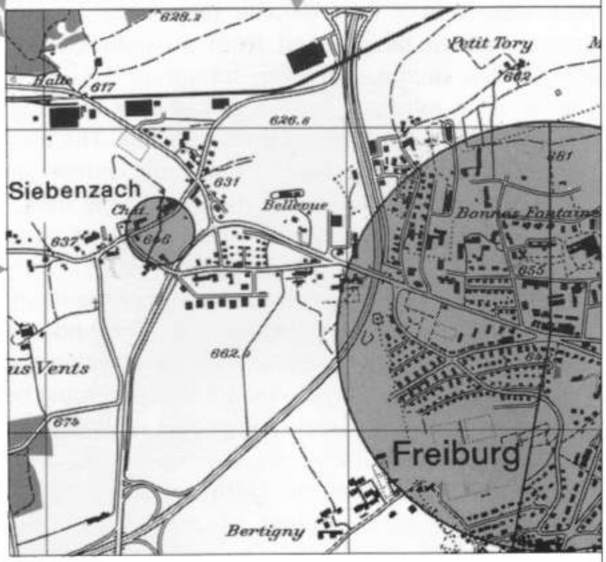


Fig. 2.6 Map compiled on the basis of all the above source data

4. *Data banks* can also hold geographic information in coordinate form. Details are stored in the internal memory of computers, on hard disks, magnetic and optical disks or cartridges. They can be made available for use during any subsequent computer-assisted map editing process. Any feature that is attached to particular coordinates can be represented in this way.
5. *Base maps at different scales and with a variety of contents*, which can be related, one to another, by means of the map grid or unequivocal control points. In digital processing such analogue base maps are usually scanned. It may be advantageous not to use the printed maps but their individual plates containing separated map elements.
6. *Further information* can be gained from published literature, by personal enquiries or telephone calls, but here again this detail must be able to be specifically located.

In many cases the problems of *copyright* have to be considered. The use of unmodified materials is normally legally restricted and must be authorised by the publisher of the original map. Such a grant of reproduction rights may result in considerable costs. Under certain circumstances the use of such maps is legally acceptable provided that they are subjected to a complete redesign and recompilation also involving the use of other sources.

2.3 Evaluation and processing of data

In view of the amount of data available in various forms, their informed selection and evaluation is extremely important. Every detail in the map has to be correct, precisely located, complete, in the right order, and as up to date as possible.

To verify each individual detail with respect to these criteria is a very difficult task. Ideally every element should be checked from an independent, authoritative source. However, topographic surveys especially are normally unique and at best can only be checked with reference to small samples. The map editor should therefore have a thorough knowledge of the evolution of the source map that he is using, and make a number of comparisons with other up to date materials.

The evaluation of a compilation relies primarily on checks of this sort. The objective is to find and use the best source for every detail contained within the map. Furthermore the employed information must be homogeneous for the whole map sheet, and gaps in the detail must be filled in.

Figures 2.1–2.6 illustrate, with reference to an example, how map content is assembled from various information sources:

Fig. 2.1 Most of the planimetric features depicted on a large scale map are valid for the project.

Fig. 2.2 The latest information on roads under construction is abstracted from an aerial photograph.

Fig. 2.3 Construction plans show the projected roads. However, this information is often very unreliable with respect to details which may be changed during building.

Fig. 2.4 The spelling of place names in another language is taken from a gazetteer, and the latest census figures are used to verify type sizes as a function of class intervals of the population.

Fig. 2.5 Population figures contained within a data bank are used to compute the sizes of the proportional circle diagrams.

Fig. 2.6 The final map has thus been compiled from several completely different types of source materials. It is important for the map user to know on what bases it has been established, and a list of sources should form a part of included border information.

2.4 Map purpose

An important factor in the design of any map is in the envisaged purpose. Also of great interest is how it will be read – either detail by detail, globally, or by making comparisons.

Figures 2.7–2.11 have been designed to illustrate the different types of maps which can be prepared and relate to various aspects of ground water in the neighbourhood of the river Rhine.

A *reference map* (Fig. 2.7) may have a very detailed content and is read item per item. No immediate comparisons can be drawn, except in restricted areas around specific points of information. Answering a question concerning the whole map will require its close study for a considerable period of time. The main purpose of a reference map is to store detail that is retrievable by the map reader at any time.

Conversely, a *map for education purposes* (Fig. 2.8) contains only a limited amount of information in comparison with the reference map. Detail is presented in a straightforward, easily remembered form and caters for the requirements of specific users. Figure 2.8 is a simple version of the hydrological map illustrated in detail in Fig. 2.7, and shows only the main course of the ground water stream.

In Fig. 2.9 the information is presented as a *series of analytical maps*, which are suited for detailed analysis and for the regional comparison of phenomena represented. An ideal solution is the production of a set of graphics at the same scale and with similar base map elements. Each depicts only one component, but shows all of the information available about this feature. In the example the three maps illustrate information at different ground water levels.

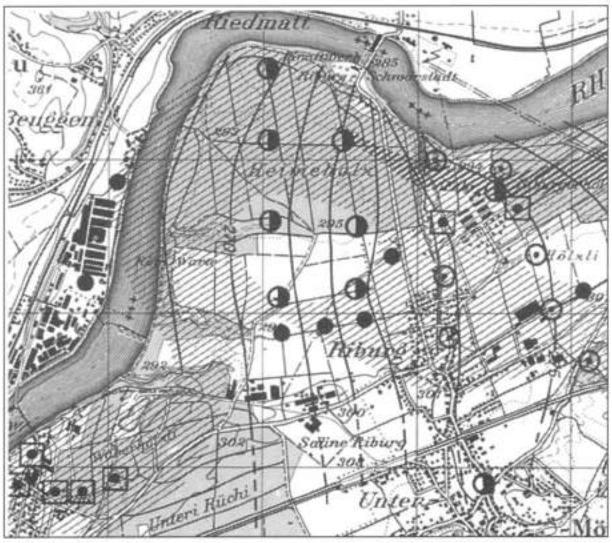


Fig. 2.7 A reference map to be read item per item

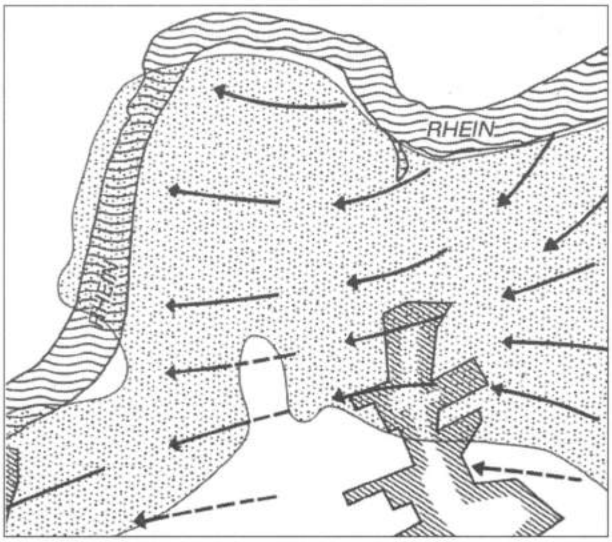


Fig. 2.8 A simplified version of the map to the left to be used for educational purposes

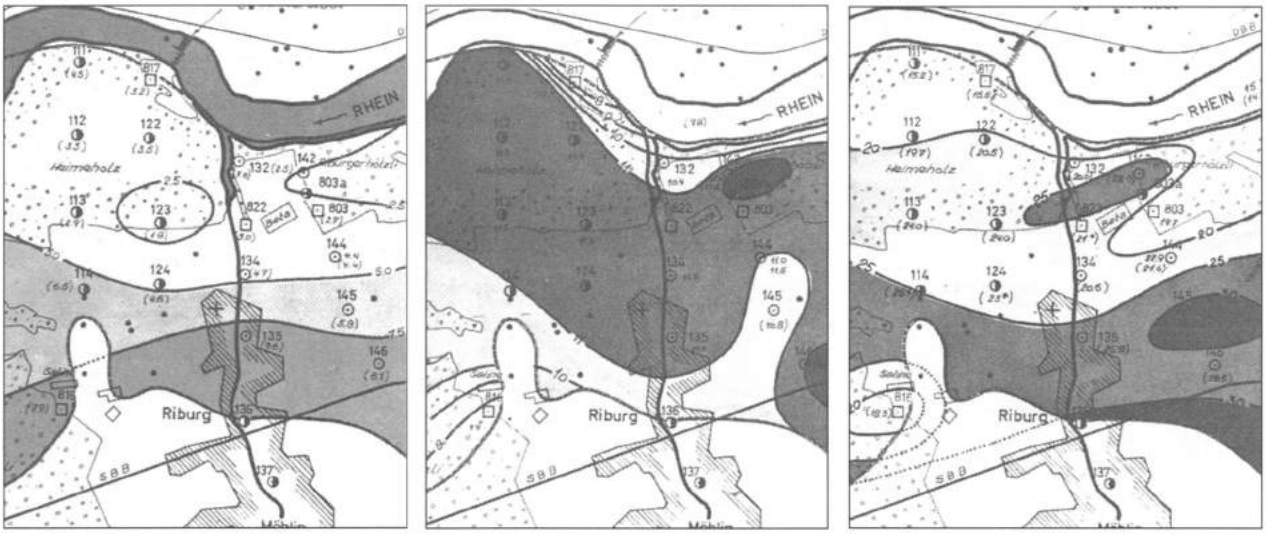


Fig. 2.9 A series of analytical maps for individual study and comparison

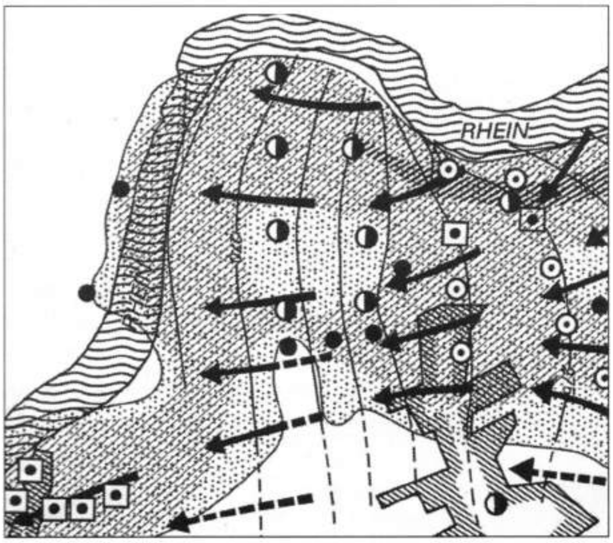


Fig. 2.10 A complex thematic map containing three levels of information

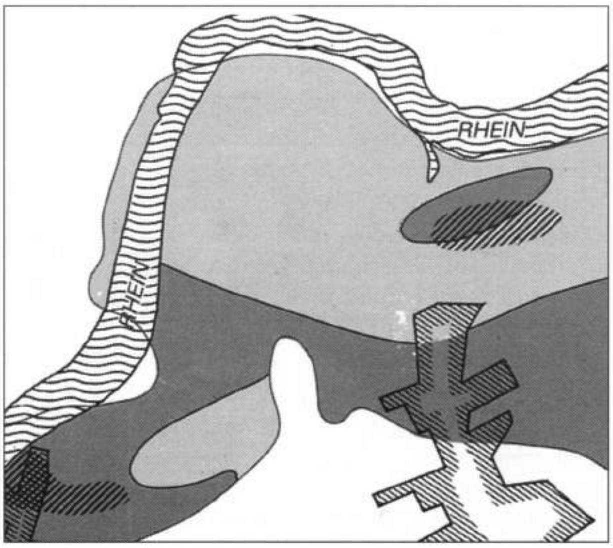


Fig. 2.11 A generalised synthesis map including aspects of all the original categories of information

Figure 2.10 presents the same detail in the form of a more *complex thematic map*. Three major components are included in one graphic to facilitate the study of the interrelationship between the different features. The solution employed in this case must provide for a significant amount of image contrast between the different features. Ideally they should be arranged on three different visual planes. One element is selected for the foreground (stream line arrows), another category employs area tints to form a background (ground water zone), and the third component (isolines) is placed between these two.

Finally, in Fig. 2.11, the original information is summarised into a few general categories. The resultant product can be called a *synthesis map*. Its graphic form is extremely simple and easy to recall, while the legend is exhaustive and includes all the factors that have been considered in this categorisation.

Before starting any compilation it is necessary to make a decision with respect to the type of map envisaged. Data have to be treated in entirely different ways depending on the chosen purpose of the graphic.

2.5 The map compilation process: the different steps and their optimisation

Figure 2.12 is a synopsis of the compilation process which involves the making of a number of decisions based on a graphical, technical and/or economic evaluation of the map concept. If at one stage results are not satisfactory, earlier decisions may have to be revised in order to find the optimum solution.

A map compilation is based either on an order to conceive and produce a map on contract, or on a personal initiative to communicate information via the medium. The first step is to analyse the needs for a map and thus its intended purpose (see section 2.4) and the related user requirements. Also the area to be mapped can usually be delimited from the outset.

The next step will be to enquire about source material availability and to collect all relevant surveys, statistical data, source maps and other information. The decision about the features that can be mapped ought, ideally, to be based on a broad and even excessive assemblage of materials. This implies the need for a careful analysis, cross-checking and evaluation of these data.

An initial consideration of the intended form of publication, and the media by or on which the map is to be produced, is strongly recommended. For a map intended to be printed on paper the publication format, folding and binding system has to be determined. In the case of graphics that are to be displayed on screens, an awareness of the technical limitation of this medium (screen size and resolution) is imperative.

A decision has to be taken whether during compilation use will be made of conventional or digital techniques. This, as we will see, has major consequences for the whole production process.

When a provisional selection of those features to be represented has been completed, it is then necessary to determine the map scale and, if necessary, the projection. Map purpose, publication medium, area to be shown, format and scale are mutually related one to another. For this reason the sequence in which these decisions are made may sometimes be reversed.

In the next step all source data has to be converted to the same working scale and compiled upon the chosen projection. Conventionally this normally means undertaking photographic reductions. However, in the digital mode it involves the conversion of analogue maps into a digital form by scanning or digitising. These processes are often complemented by coordinate transformations to ensure a precise match with the projection selected.

Before making a choice of the representational methods to be used, an analysis of the structure and information content of each potential map component is recommended. subsequently a decision has to be taken on the legend and map specifications.

As it may be difficult to foresee the likely consequences for the final map it is suggested, when employing conventional techniques, that a small sample, preferably of a highly detailed area, should be drawn using the intended specifications and thus creating an example of the final appearance. With the digital procedure several components may be available as layers in a more or less final version. Other map levels can be the result of a computation and software-driven construction from statistical data. All this allows the rapid production of a set of cheap preproofs covering the whole of the area mapped, and possibly including variations of specifications.

These 'samples' or preproofs form a basis for the final evaluation of all decisions previously taken relating to map scale, content and particularly graphic design. A small specimen, or proof, may be required and is useful in persuading a customer to reach a final agreement on a project. It also allows the planning of production procedures and estimation of the time needed, and cost involved in the compilation and generation of the finished map.

At this stage one may again question earlier decisions, for example as to the intended purpose. Data collection may simply not allow satisfaction of original requirements. Research for more, or better, data may be needed to compensate for gaps or to improve quality.

Several cycles may be needed before, or until, the proof is accepted as a result of having carried out necessary modifications. In the conventional process the next step consists of a final compilation including all details relating to the mapped area. The various components of this will be discussed later, but they must

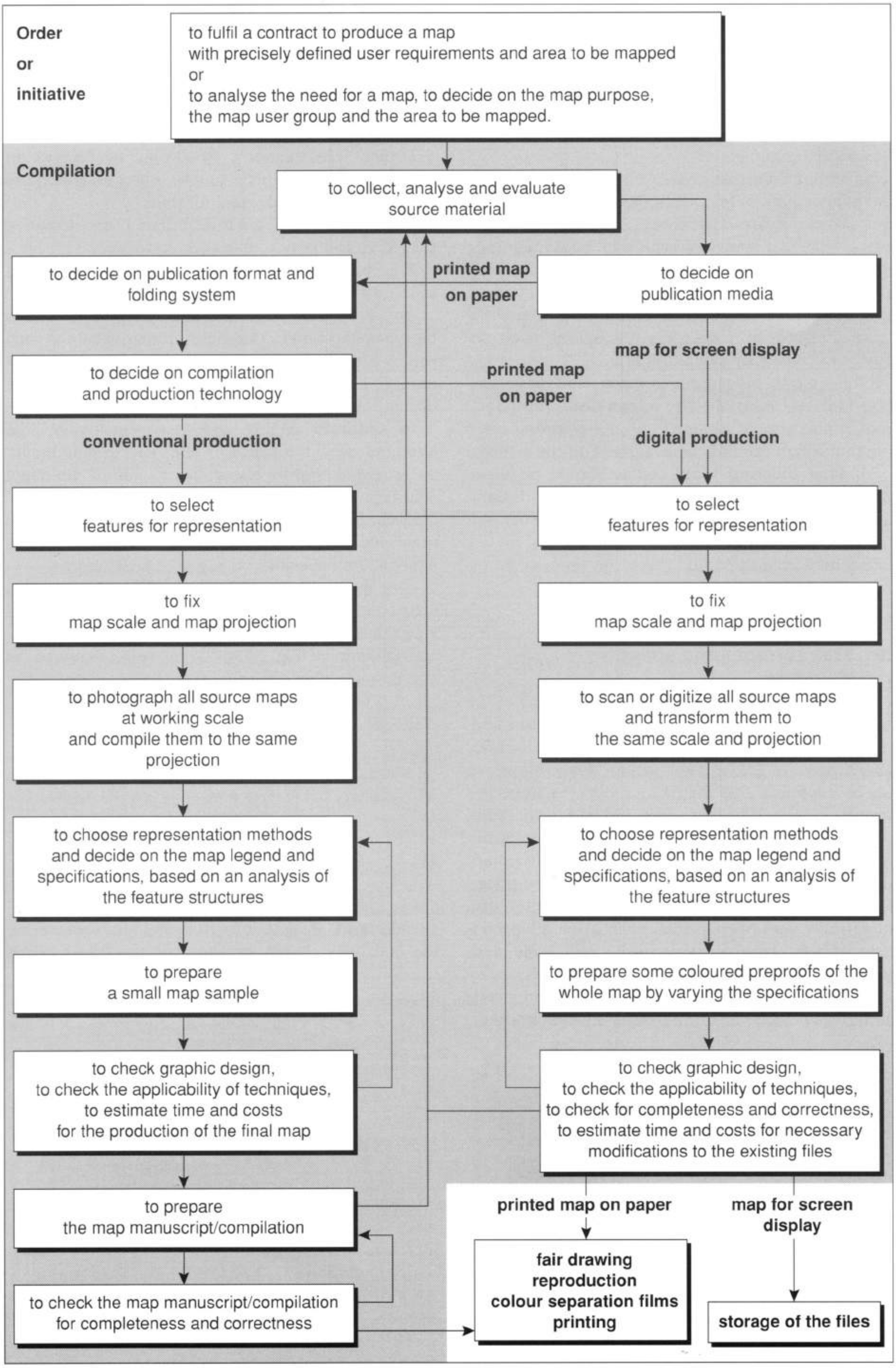


Fig. 2.12 Synopsis of the map compilation process

be checked for completeness, precision and accuracy, and may require some corrections. Only after this can the compilation be passed to cartographers for the production of fair drawings, scribings, masks, lettering, photographic processing, colour separation films, offset prints, etc.

In the digital process once proofs are accepted the final adjustments of features to conform to specifications is performed 'on-screen'. Using 'interactive editing' allows a seamless transition from a compilation into implementation of the production process. When the map is to be reproduced on paper, colour separation films are printed either from the final digital files, or by employing procedures such as computer-to-plate or digital printing.

Similar digital procedures to those used for generating hardcopy are applied for screen-displayed maps. Proof copies should be used only for checking content, but design can only be evaluated on the screen.

For final checking proof copies should be used only for the map content. The graphic design, however, cannot be evaluated positively on paper but only on the screen.

Resultant images can be stored on disks or burnt onto a CD-ROM.

2.6 Map formats and sheet arrangements

As has been suggested by the diagram illustrating the compilation process (Fig. 2.12), the map format has necessarily to be fixed at an early stage. It may be supposed that the geographic area to be represented is sufficiently well defined and that, therefore, format is solely dependent on map scale and vice versa. On the other hand, freedom in map design is very much controlled by the intended scale, or more directly by the area available for the map. Thus it may well happen that, even at an advanced stage of the compilation process, map scale and format have to be reconsidered.

For economic reasons the format of a map sheet should take account of the sizes of the printing presses available, of commercial available printing paper, and also the dimensions of film to be used during reproduction.

Consideration should be given to the appropriate proportions of rectangular map sheets.

Figure 2.15 illustrates what may be termed an oblong/rectangle, which can be used in either the 'portrait' or the 'landscape' forms.

The format of Figure 2.16 has been designed according to the rule of 'golden proportion'.

Figure 2.17 demonstrates proportions conforming to the 'A-formats' – A0 being one square metre.

In the A4 case (Fig. 2.18) the A0 sheet has been bisected four times. The diagram shows how a map can be arranged within this format, and what considerations have to be applied if it is intended that sheets of this size should be included in a binder.

In order to ensure optimum viewing by the intended user, the centre of the map image should be arranged slightly above the middle of the sheet (see Figs 2.19 and 2.20), so creating a 'visual centre' that conforms with experiences of perception. In other words the margin at the head of the page is slightly smaller than the one at the bottom.

The available *format on computer monitors* is controlled by the size of the screen. The different types are characterised by the dimension of the screen diagonal (Fig. 2.13). The following list gives the approximate dimensions of standard monitor types:

diagonal	ca. width x height	optimal resolution dots x dots
14″	27 x 20 cm	640 x 480
15″	28 x 21 cm	800 x 600
17″	32 x 24 cm	1024 x 768
21″	40 x 30 cm	1280 x 1024 and 1600 x 1200

Usually part of this format is not unavailable for the map, as it is required to accommodate various

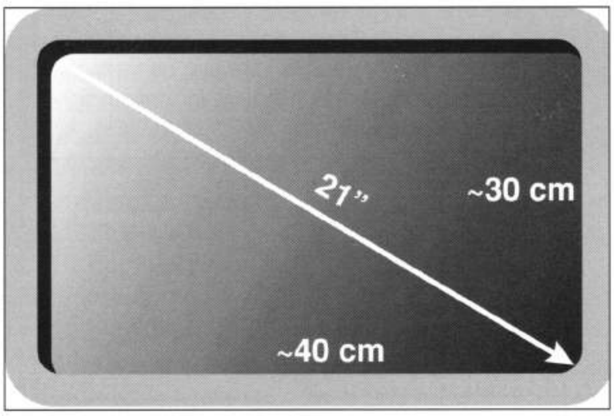


Fig. 2.13 Screen size of a 21″ monitor

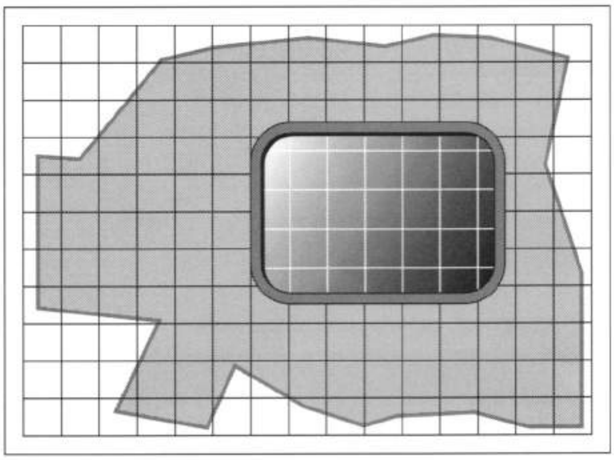


Fig. 2.14 The screen display may be only an excerpt of the whole digital map

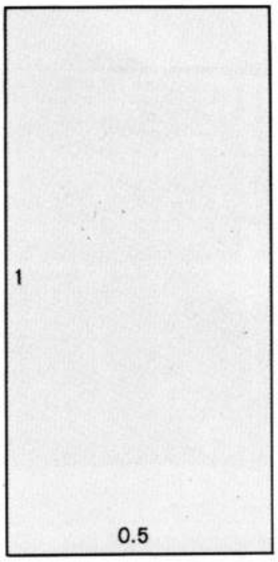


Fig. 2.15
Oblong/rectangle in 'portrait' form; turning through 90° will produce a 'landscape' format

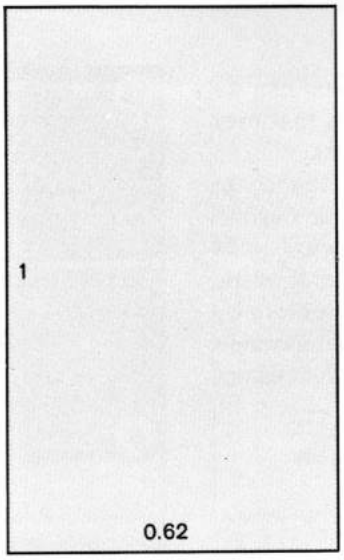


Fig. 2.16 Rectangle with 'golden proportion'

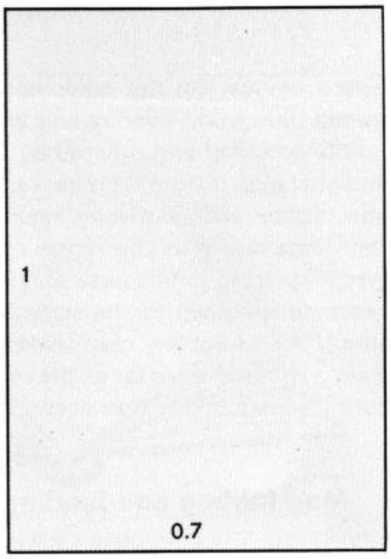


Fig. 2.17 Proportions of the A-formats

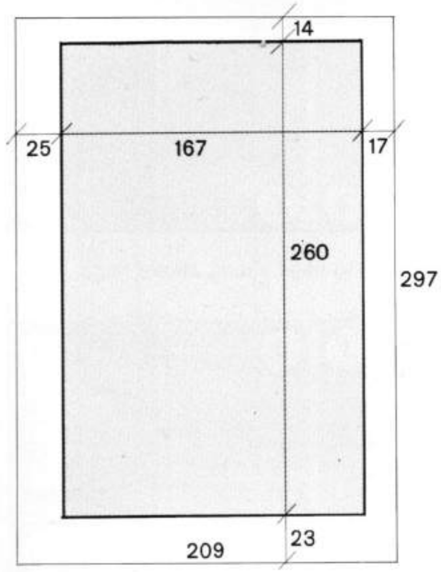


Fig. 2.18 Map frame arrangement at an A4 format, with punch-holes or binding on the left side

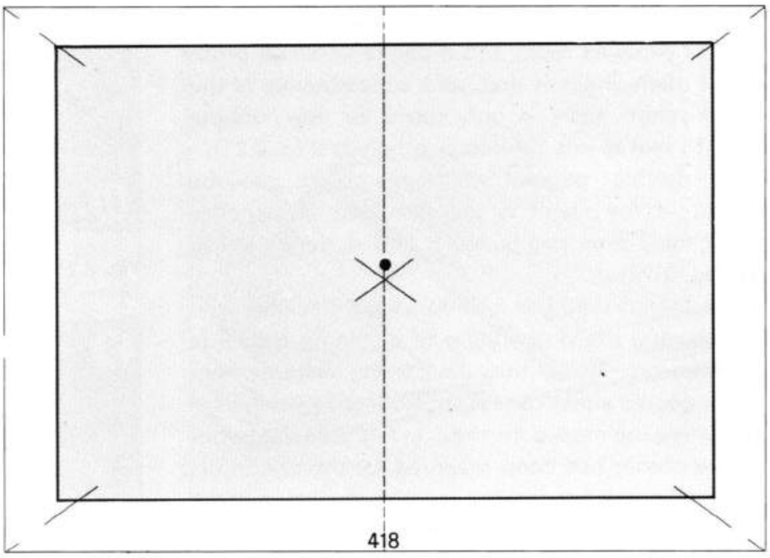


Fig. 2.19 Map frame within an A3 format (● = visual centre), 'landscape' case

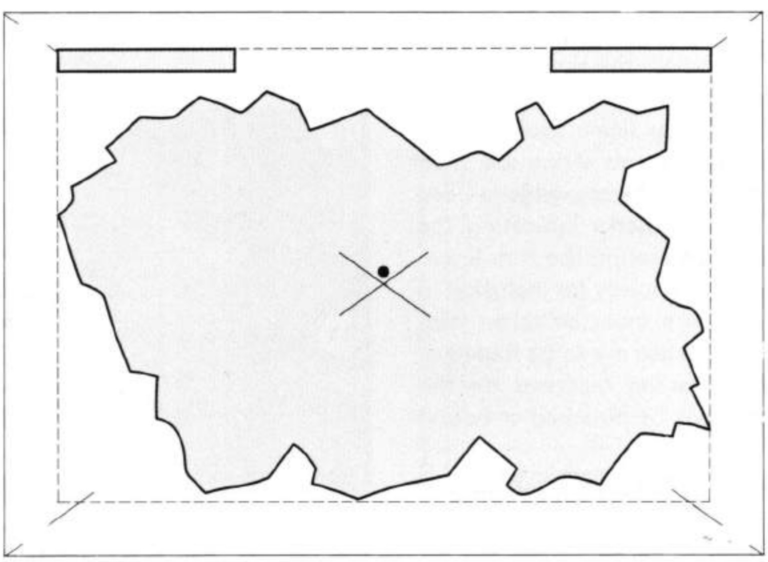


Fig. 2.20 Map with an irregular perimeter drawn inside this frame

software menus. On the other hand, maps can be arranged on several overlapping windows that may be easily accessed and ordered by priorities.

A digital map is, however, not restricted to the size of the display area, but may extend as far beyond screen dimensions as the range of numerical units allows (Fig. 2.14). In this case only an excerpt of the whole map is shown on the screen. Furthermore by zooming in and out any map scale may be allocated to such a window, in as far as the resolution does not disturb the map image (see section 2.12).

2.7 Map folding and binding

If maps are bound in *publications* or *atlases*, they are usually printed on the recto and verso of a large printing format. The imposition of a series of maps has to ensure that when the sheets are folded, after printing, the graphics and text pages appear in the right sequence. Figures 2.21 and 2.22 each show a layout for 8 pages recto and 8 pages verso. A problem that often arises is that, as a consequence of the folding system, there is only room for one double page (8/9) that is not cut into two halves (Fig. 2.21).

Two double pages (4/5 and 12/13) can be arranged, if the sheet is cut into two strips after printing with four pages recto and 4 pages verso each (Fig. 2.22).

For a *folded map* the final format is decisive (see Fig. 2.23), and the preparation of a folding model is recommended. Using this device the arrangement of detail upon a sheet can be coordinated with the situation when the map is finished. In Fig. 2.24 the upper left-hand corner has been reserved for the title information and consequently can serve as the cover of the folded map. If folding is considered only when the map design is finished there are often problems relating to the arrangement of detail. These may be caused by the position of the folds on the flat map sheet, or by the cover or intended format of the folded product.

An arrangement of the type exemplified in Figs 2.23 and 2.25 is particularly easy to fold and unfold.

Figure 2.27 demonstrates how the map illustrated in Fig. 2.25 can be positioned on a layout guide.The corners are provided with trim lines; four register marks together with colour-control strips are then positioned outside these lines. The top edge is used for the punch register holes. Marks indicating the intended fold lines are added around the trim lines.

When a map is prepared especially for inclusion in a binder or book, special care must be taken with respect to the way in which pages are to be folded or bound. Sufficient space must be reserved for the gutter or border areas that will be punched or bound (see Fig. 2.28).

If a map is to be folded, as in Figure 2.24, detail must be positioned at an appropriate distance from the trim lines in order for it not to be lost during eventual guillotining. In the volume illustrated in Fig. 2.24,

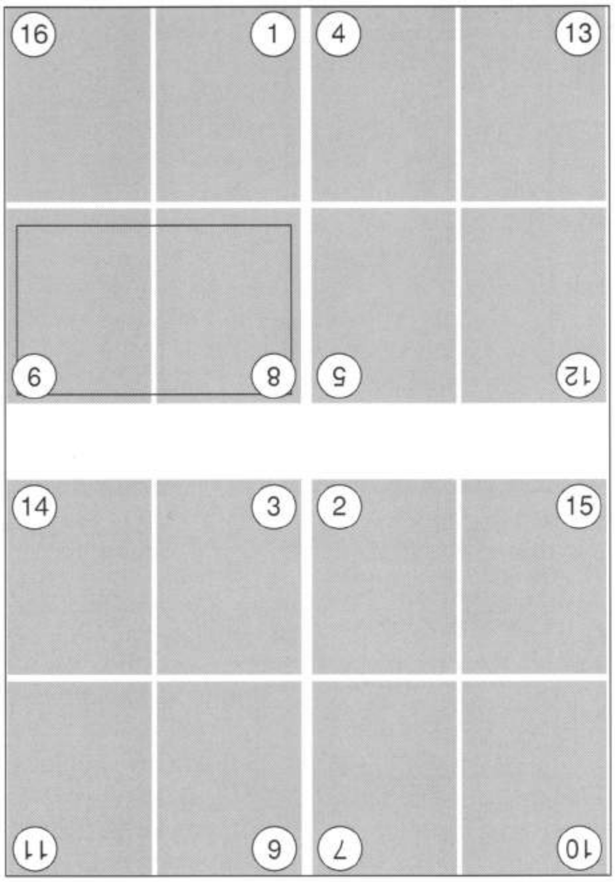


Fig. 2.21 Imposition of a 16-page sheet, above recto, below verso

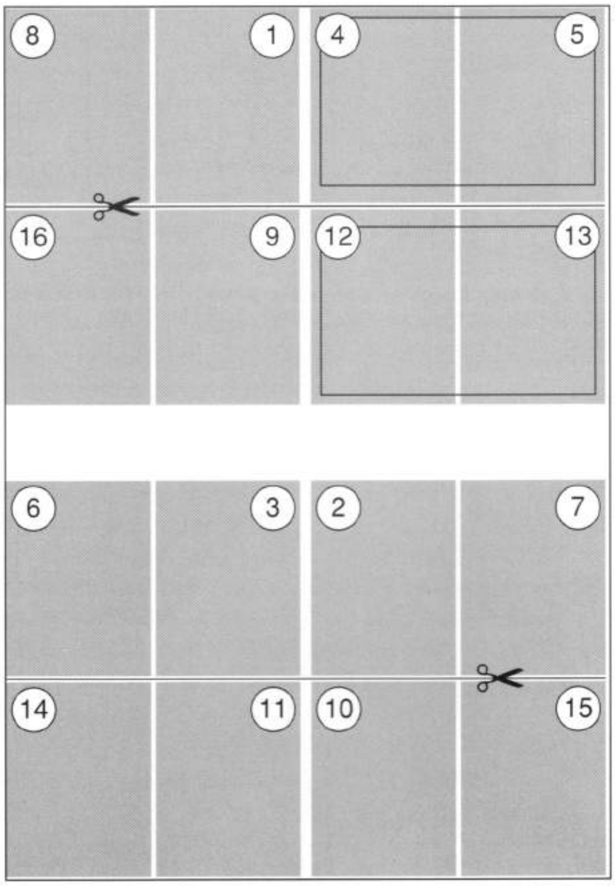


Fig. 2.22 Imposition of 16-page sheet, above recto, below verso, with two double pages

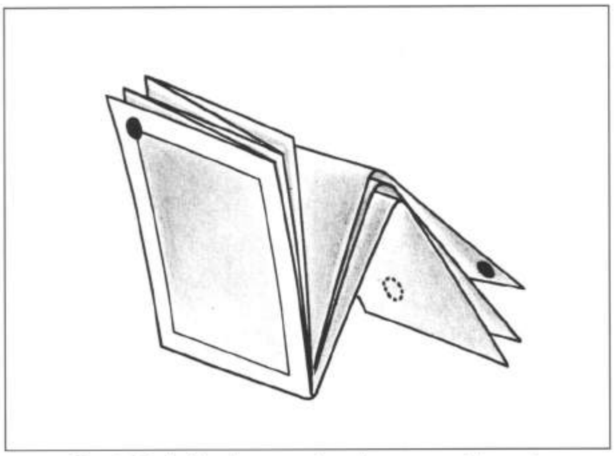


Fig. 2.23 Folded map printed on one side only

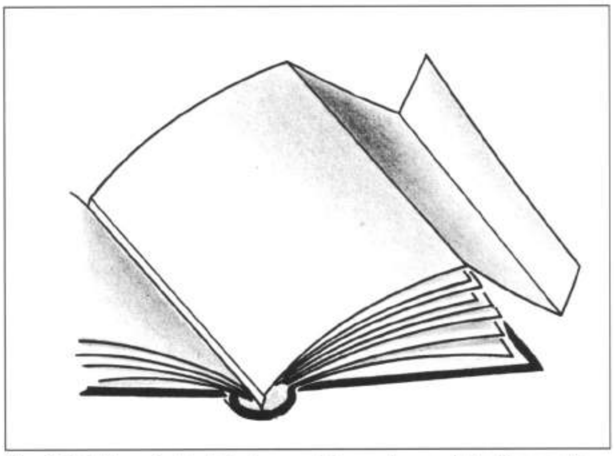


Fig. 2.24 Map folded twice and bound as a 'bled' page in a volume

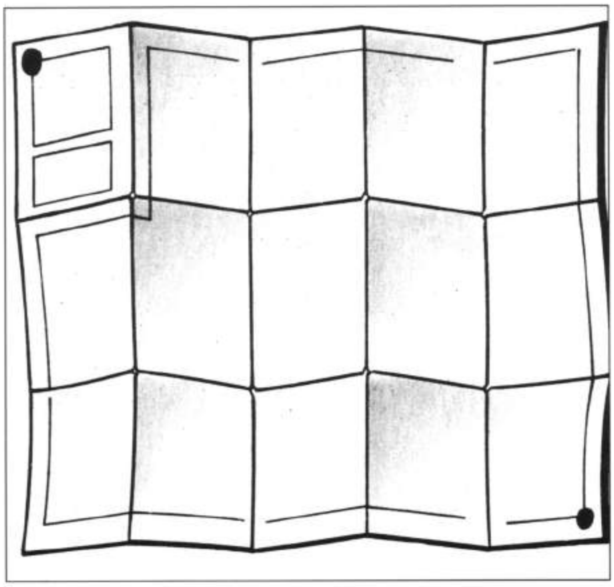


Fig. 2.25 Unfolded map sheet

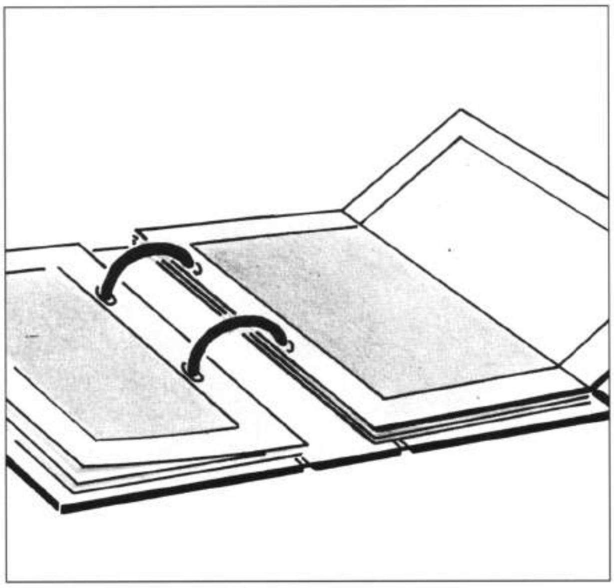


Fig. 2.26 Folded map included in a binder

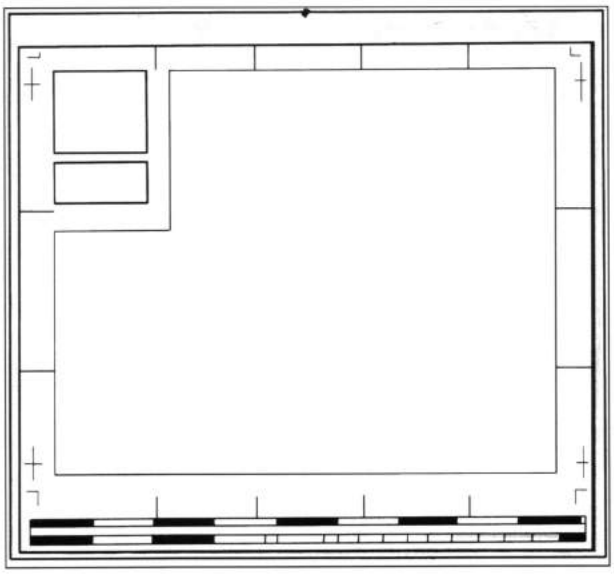


Fig. 2.27 Layout guide incorporating folding and register marks, colour-control strips, and trim lines

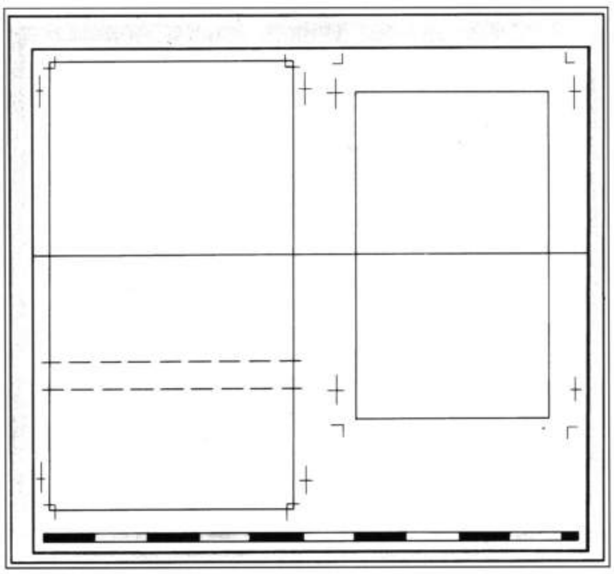


Fig. 2.28 Layout for the two maps shown in Figs 2.24 and 2.26

maps have been bound as 'bled' pages (i.e. they are not surrounded by a margin). As a consequence the trim lines in this case are placed within the map image (see Fig. 2.28).

On an untrimmed sheet of paper a strip, at least 2 cm in width, must be provided outside the printing area in order to allow for the action of the grippers on the printing press (see Figs 2.27 and 2.28).

2.8 Preliminary layout

The preparation of a preliminary layout is strongly recommended at the start of every map compilation. This is the only way to ensure the availability of sufficient space for the inclusion of map titles, legends, marginal information, and register and colour-control marks. The importance of the layout and arrangement of the different map elements should not be underestimated. Everything must be positioned in a logically developed, unambiguous and graphically balanced arrangement. Items should be placed in order of importance with respect to the rules of visual perception, and the whole display clearly structured. The main map, additional insets, title and legend, text, and indications of the source of data, etc., must all be arranged with regard to their appropriate degree of visual prominence within a very simple though invisible frame.

This is true also for the size of all lettering within the map frame. The main title is given in the largest size and is displayed in a bold type style. Subtitles, for instance of the major map components contained, are slightly smaller. The texts accompanying the boxes and symbols in the map legend should be of an equal size, but with items of minor importance in a smaller font. Source information, and details relating to the editor and publisher have to be incorporated but must not be very prominent. Copyright notes are often printed in the smallest type size.

A special problem is created by multilingual map lettering. In order to achieve a better distinction between two languages which both use Latin script, one may employ different type styles – for example, normal and italic characters from the same type family. Another solution is always to arrange texts in the same order, with one of the languages on the first line and the others in the same order being added beside or below it. To accommodate more than two languages usually presents serious problems of differentiation.

Figure 2.29 shows an illogical and chaotic selection and arrangement of type. There is no need for such an extreme variation of fonts and styles. Figure 2.30 is a proposal to improve on this situation.

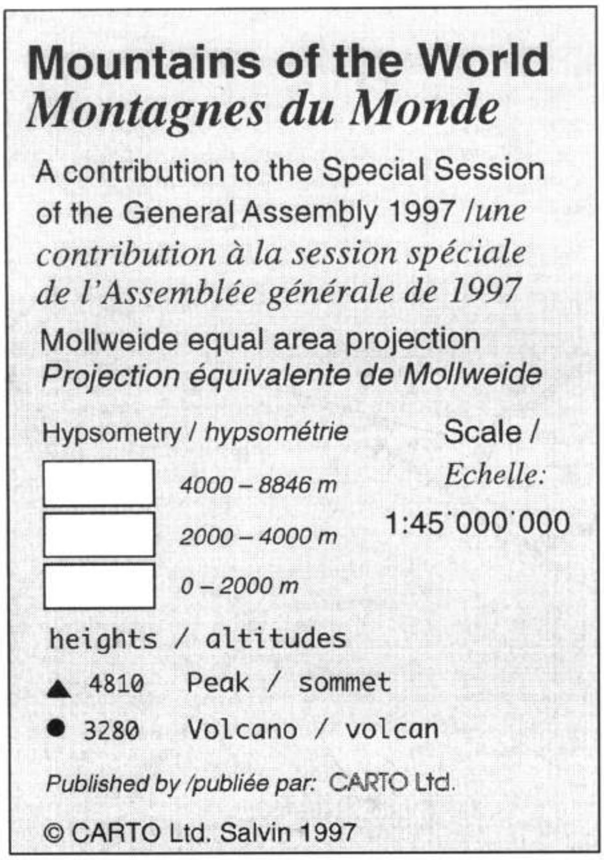


Fig. 2.29 Chaotic selection of type sizes and type styles for the texts along the map frame

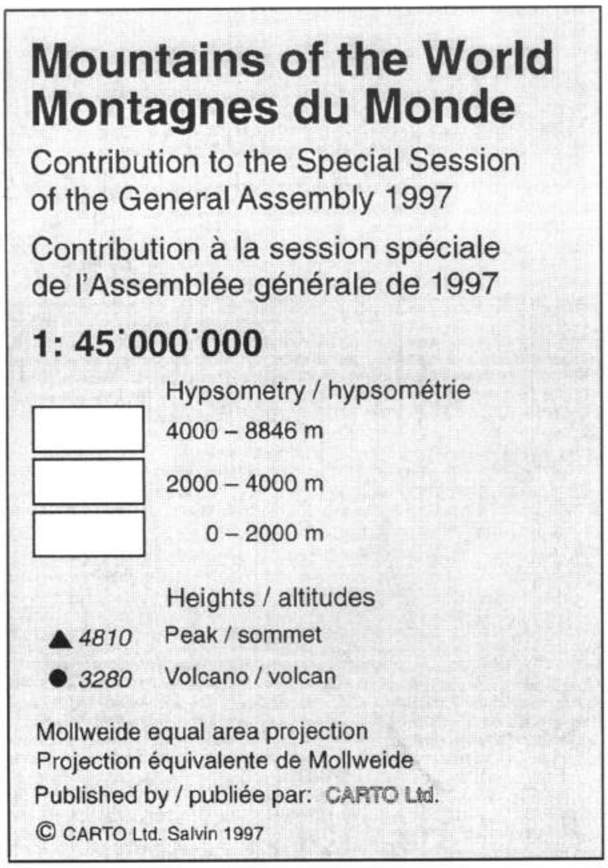


Fig. 2.30 Improved version of the example to the left; hierarchically structured and scaled texts

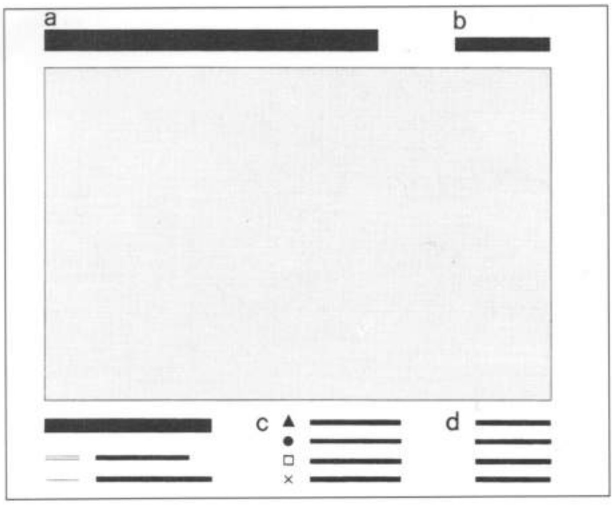


Fig. 2.31 Title and scale at the top

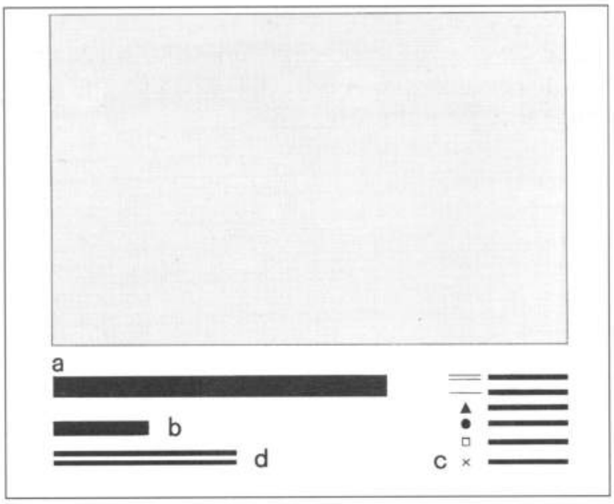


Fig. 2.32 Title and scale below the map

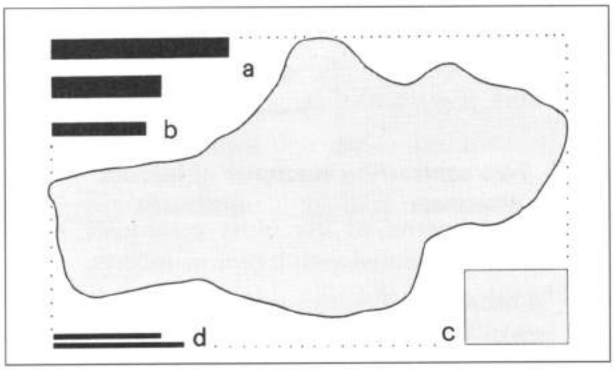


Fig. 2.33 Open spaces around irregular shape used for legend detail and arranged within a frame

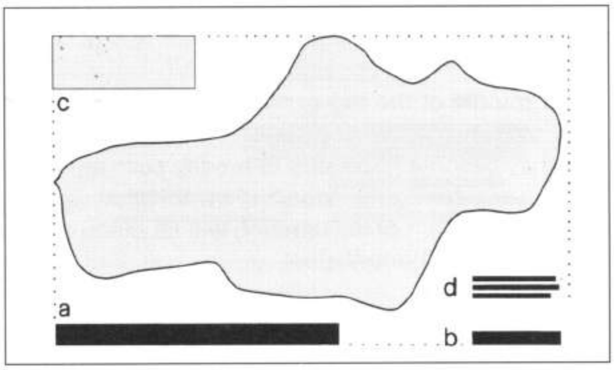


Fig. 2.34 Same shape with title in lower left corner

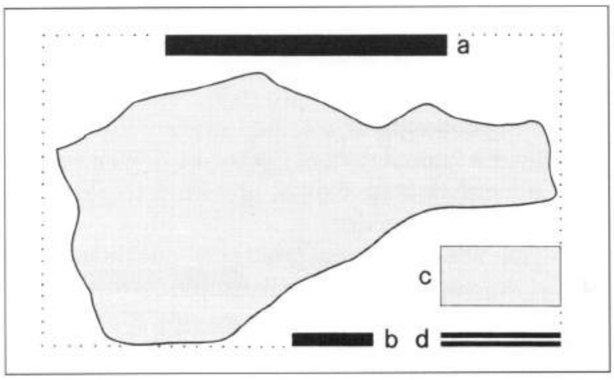


Fig. 2.35 Title centred at top

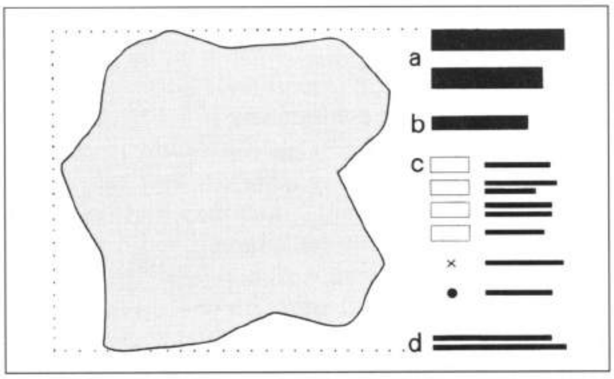


Fig. 2.36 Title, scale, legend and sources contained in a separate column

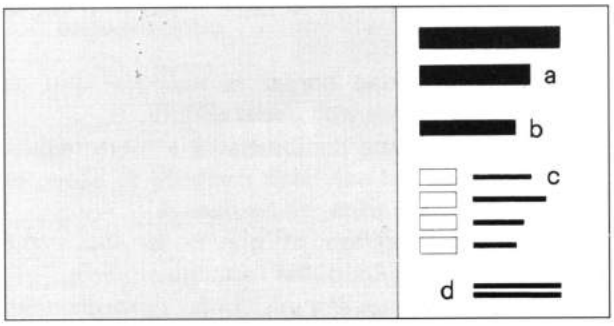


Fig. 2.37 Map details bleeding off sheet and explanatory detail in a separate column

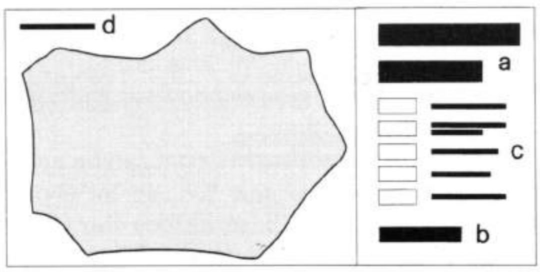


Fig. 2.38 Frame line around map and text encloses all detail

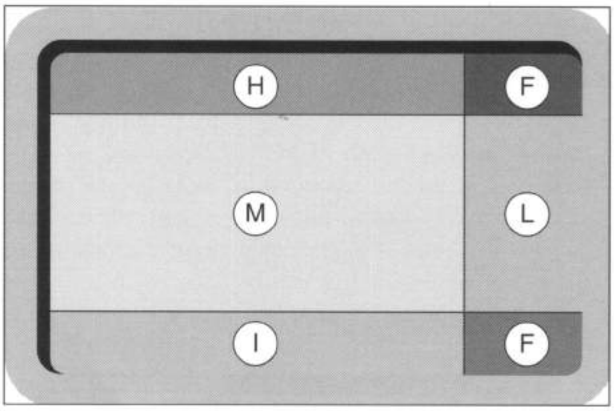


Fig. 2.39 Fix assigned screen segmentation

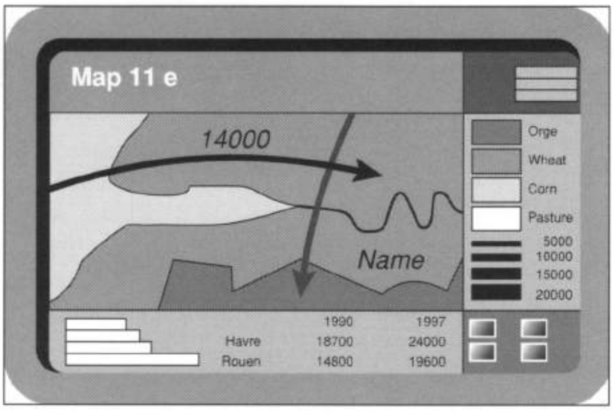


Fig. 2.40 Example of a screen segmentation

Figures 2.31 to 2.38 illustrate various possibilities for the layout of the title (a), map scale (b), legend (c) and sources of contained information (d). The first of these should be allocated the dominant position, for example in the upper or lower left-hand corner, in the middle of the top or bottom border, or at the head of a column.

It may become necessary to modify such a preliminary layout during the course of compilation work. A final arrangement of the lettering will be made on the text manuscript/compilation.

2.8.1 Layout of screen-displayed maps

The layout of maps within a geoinformation system, or an electronic atlas, is conditioned by the size and proportions of the monitor screen. One of the disadvantages of this medium is that available space is somewhat limited. This can be offset by temporarily removing map elements, e.g. by having a pop-up legend. Image resolution is also quite coarse as compared to that exhibited by paper-based maps. However, major advantages lie in the medium's scrolling and zooming capabilities, and also in the facility to call up, instantly, any map that resides in its storage capacity. Time intervals required to do this have now become so short that they enable generation of animated maps, on-line, on the screen.

As all the maps which are sequentially built up appear within the same frame, division of the screen into fixed segments with standardised, assigned functions is recommended (Figs 2.39 and 2.40). The head strip (H) may be reserved for the presentation of the menu including a table of contents and additional information.

Maps and other images or graphics are displayed in the large main segment (M). This section may have to be split into overlapping windows for purposes of comparison between maps.

On the lateral strip (L) to the right can be arranged all of the variables available for use in interacting with a particular map. These include the legend; a selection of levels for display; the map's degree of data aggregation; time intervals; etc.

If additional information is requested this may be positioned in the bottom strip (I).

Finally the corner (F) contains the regularly required general functions which should be always available – for example, quit, forward, backward, help, print, copy, home, etc.

2.8.2 Two contrasting examples of layouts

In Fig. 2.41 some of the most commonly made mistakes are indicated with letters as follows:

- a A broad white border around the map tends to make it appear much smaller than it actually is.
- b Broken and irregular map borders are extremely ugly and visually disturbing.
- c The map area, with its higher image density, has been positioned below the visual centre of the sheet. The optical centre of gravity is slightly above the geometric centre of the sheet, and thus the majority of the map area should be placed above this.
- d The continuity of the map margin is disturbed by the figures defining graticule or grid values.
- e An empty area that is not used to optimum effect.
- f The title has been arbitrarily positioned and does not fit the imaginary border.
- g Legends and other texts are not aligned with the border of the main map.
- h There are irregular spaces between lines of text.
- i Text lines are positioned too close to the map border.

In Fig. 2.42 an attempt has been made to improve these defects:

- a The white map border is narrower and its proportions are well under control.
- b The map frame demonstrates a more regular geometry and has been designed to allow for extensions outside the border.
- c The visual centre of gravity is above the geometric centre of the rectangular sheet.
- d Graticule figures are positioned inside the map area.

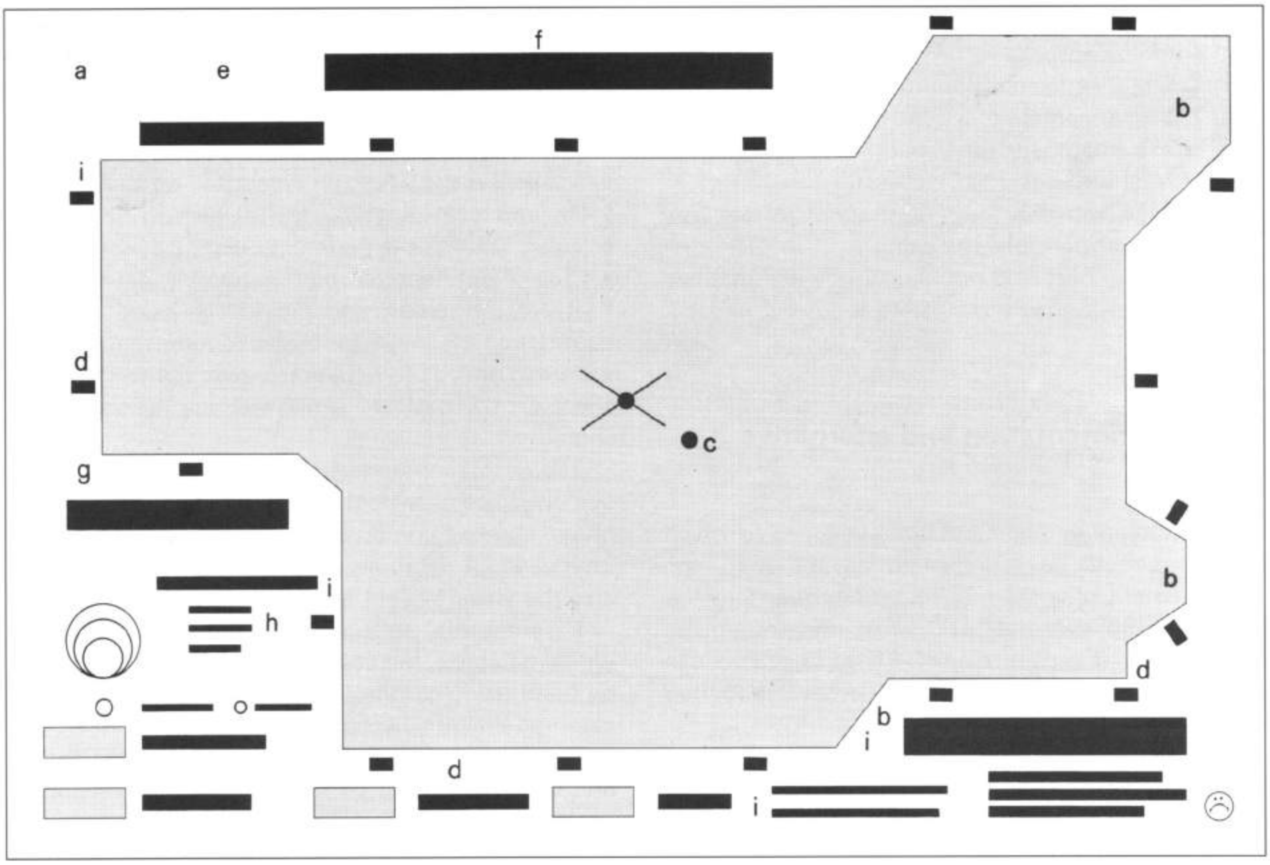


Fig. 2.41 Chaotic layout (for details see comments in the text)

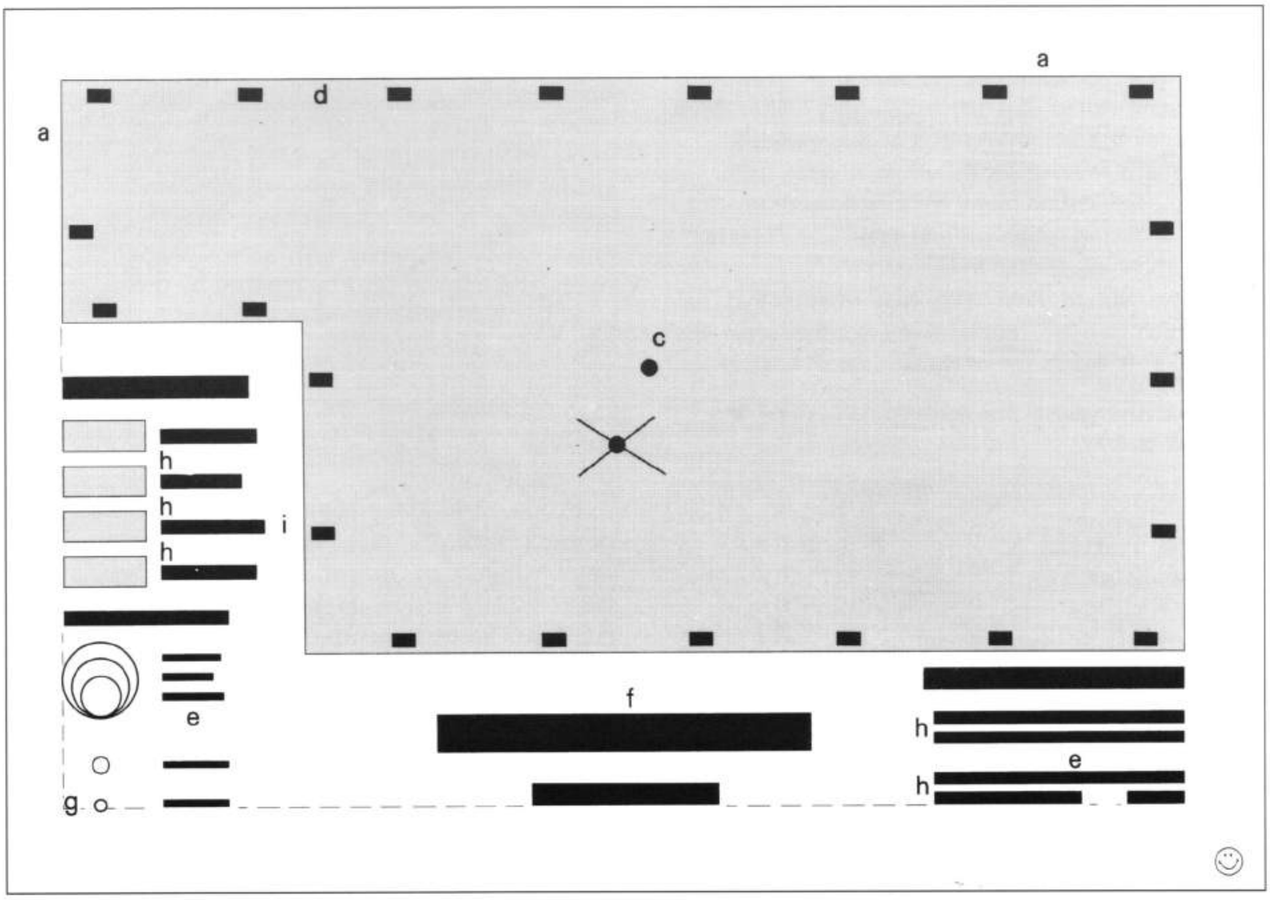


Fig. 2.42 Well-organised and arranged layout

e Texts and legends are distributed evenly within empty spaces.
f The title is given a dominant position.
g The arrangement of legend detail takes account of the imaginary map margin and consists of several well-designed blocks.
h Spaces between lines of descriptive text are, wherever possible, the same.
i The map border is not affected by text that has been positioned too close to it.

2.9 Experimentation and alternative solutions

When an initial decision has been taken as to which features should be represented on the map, the establishment of *a list of all possible questions* the intended map user may ask, when interpreting the map content, is recommended. These questions can be grouped and ordered by priority according to their importance.

The chosen map content must then be analysed with respect to the natural structure and information level of each category of features. The letters and symbols refer to the Example below:

- Does a feature category relate to points (P), lines (L) or areas (A)?
- Are they of a purely qualitative nature? If so, a nominal scale (≠) would be the answer in representing this part of the data. What is the number of different features that have to be distinguished in such a category? That determines the length (n = . . .) of this variable.
- Does a feature group show a clear order, as, e.g., few–more–many, or small–medium–large, thus asking for an ordinal scale (<)? What is the number of classes (n = . . .)?
- Have we to deal with real quantitative data which can be rendered by a ratio scale (Q)? What is the range of these data (R = . . .)?

Example: Analysis of the feature categories used in Figs 2.43 to 2.47

Category	P L A	≠< Q	n or R
Rivers	L	<	n = 3
Lake	A	≠	n = 1
Boundaries	L	<	n = 1
Employees	P or A	Q	R = 1:1700
– by economic sector	P or A	≠	n = 3
– by gender	P or A	≠	n = 2
Hill shading	A modulated		
Names	N	≠	n = 2

The next step is to decide which visual variables should be employed to provide the best analogy with the true structure of each of the features. Such decisions, relating to the method of representation, may require the consideration of a number of possible solutions each of which has to be evaluated before a definite symbology can be chosen.

In conventional production it will seldom be possible to produce more than one complete compilation which covers the whole area depicted on a sheet (Fig. 2.43), and only a small, typical section should be selected for these experiments (Figs 2.44–2.47). This section should contain both extremely detailed and nearly empty areas, and provide an opportunity to consider all the major problems of representation. As it is often difficult to extrapolate over the whole of the sheet on the basis of small sections, those chosen should not be too small.

The evaluation undertaken relates to image densities; the necessary degree of generalisation; possible image contrasts; unavoidable overlaps; the legibility of individual symbols and complete features; and also the visual weight of the whole map.

Different trial versions may be created from a digital database, but can also be sketched and drawn by hand using common media such as pen and ink, coloured crayons, water-colour paints, etc. However, care must be taken to ensure that relatively coarse and unsharp images do not result in the drawing of misleading conclusions.

Figure 2.43 is part of the first compilation of a map which uses proportional circles to depict the whole data set. The circles represent employment by communities in densely populated areas, but also illustrate regions with smaller settlements. A few base map elements have been included to assist orientation. The section chosen for the design experiments is indicated.

In Fig. 2.44 an attempt has been made to avoid some of the overlaps by selecting a smaller scale ration. Criticisms: the hydrography overlay used for orientation is too detailed; the numerical scale is small for communities with only a few employees; rivers and lakes should be masked by the circles.

In Fig. 2.45 the data are represented by bar graphs which are subdivided into three classes (primary, secondary and tertiary sectors of employment), but many of these subitems are too small. The quantities vary too much to allow the use of a linear means of representation.

In Fig. 2.46 the numerical scale has been optimised, and the ratio of one of the classes is demonstrated by graded tints (percentage of the economically active population employed in agriculture). The community boundaries shown are too coarse; hydrology has been reduced to a minimum; overlapping circles are graphically separated, and a few of them require further modification (the smaller circles should be positioned on top of the larger ones); a few selected names should be added.

In Fig. 2.47 a more pictorial approach has been attempted with symbols representing 50, 200, 1000 or 5000 employees in each of the three classes. Criticisms: not all of the communities can be repre-

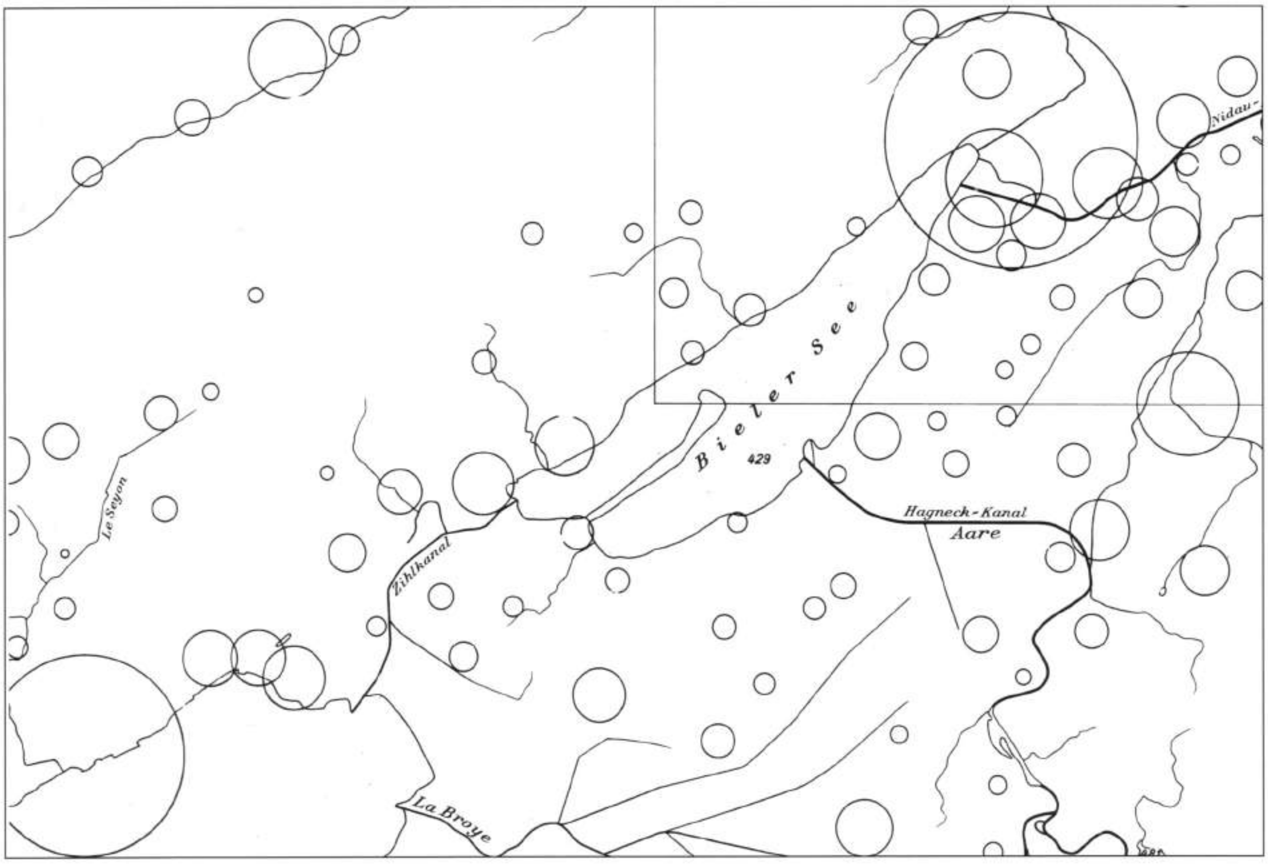


Fig. 2.43 First compilation depicting the complete dataset

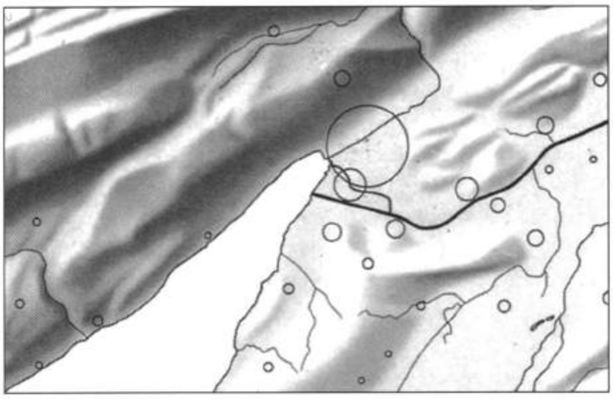


Fig. 2.44 Proportional circles based on a smaller numerical scale (tested in a section of the map)

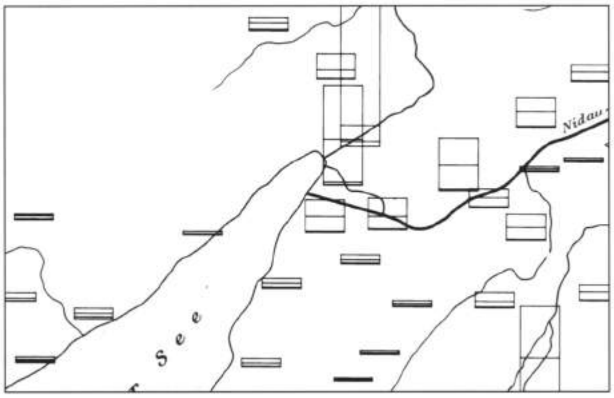


Fig. 2.45 Subdivided bar graphs to illustrate three classes of data

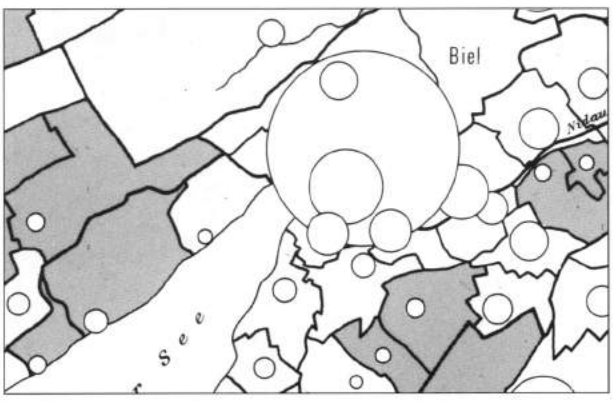


Fig. 2.46 Improved numerical scale; overlapping circles are graphically separated and one of the classes is shown by graded tints

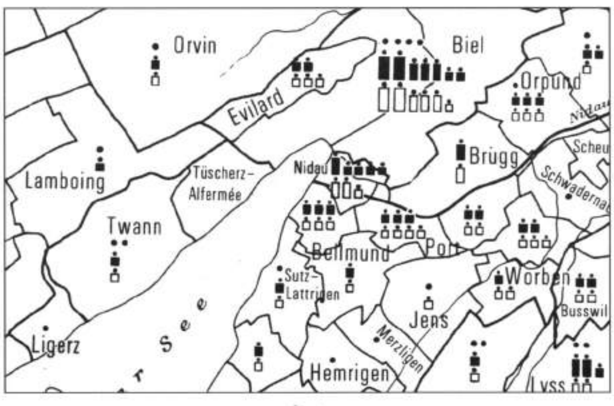


Fig. 2.47 Pictorial symbolisation applied to three classes. Problems relate to their centring within the space occupied by the community

sented as the symbols are relatively space intensive; too many names have been included; the base map is too clumsy; and the lakes are not integrated in a river system.

On the basis of these five test samples a definite selection of an appropriate representational method can be undertaken. We propose in this case a base map with the hydrography in blue, a grey hill shading – because it explains the concentration of employment in the plains – relatively fine community boundaries in black with five to seven names and finally employment shown as pie diagrams with the three coloured sectors.

2.10 Map legend specification

After making a decision with respect to the map's purpose, and a thorough analysis of the topic which it is intended to illustrate based on representational experiments, the legend can be specified. Criteria influencing the selection of appropriate graphic techniques are cited later in this chapter.

In general, unless a continuous transition from one device to the next is specifically required, adequate differentiation must be created between all map symbols. Scarcely noticeable differences between two symbols must be avoided to ensure good map design. Letter sizes, patterns, screens, double lines or line widths must be easily distinguishable from one another.

In conventional production once the compilation manuscripts are approved the cartographers will take over the job. The cartographers are thereafter responsible for the preparation of the colour separated films needed for platemaking. In order to ensure that the concept of the map author is strictly observed, formulation of a *detailed instruction* is recommended.

Each symbol intended for use on the final map has to be clearly described and also annotated with reference to its size. The specifications for the legend of the compilation manuscript can be more straightforward but must, initially, show clearly in which respects individual symbols differ from one another. Figures 2.48 to 2.54 illustrate the nature of such specifications.

For example, in the proportional circles shown in Fig. 2.48 both the maximum and minimum dimensions, and the formula for determining symbol sizes, must be quoted. In the case of an interval scale the intermediate steps must also be indicated.

Area patterns (Fig. 2.49) must be specified with respect to form; sizes of the individual composing elements; spacing between these; and by their orientation. They may also be characterised by the percentage of an area unit that is covered by pattern elements.

Specifications of width are vital for line symbols (Fig. 2.50) and also, if applicable, for the spacing between double lines or the length of line elements and spacings in pecked or dotted lines.

Type style, size, weight, width and italic character (if relevant) have to be determined (Fig. 2.51). In some cases the length of a name, or its spacing, must also be quoted. Usually all of these factors are coded in the type manuscript to ensure that the latter is correctly set.

In the cases of screens (Fig. 2.52) the indication of the percentage of the whole area that is to be covered by the screen in each printing colour, and for each tint in a screen table, is usual practice. Further information is given later on screen spacing and structures (dot, line, random dot screens, etc.). An alternative way of specifying colours is by making reference to a particular colour chart.

Figure 2.53 illustrates the map for which the above specifications have been formulated. The intended multicolour production is, however, reproduced here in monochrome and as a two-times enlargement (Fig. 2.54). The map shows the number of inhabitants by community with graded circles, and whether there was a considerable increase or decrease over a defined period by using hachures with different orientation and colour. Population density is represented by graded tints varying from a light yellow to an intensive red. There is a hierarchy of four categories of boundaries in black, a river system in blue, and names in black (none of which is included in this black and white reproduction).

Additional information will be needed on how to handle overlaps. In this case smaller symbols are to be placed above larger ones with a small space that separates them visually (see section 2.25). Also we might ask for area tints to be spread so that no white gaps are left between them, as is the case in Fig. 2.54 under the pecked lines.

Furthermore all the other masking procedures have to be determined: the graded circles mask out everything else; the boundaries mask the hachures; the rivers mask the boundaries, etc. The overlap of rivers and boundaries is a common problem in this type of map. One of the two categories has to be given priority, usually it will be the rivers which will be given preference (Figs 2.55 and 2.56) in spite of possible ambiguities.

In digital production it is common practice to arrange the different levels or layers according to their masking priority, or to specify allowed overprints.

2.11 Thresholds of perception, differentiation and separation

In map compilation one of the essential decisions needing to be made by the cartographer relates to the appropriate dimensions of each of the symbols which it is intended to use. Figures 2.57 to 2.64 are drawn at publication scale, but if the compilation is prepared at a larger scale all of its dimensions must be increased proportionally.

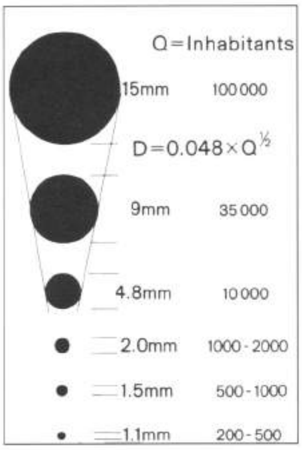


Fig. 2.48 Specifications for proportional circles

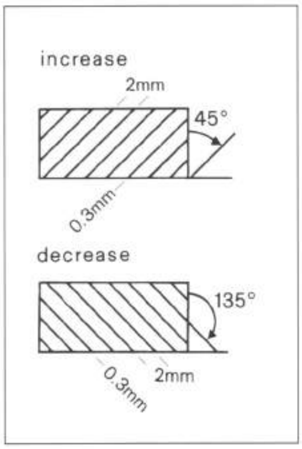


Fig. 2.49 Specifications for coarse area patterns

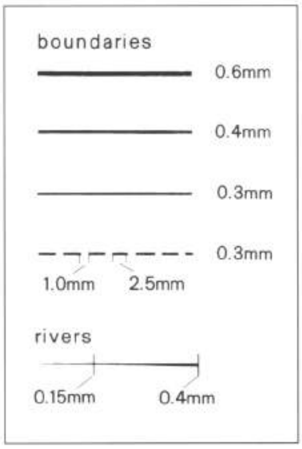


Fig. 2.50 Specifications for line symbols

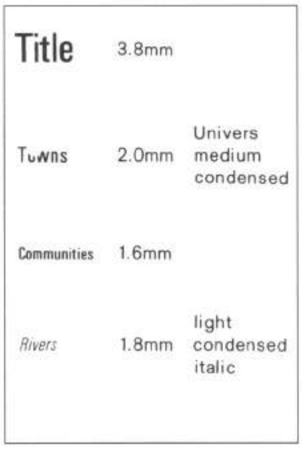
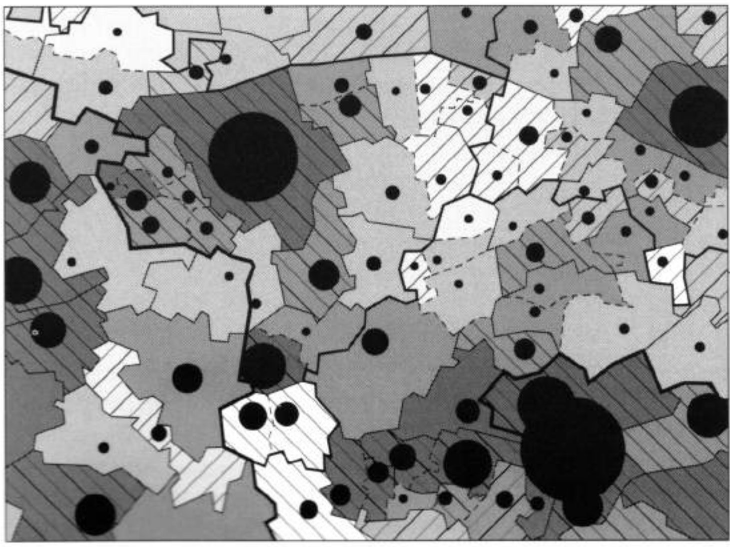


Fig. 2.51 Type specifications

degree		90°	75°	105°	45°
colour		Yellow	Cyan	Magenta	Black
			100%		
				100%	
	>2000	100%		100%	
	1000-2000	100%		75%	
	500-1000	75%		50%	
	100-500	50%		25%	
	20-100	25%		10%	
	0-20	25%			

degree	90°	75°	105°	45°
colour	Yellow	Cyan	Magenta	Black
		100%		
			100%	
				100%
				100%
				100%
				100%
		100%		
Names				100%

Fig. 2.52 Tabulation of the specification of screens to be used in producing a four colour map including the symbols illustrated above



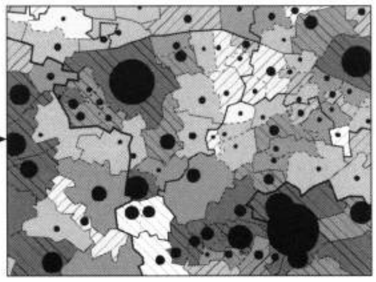


Fig. 2.53 The map shown in Fig. 2.54 at publication scale

Fig. 2.54 Monochrome illustration of the intended map reproduced as a two times enlargement

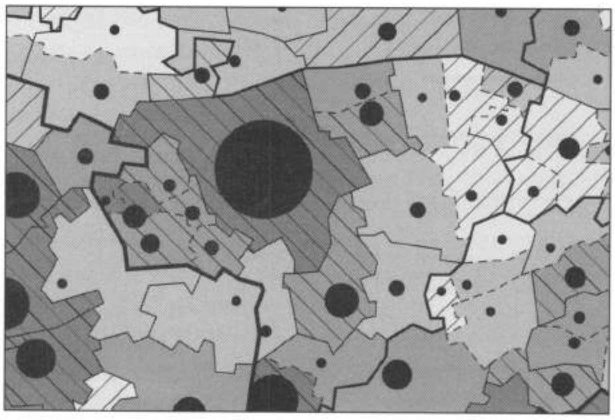


Fig. 2.55 Priority of boundaries interrupts rivers

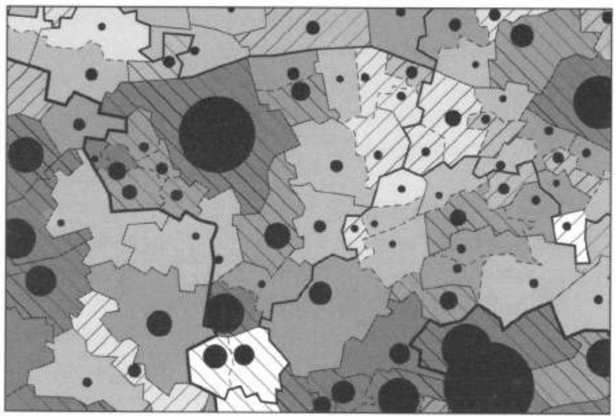


Fig. 2.56 Priority for the rivers leaves some ambiguity as to the areas that belong together

Three thresholds can be distinguished in a series of increasing *symbol sizes*: at a certain level the presence of a symbol can be clearly discerned – this is the *threshold of perception* (column 2 in Fig. 2.57); a clear difference of form or shape can be recognised at a later stage – this is the *threshold of differentiation* (column 3 in Fig. 2.57). Further steps of increase in symbol size are necessary to ensure the absolutely certain identification of a symbol larger than that appearing in column 3, and column 5 corresponds with the *threshold of separation*. These thresholds must be determined empirically and individually for each type of symbol.

Besides the size of the symbols, the *spacing* between them is another element which must be chosen in relation to their visual perception (Fig. 2.58). Spacing is too small in column 1, but just sufficient in column 2. Their separation in column 4 is equal to the dimension of the symbol – a proportion that causes irritation and should therefore be avoided. In column 5 the symbols are isolated to such an extent that they no longer seem to form a row, but start to have individual functions.

2.11.1 Line work

The narrowest line that can be perceived with certainty when printed in black is 0.08 mm wide. Significant increases in width are necessary to produce lines that can easily be distinguished one from another (Fig. 2.59). Such a series of well-differentiated line-widths is shown on the right of Fig. 2.61, and is contrary to the often recommended 'square-root-two-range' on the left of Fig. 2.61 which does not demonstrate sufficient varieties on the finer side of this range of lines.

The thresholds of perception for fine and coarse double lines are shown above 2 in Fig. 2.60. The broad double lines above 5 are too widely spaced to remain easily recognisable as a single symbol.

A few other line textures are illustrated in Fig. 2.62. Apart from width thresholds, in the case of a pecked line the selection of the correct proportions for the length of a dash and the interval of its separation from the next one can provide further problems. Lines above 1 show the effect of having an interval which is two small; all lines marked 2 are recommended; and the intervals are too large in lines labelled with a 5.

Figures 2.63 and 2.64 contrast poor and good applications of the separation of linework and pecked lines with respect to the conditions explained above. Sufficient differentiation is necessary if the map user wants to unambiguously attribute all lines of the same width or texture to one and the same feature group. However, if the categories show a distinctly different structure, as, e.g., the map grid and contour lines, minor or even no differences will be acceptable. In Fig. 2.65 grid lines, land contour lines have the same width.

2.11.2 Perception of maps to be displayed on screens

With maps intended for display on screens, we are confronted with a completely different physical situation. Every graphic element represented by the monitor is composed of small squares or dots, be it a point or line symbol, a solid, screened or halftoned area. These picture elements, called pixels, have an on-screen dimension of approx. 0.3 mm. Generally speaking a map on paper will have to be enlarged three times to produce a visually acceptable image on the screen. Therefore, thresholds and minimal dimensions must take account of this technical limitation which causes a rather coarse image with rugged lines as is simulated in Fig. 2.66. This staircase effect may be mitigated by the aliasing technique, which adds toned down pixels to the outlines to smooth their appearance.

2.12 Minimum dimensions, differentiation and separation of point symbols

Point symbols of approximately equal size may vary considerably in shape, orientation and colour (Fig. 2.68). In the case of black symbols, the smallest sizes

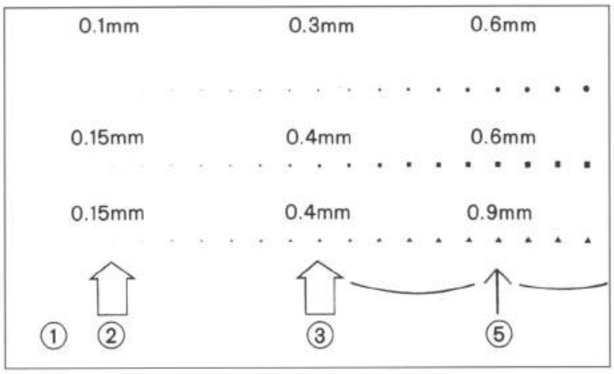


Fig. 2.57 The perception of point symbols (2), and the differentiation of their shapes

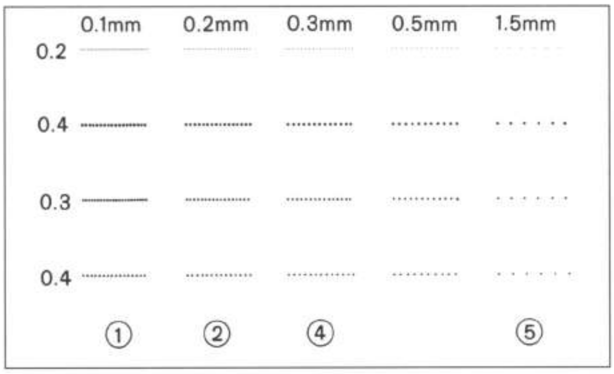


Fig. 2.58 Threshold of separation between point symbols: (1) too little, (2) recommended, (5) too great

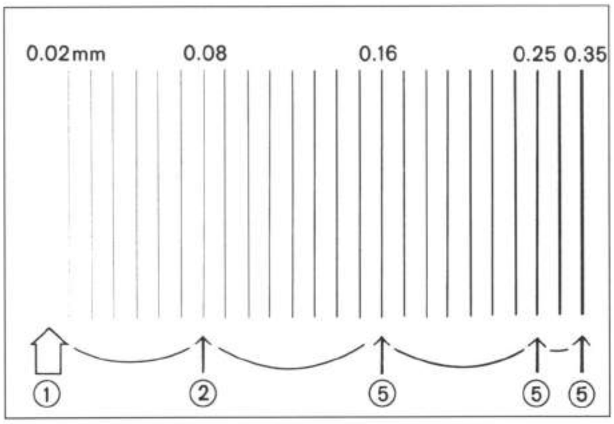


Fig. 2.59 Line symbols: (1) line perceptible, (5) widths sufficiently different to be distinguishable

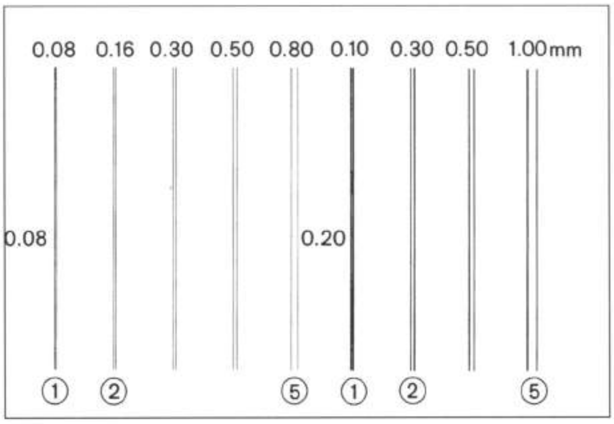


Fig. 2.60 Double lines: (1) spacing too small, (2) minimum spacing, (5) spacing too wide

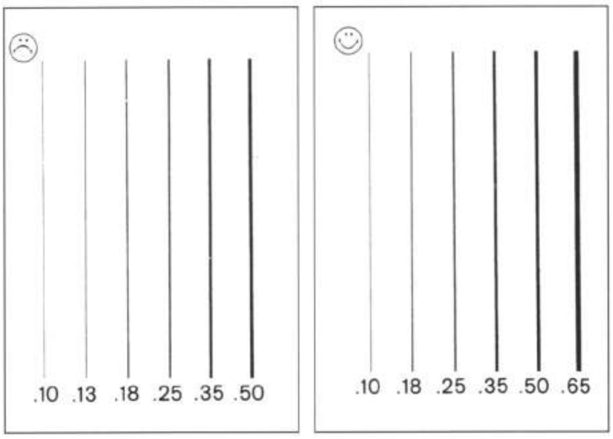


Fig. 2.61 Line width separation too small (left); good line width separation (right)

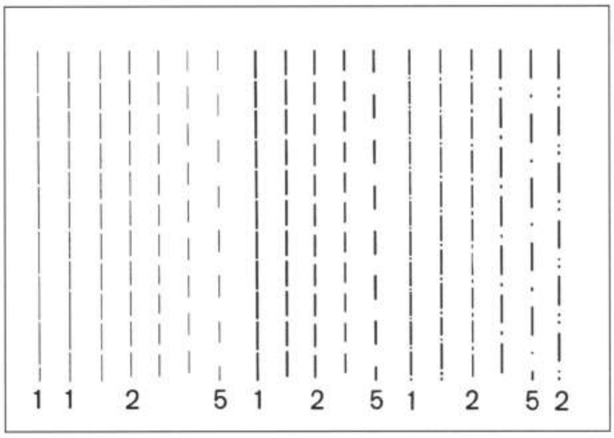


Fig. 2.62 Pecked lines: interval between solid elements too small (1), recommended (2), too large (5)

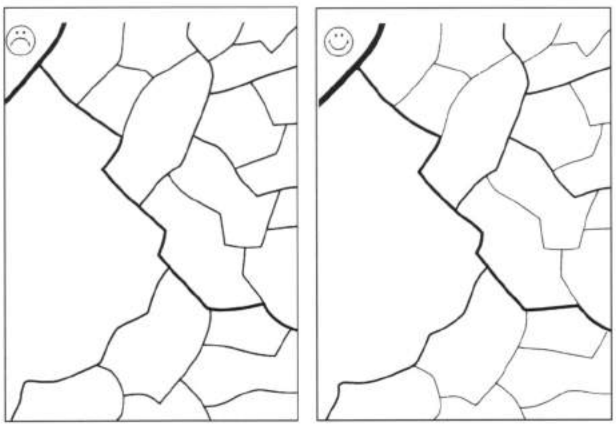


Fig. 2.63 Line width separation too small (left); good line width separation (right)

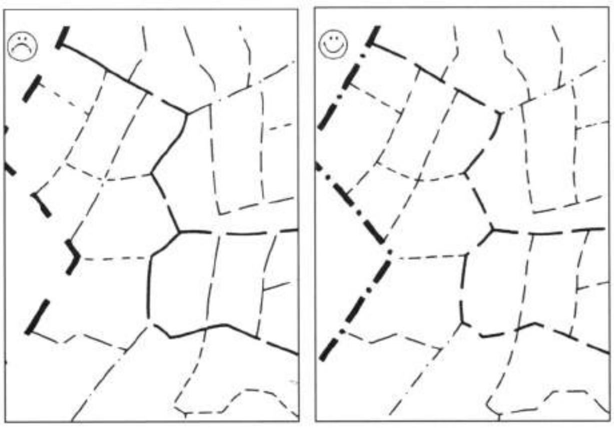


Fig. 2.64 Poorly proportioned line work (left); well-proportioned line work (right)

that can be seen are dependent upon their shape. The minimum dimensions of a selection of clearly distinguishable solid symbols are illustrated in Fig. 2.69, and of open symbols (with an outline of 0.1 mm) in Fig. 2.70.

The dimensions given for the symbols – which are shown at true publication size in the centre – are somewhat borderline examples. In practice *doubling these values is recommended*, so resulting in the creation of effective symbols which leave no doubt as to their form. We should also be aware that point symbols do not usually enjoy the benefit of an undisturbed white background. Normally they compete in a 'noisy' environment and are surrounded by other symbols. Once again it must be emphasised that the values given here are based on the use of black ink. For other, naturally lighter colours the quoted minimum dimensions will require increasing for proper discrimination to take place.

A range of graduated symbols can be discriminated if the size step between any two which are adjacent within a range is large enough to be recognised. Bertin has developed a so-called natural scale to demonstrate this (Fig. 2.67).

So far this discussion has related to neighbouring symbols within the map borders. However, identification and discrimination are considerably more difficult if a comparison is attempted between symbols on the map and their counterparts in a legend.

Another threshold value is the scaling necessary between one symbol size and the next, if each category of similarly shaped symbols is to be individually perceivable. In Fig. 2.71 the five intended classes of information cannot be separated, but they can in Figs 2.72 and 2.73.

Point symbols are commonly used to depict individual *buildings* on topographic maps and, as far as possible, their sizes and spacing are made similar to the planimetric extent of the features at the respective map scale. The minimum perceptible dimensions of a number of shapes are illustrated in Figs 2.74 to 2.97.

The sizes of the symbols shown at the top right of Fig. 2.74 are, in most respects, below the thresholds of perception for the following reasons:

1. The sides of the small houses are too short.
2. The spacings between the properties are too small.
3. Their distance from the edge of the road is too short with the result that they tend to merge with its border.
4. Irregularly shaped buildings do not exhibit a sharp outline.
5. The indentations and projections of building shapes are too tiny.

However, the drawing at the bottom right of Fig. 2.74 observes the thresholds of perception with the result that details can be unambiguously identified. The minimum dimensions which must be observed are indicated in Fig. 2.77. Again these dimensions must not be undercut, as they represent the absolute minimum for clear identification. In practice these minimum dimensions are increased by 0.05 or 0.1 mm.

In Figs 2.75 and 2.76 one can compare two different map revisions relating to one and the same

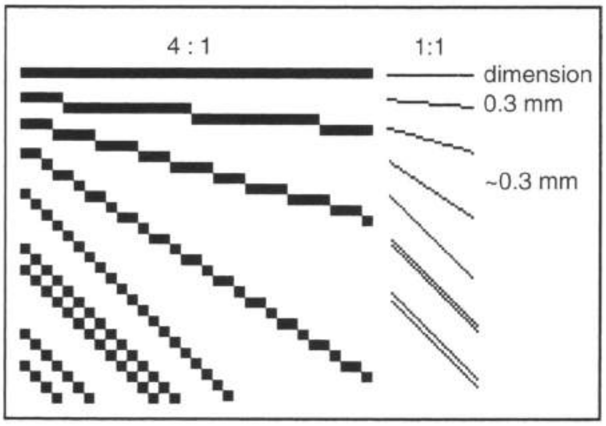


Fig. 2.66 Line structures as displayed on a screen. (Left: 4 times enlarged. Right: as appearing on the screen)

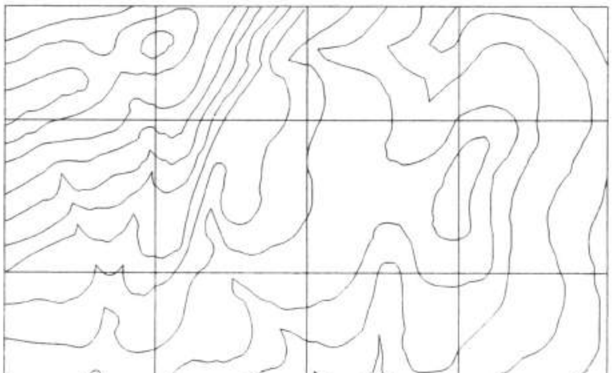


Fig. 2.65 Two line networks with the same widths but different structures

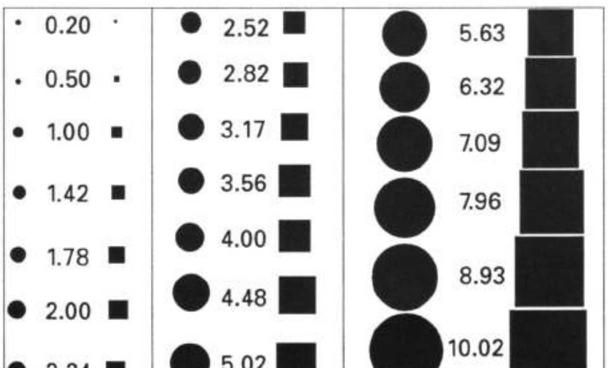


Fig. 2.67 Bertin's natural scale of graduated circles, squares of the same size; diameters in mm

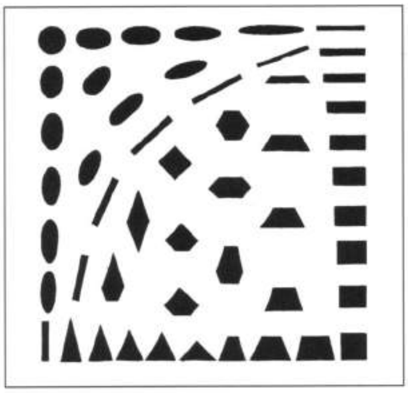


Fig. 2.68 Variation of symbol form and orientation

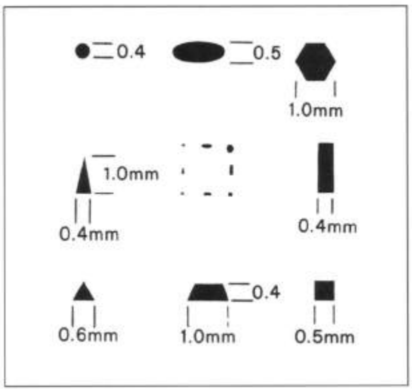


Fig. 2.69 Minimum dimensions of well-separated solid symbols

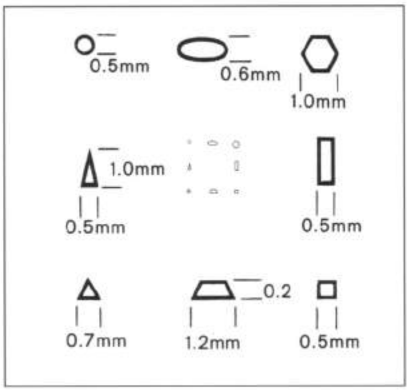


Fig. 2.70 Minimum dimensions of open symbols

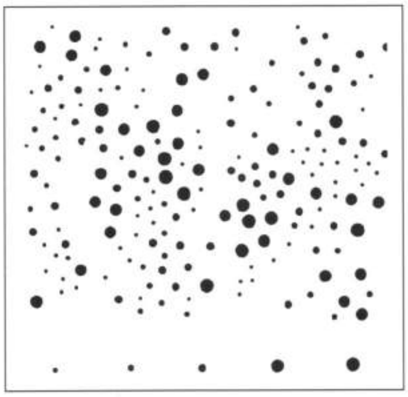


Fig. 2.71 Five categories of dot symbols that cannot easily be distinguished

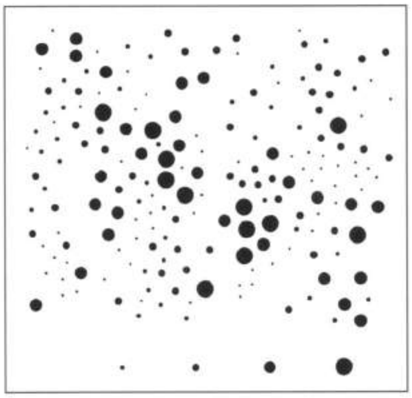


Fig. 2.72 Five categories of dot symbols that can be perceived

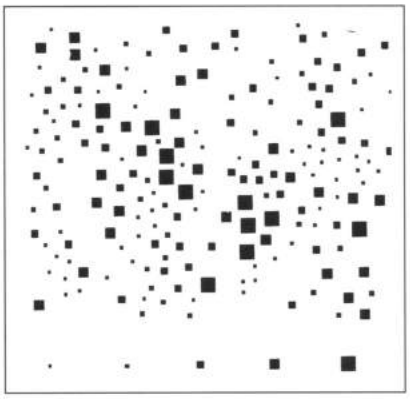


Fig. 2.73 Five categories of square symbols that can be perceived

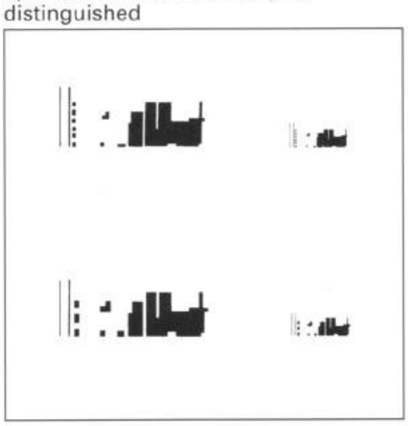


Fig. 2.74 Minimum dimensions of building symbols

Fig. 2.75 Building symbols with outlines below the threshold of differentiation

Fig. 2.76 Threshold of differentiation respected

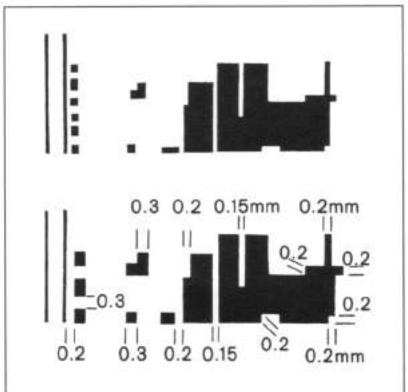


Fig. 2.77 Above figures 5-times enlarged with minimum dimensions

Fig. 2.78 Section from above, figure 3-times enlarged

Fig. 2.79 Section from above, figure 3-times enlarged

settlement area. While in the left-hand figure the sides of buildings are frequently below the threshold level, the map on the right is well designed except for the use of some rather small spacings between houses and roads. To illustrate things better, parts of the map sections have been reproduced as three-times enlargments (Figs 2.78 and 2.79). Compare also the new quarter at the left-hand margin of Figs 2.75 and 2.76. The houses in the figure to the left do not show sharp outlines.

Such an example demonstrates the benefits of compiling an area of settlement at a larger working scale than that of the intended publication, but special care must be taken to ensure that minimum dimensions are respected.

2.12.1 Minimal dimensions of point symbols on screens

If small point symbols are included in maps displayed on screens, e.g. in geographical information systems and electronic atlases, their sizes are restricted by the physical properties afforded by the media. The means that every symbol has to be build from a fundamental pixel – a small square of approx. 0.3 mm.

Figures 2.80 and 2.81 exhibit a range of solid and open circles, squares and triangles created by various arrangements of pixels. A 1 x 1 dot is barely visible, and a 2 x 2 symbol may be interpreted as either a circle or square. The 3 x 3 symbol, with sides of 0.9 mm, is recognisable as a square and not a circle. From the row consisting of 5 x 5 pixels it is possible to see a symbol that is unambiguously a circle, but interestingly enough larger constructions result in the formation of less perfect circles.

As to the open symbols the minimal dimension for both symbols, the circle and the square is given by the 4 x 4 pixel arrangement, i.d. at approximately 1.2 mm. Small triangles are rendered only in three angularities.

2.13 Minimum dimensions of line detail

The geometry of every line must satisfy certain requirements if the course of the feature is to be perceived without ambiguity. Generally speaking indecisive linework, with many scarcely visible peaks, is considered merely to be bad drawing. Only curved or angular deviations exceeding a particular threshold are understood as real changes of course, and therefore special care must be taken to smooth the geometry of all line elements that do not demonstrate a conspicuous change.

In Fig. 2.82 irregular linework is illustrated. Any discernible variations must deviate from the norm by one and a half or two line widths when the features are relatively small. The spacing of tiny loops should also measure at least two line widths.

In the relevant figures, both involving the outlining of detail with contour lines, a poor line geometry is compared with a good one that confirms to the rules cited above. parts of the figures are enlarged three times to facilitate the demonstrate of what can be termed poor or good line forms.

In Fig. 2.83 angular line types are represented. The threshold for the perception of short elements is of the same order of magnitude, i.e. approximately twice the width of the line. This example, serving to show a poor and a better solution, relates to administrative boundaries which often exhibit an angular structure.

Double lines may be considered in the same way as single lines (Fig. 2.84). Changes in direction which are too weak tend to distract the reader's attention from the main lines, and therefore very small undulations should be eliminated. Another important case is presented by a regular parallel pattern comprised of double lines with equal spacings and intervals. Visual problems are also caused by the intersection of too many double lines at a crossing, or by acute angles. Again, the illustration on the right-hand side of Fig. 2.84 attempts to avoid these defects.

Finally, minimum dimensions must also be observed with respect to area contours (Fig. 2.85). Depending on the grain of the area filling, limits must be set with regard to the size of the smallest possible area and, independently, for rounded and oblong shapes. Again stretched or acute angles are not to be recommended because the infill will not be distinguishable from surrounding detail.

2.14 Visual interaction between adjacent symbols

There is a distinct visual interaction between adjacent symbols, and in consequence it must be ensured that each of them contrasts sufficiently with its neighbours. Crowding should be avoided wherever possible in order that individual symbols can be discerned and are not suppressed by those around them. In addition, each of the devices should stand out from the background. Symbols depicting spot heights are especially critical in this respect, as they indicate the precise position to which an indicated value belongs. Such point symbols must not take up too much room, and spot heights are normally shown by small dots, crosses or triangles.

Figures 2.86 to 2.87 illustrate poor and good solutions to the problems relating to spot height positioning:

- The outer casing of a sharp bend on a road must not be interrupted by a symbol (Fig. 2.86).
- Squeezing a dot between narrow double lines is not recommended. It is preferable to centre it on one side of the lines and to clear some free space around it. Such a break in a continuous line helps to identify the spot height (Fig. 2.86).
- Road junctions are often chosen as appropriate positions for spot heights. The dot has to be centred at the intersection of the road axes and not offset (Figs 2.86 and 2.87). In this instance symmetry helps to distinguish the point.
- The symbols for bridges are often too small to allow the location of an additional dot centred on the bridge. It is therefore preferable to position the device on one side or the other of the feature (Fig. 2.87).
- If a spot height falls on a dotted line, a cross provides a better contrast than a dot (Fig. 2.87).

In the left-hand section of Fig. 2.88, ambiguity exists between the representations of buildings and an embankment. On the right, the triangle-shaped slope hachures contrast favourably with all other elements.

It is often intended to create a notional balance between the appearances of different symbols. Above in Fig. 2.89 the double lines of the roads and the circles illustrating built-up areas lack such a balance. One of them is too large and the other much too small. Below the two symbols are shaped for a better match.

In areas where two features naturally coincide, a common occurrence in the case of boundaries, it may be possible to split a symbol along its axis of symmetry and to show only half of it. Alternatively, a boundary may be partly substituted by a river or street (Figs 2.55 and 2.56).

Figures 2.86 to 2.89 are reproduced as five-times enlargements, but Fig. 2.90 exhibits them at publication scale.

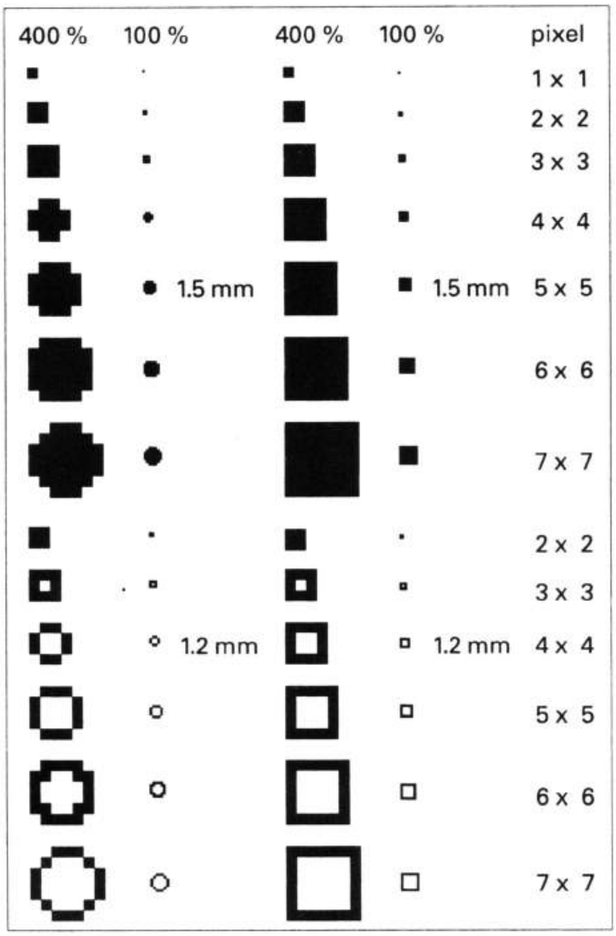


Fig. 2.80 Small circles and squares as displayed on a screen

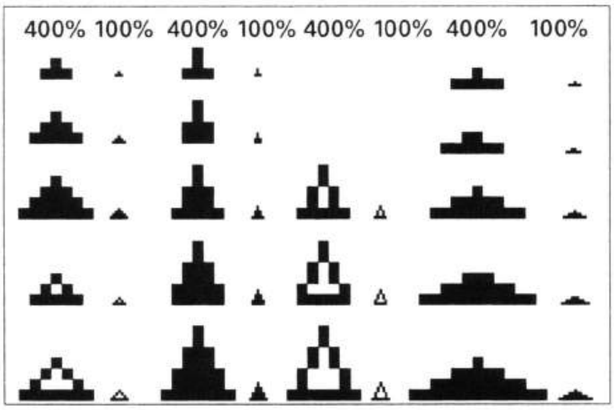


Fig. 2.81 Small triangles as displayed on a screen

2.15 Visual interaction between road and house symbols

Due to the necessary minimum dimensions of house symbols (0.3 to 0.4 mm), there may be considerable interference with road symbols composed of lines which are between 0.15 and 0.2 mm in width. Figures 2.91 to 2.99 illustrate some of the problems and how they may be overcome.

In Fig. 2.91, a number of houses and a church are closely grouped along a major road, the casing of which partly fills the spaces between the buildings. The suggested remedy involves the reduction of the line width between the houses, and the breaking of the road casing to allow clear distinction of the church symbol (Fig. 2.92). Another important factor may be the design of a footpath bordered by buildings (Fig. 2.91). The positioning of the segments of the proposed pecked line must be carefully attuned to the sequence of houses (Fig. 2.92).

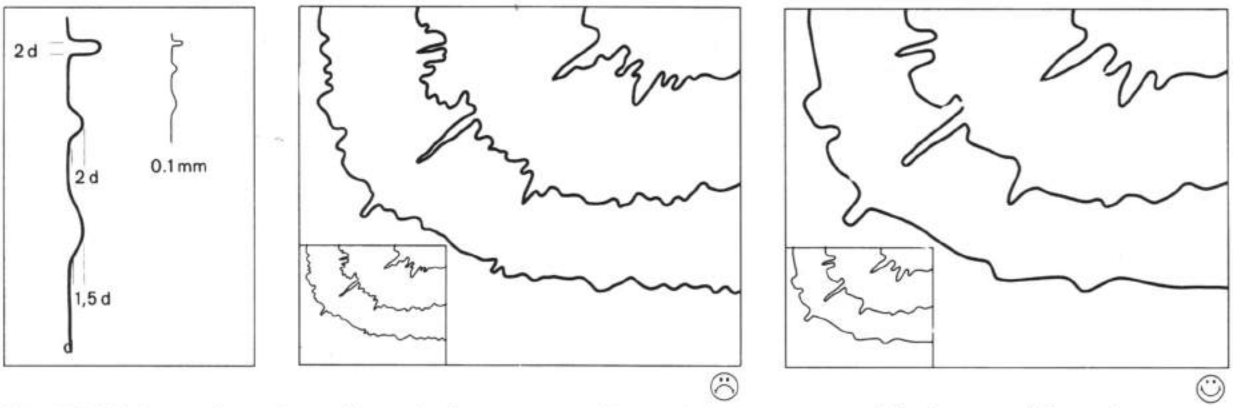


Fig. 2.82 Minimum dimensions of irregular line geometry. Line variations are too small in the central figure, but correct in the one on the right. (Contour lines have been reproduced at publication scale and enlarged 3 times)

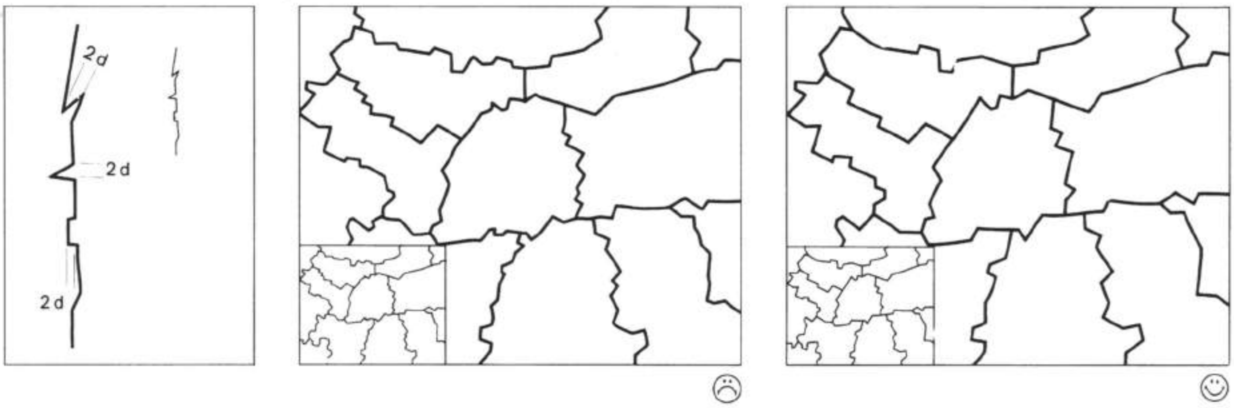


Fig. 2.83 Minimum dimensions of angular line geometry. Details are too small in the central figure, but correct in the one on the right. (Administrative boundaries have been reproduced at publication scale and enlarged 3 times)

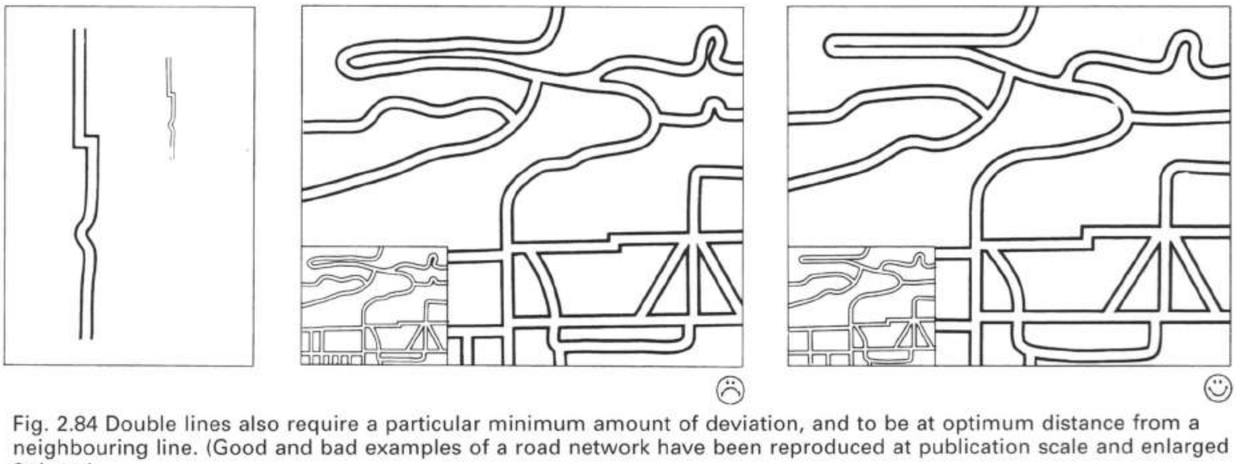


Fig. 2.84 Double lines also require a particular minimum amount of deviation, and to be at optimum distance from a neighbouring line. (Good and bad examples of a road network have been reproduced at publication scale and enlarged 3 times)

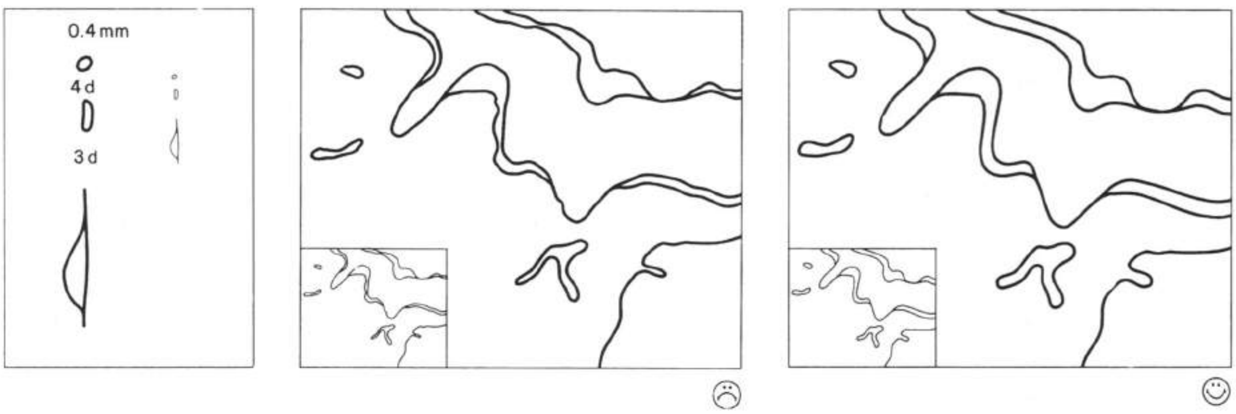


Fig. 2.85 Minimum dimensions of area outlines. Details are too small in the central figure, but are correct (although still small) in the one on the right. (Outlines of geological features have been reproduced at publication scale and enlarged 3 times)

Sometimes it may be advantageous to increase the apparent spacing between the buildings in a densely built-up area by omitting the road casing symbols (Figs 2.93 and 2.94). It is somewhat pointless, and may even be misleading, to attempt to squeeze a pecked line into a narrow gap between buildings as is illustrated in Fig. 2.95. White spacing can equally well represent a line segment (Fig. 2.96).

Similar problems occur at the junctions of minor and major roads in the middle of built-up areas (Fig. 2.95). Their possible solution is demonstrated in Fig. 2.96.

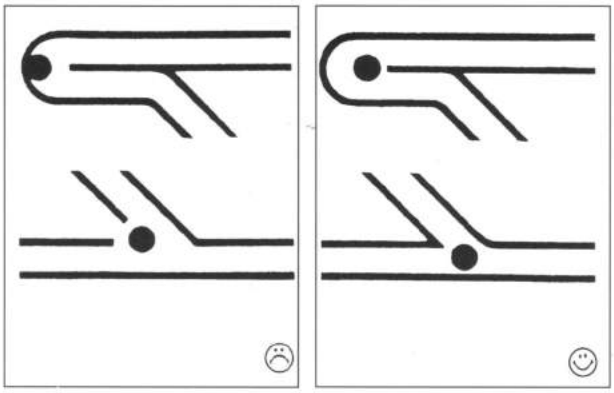


Fig. 2.86 Positioning of spot heights on sharp bends or at road junctions

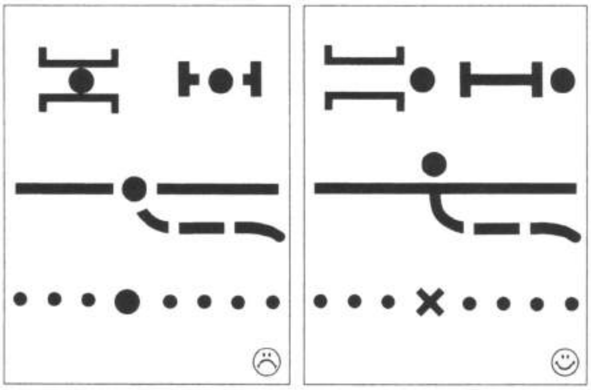


Fig. 2.87 On minor road junctions, bridges, dotted lines

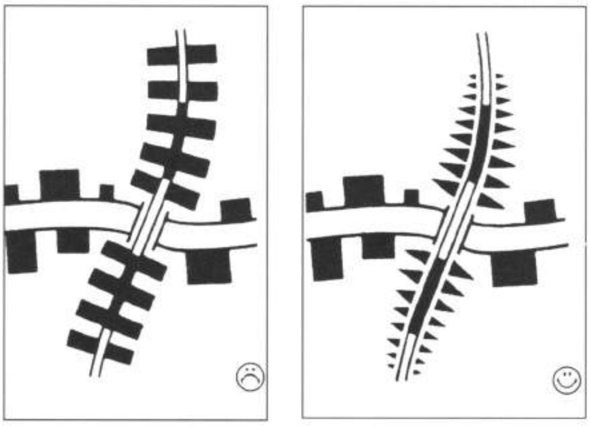


Fig. 2.88 Creating improved contrast to houses in representation of a railway embankment

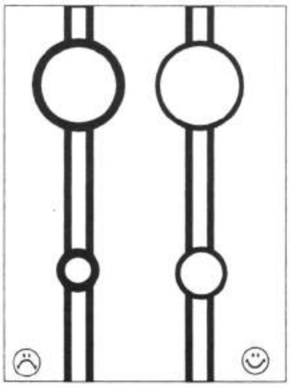


Fig. 2.89 Balance between road and town symbol

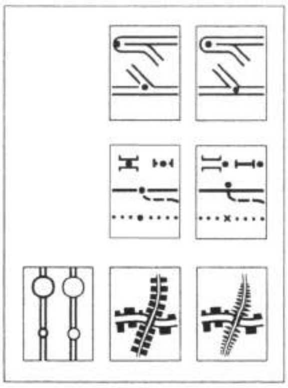


Fig. 2.90 Reduction of all figures to publication scale

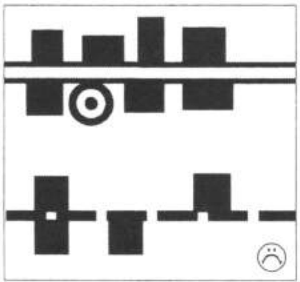


Fig. 2.91 Road casing fills spaces between buildings

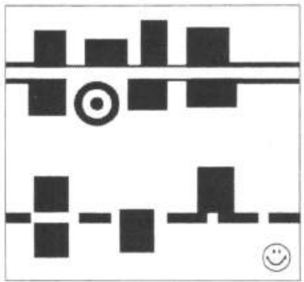


Fig. 2.92 Thinner road casing used in built-up area

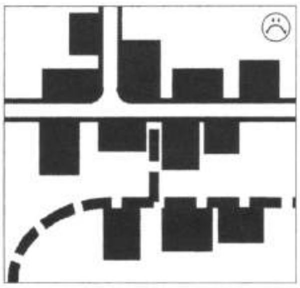


Fig. 2.93 Footpath symbol fills space between houses

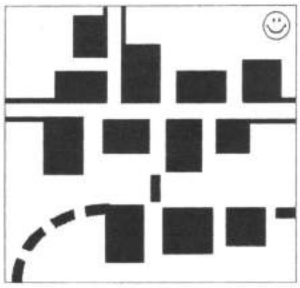


Fig. 2.94 No road casing in built-up area, omission of segment of footpath symbol

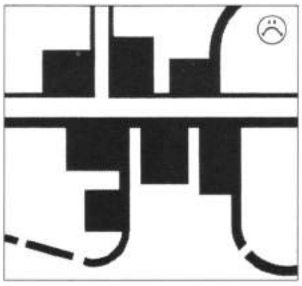


Fig. 2.95 Too many connections of lines with building system

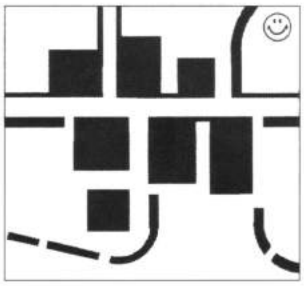


Fig. 2.96 Improved version for the minor roads that lead into the main road

It is usually quite important for the map user to depict the level of all traffic lines when they cross and intersect one another or bridge rivers (Fig. 2.97). There are three cases to differentiate, the overpass, the underpass and the crossing at equal level. Furthermore various types of bridge symbols are in use. In Fig. 2.97 there is ambiguity at nearly every crossing point. In some instances the symbolisation is confusing. In Fig. 2.98 a clear and simplified solution has been substituted for each individual case.

Figures 2.91 to 2.98 are six times enlarged. With these magnifying glass images the problems are somehow played down. A true representation of these tricky situations and their solutions can be gained only from Fig. 2.99 which illustrates all eight figures reduced to publication scale.

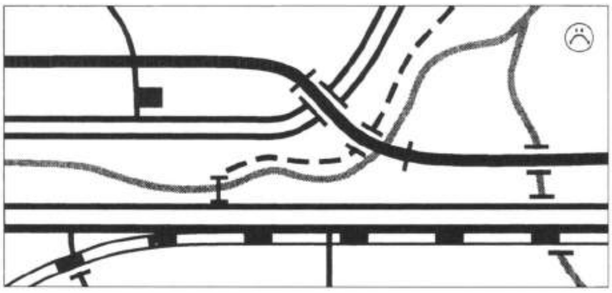


Fig. 2.97 Unclear solution for overpasses, underpasses and bridges

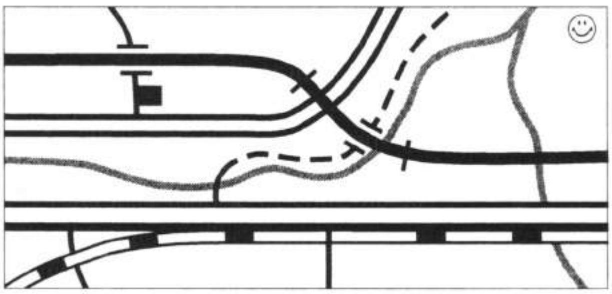


Fig. 2.98 Improved version with a simplified representation of the whole situation

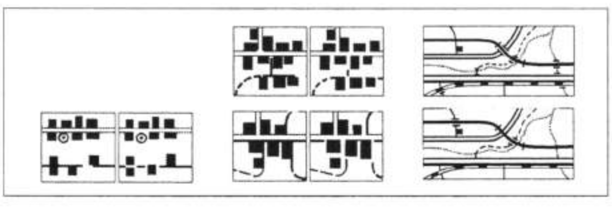


Fig. 2.99 All figures above reduced to publication scale

2.16 Differentiation of point symbols

One of the principal goals in designing any sort of symbol is the achievement of optimal differentiation between the devices employed. The purpose of this is to improve their discrimination, simplify interpretation, and generally facilitate map reading. Which of the graphic variables are involved in establishing such an optimal discrimination depends on specific design problems.

Whenever variation of form or shape is appropriate, the *angles occurring along the top edge of the symbol are most important* in order to ensure the quick and correct identification of the device. Special care has therefore to be taken when the upper outline is being developed (Figs 2.100 and 2.104), and this is also true in the case of lettering. However, application of this principle can also result in possible misinterpretation at first glance – for example, in the case of a triangle or a square standing on one of its corners.

In Fig. 2.101 differences between one symbol and the next are insufficiently prominent to allow easy discrimination. As much variation as possible, in terms of both angles and curvature, helps to differentiate the black symbols one from another. However, there are not enough differences between the similar, adjacent grey symbols and it is therefore not recommended that the two types should be included in one and the same legend.

Point symbols may be designed to illustrate a whole group or family of related items, simply by retaining the same outline, e.g. a circle or a square. The two upper rows in Figs 2.102 and 2.103 are differentiated by their infills only. In each of the two lower rows the circles and squares are varied by adding extensions above or below the basic symbol. Care has to be taken to ensure that they remain as simple as possible. Here again it will be easier to discriminate symbols whose upper silhouettes vary.

Apart from differences in shape there are, of course, a number of other variables that may be considered in the search for better distinction (Figs 2.104 and 2.105). In Fig. 2.107 optimum use has been made of available possibilities by the simultaneous variation of form/shape, orientation (vertical or horizontal), and value (light, medium and dark symbols).

The **design of each individual symbol** also needs careful consideration. Figures 2.104–2.107 illustrate different experiments undertaken when investigating the suitability of symbols for use in showing agriculture production and tourist facilities relating specifically to a beach. Having a mental image of a particular characteristic of such features is only the first step, and their typical symbol shapes have still to be generated.

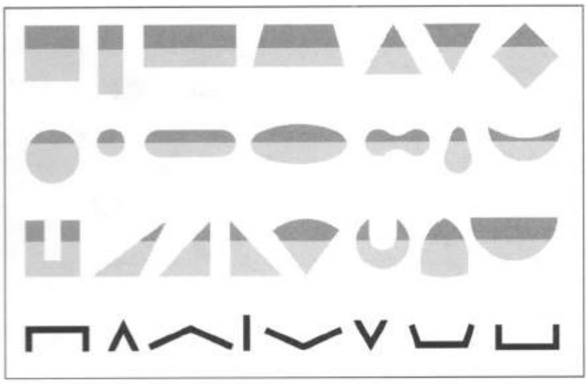


Fig. 2.100 The shape of a symbol's top edge is essential to its differentiation

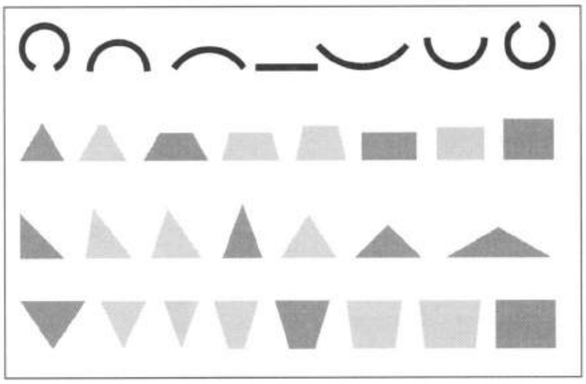


Fig. 2.101 A minimum amount of change is necessary to ensure good differentiation

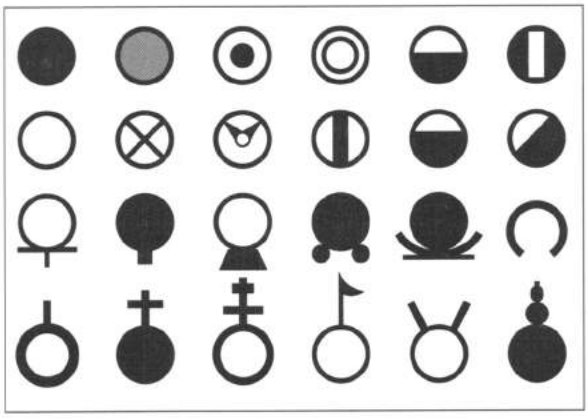


Fig. 2.102 A family of symbols based on a circle

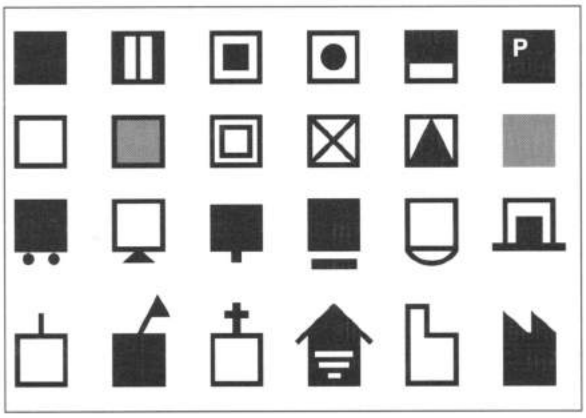


Fig. 2.103 A family of square symbols

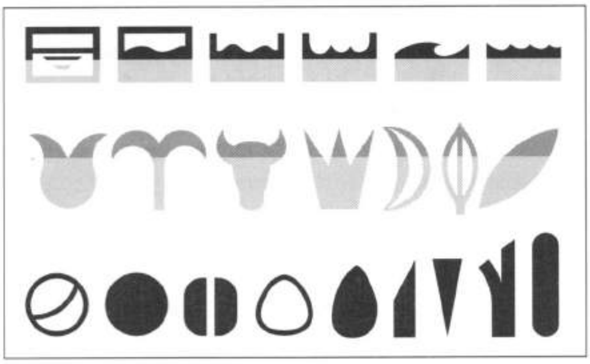


Fig. 2.104 Accentuation of the tops of pictorial symbols

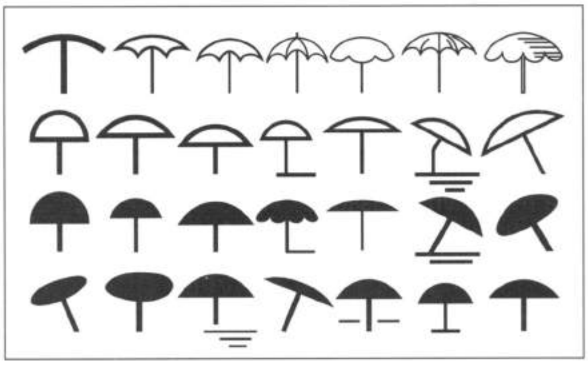


Fig. 2.105 Development of a pictorial symbol for beaches

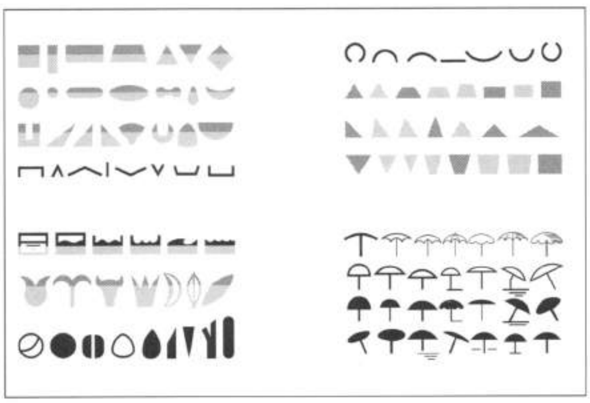


Fig. 2.106 Photographic reduction of Figs 2.100, 2.101, 2.104 and 2.105 to publication scale

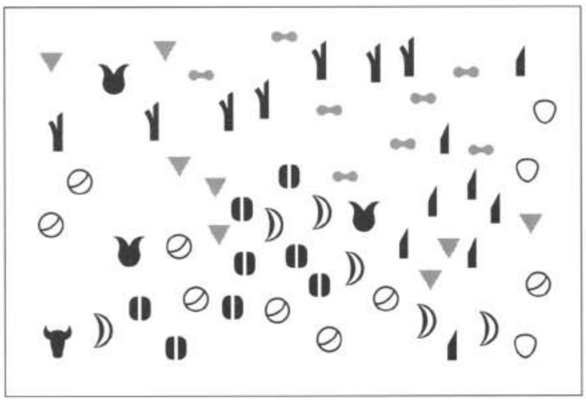


Fig. 2.107 Symbols with optimum differentiation

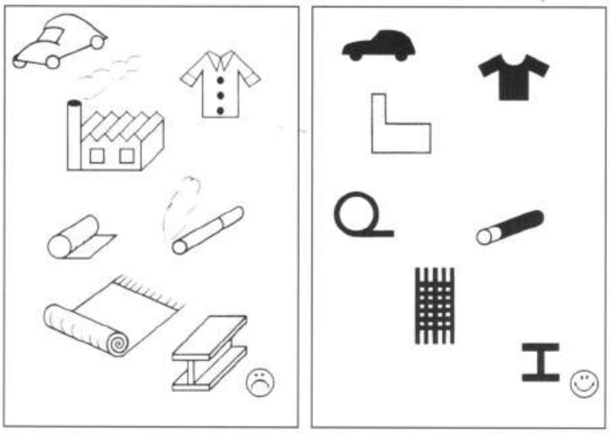


Fig. 2.108 Overdetailed pictorial symbols and poor differentiation within a series of symbols

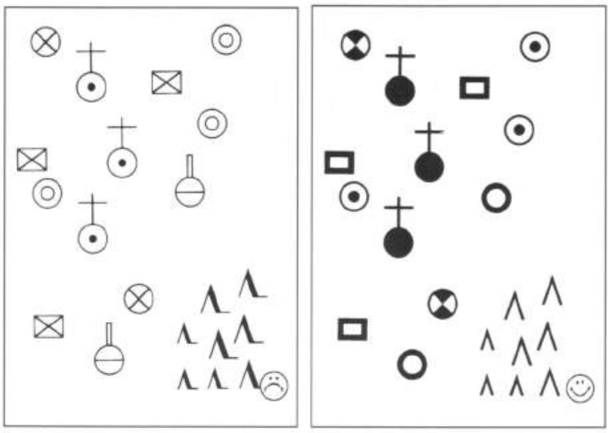


Fig. 2.109 Improved differentiation and simplified design of the symbols

Different solutions may also result depending on whether a symbol is solid, drawn only in outline, or infilled with a colour. Special care has to be taken in order to avoid using too complicated an outline, too much detail, overvariation of line widths, or other potentially unpleasant combinations (Fig. 2.108, left-hand side). Caution is also advised with respect to modifications of a basic shape.

These points are especially important with regard to small symbols (Fig. 2.109), which will only survive in the same environment as other map detail if they are simplified as much as possible in order to ensure maximum distinction.

In this respect pictorial symbols are more critical than geometrical symbols. Small detailed sketches, such as those appearing on the left-hand side of Fig. 2.108, may appear quite informative if studied individually, but are rather ineffective within the total map environment. They should be easily distinguishable from all the other incorporated symbols representing geographical detail, but yet be individually identifiable in terms of their characteristic shape in order that the references made by the user to the legend are minimal.

An old Chinese proverb may be quoted as a fitting conclusion to this section – *The best image expression is achieved when there is nothing more to be omitted.*

2.17 Differentiation of lines and areas

Non-continuous line patterns, and pecked or dotted area outlines often used as variations of line symbols, have a tendency to 'break up' and become confused with other map detail. This defect must be avoided by the careful consideration of the size of incorporated intervals and the angles of included curves, corners and crossings.

As Fig. 2.110 demonstrates, the essential features within an irrigation system are the confluences of the streams and it is therefore not a good idea to interrupt the lines at these points. No junctions should be touched, and the first break in linework should occur at some distance from the node. This is the best solution even if some irregular pecks are generated as a result of applying the policy.

In the case of a road network incorporating pecked line symbols (Fig. 2.111), sharp bends and crossings require special treatment. These 'fragile' areas must be protected at the expense of intermediate sections. Breaks must always be relocated away from those parts of a road demonstrating greatest curvature.

Many boundary lines consist of angles connected by straight lines (Fig. 2.112), and it is logical that the former should be indicated with a dot. This solution tends to disrupt the continuity of linework, but further dots and dashes can be regularly distributed between the corners with other prominent break points also being carefully treated. The same arrangement is applicable to various sorts of pecked and dotted lines depicting features (Fig. 2.113).

Differences in line texture are often used in thematic maps (Fig. 2.114), and the same rules apply to these coarser types. As is illustrated in Fig. 2.115, care must be taken to avoid regular breaks of pattern in particular geometric constructions. Slightly modified intervals can remedy the situation and create an unambiguous line geometry.

Areas of unknown extent, or those with uncertain boundaries, are often outlined with dotted or pecked lines. Figure 2.116 illustrates a woodland area that cannot be simply delineated because the trees become gradually more and more sparse. In order to retain the characteristic shapes of the areas, their interrupted outlines should conform with the rules suggested above.

Another type of differentiation must be observed when employing a representational system in producing diagrams. By changing the figure scale of the bar graphs in Fig. 2.117, the angularity of the upper edge can be significantly changed and differences in quantities are more easily discerned. However, if these angles are either too acute or obtuse visual perception will also be hindered.

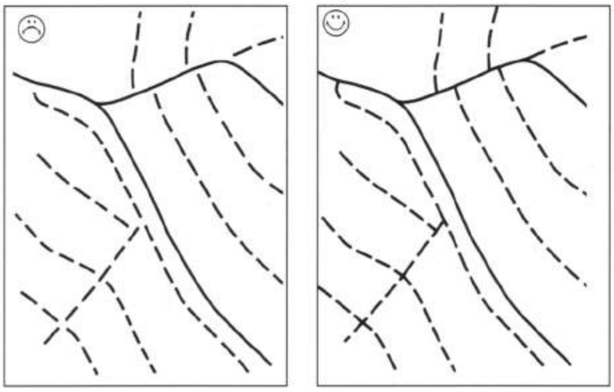


Fig. 2.110 Junctions are the essential features of an irrigation network

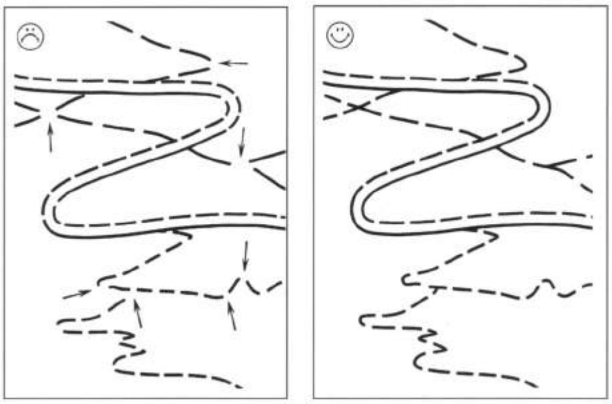


Fig. 2.111 Important elements of a road network must not be interrupted

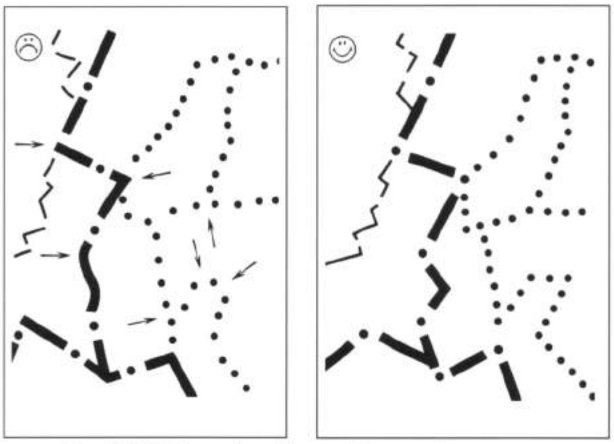


Fig. 2.112 Boundary lines with angular corners

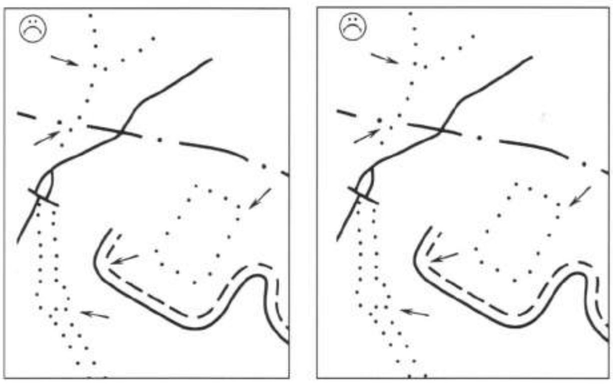


Fig. 2.113 Dots and dashes must be sensibly positioned

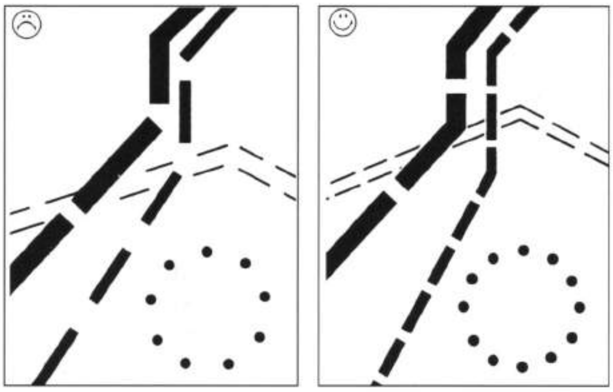


Fig. 2.114 Pecked lines require special attention

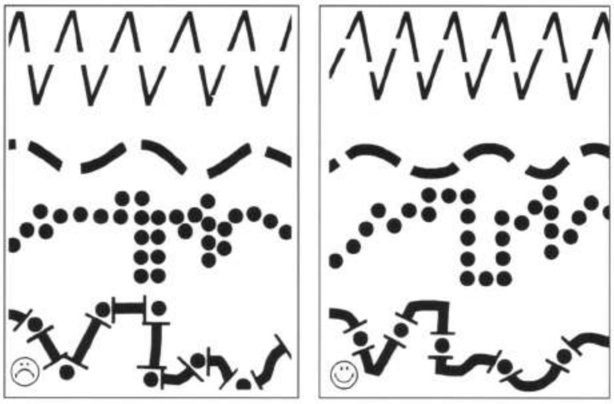


Fig. 2.115 Regular breaks of pattern should be avoided in these cases

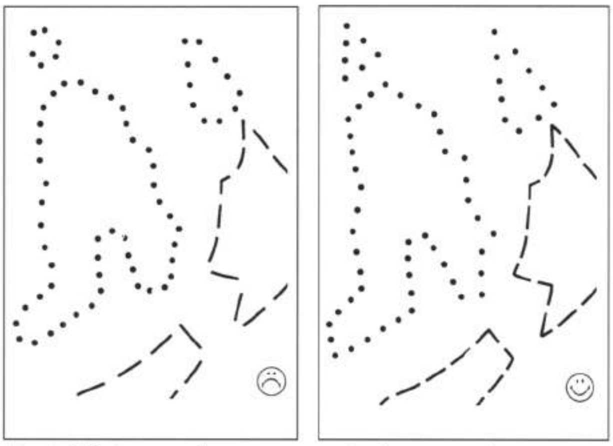


Fig. 2.116 Area outlines must not be interrupted at critical points

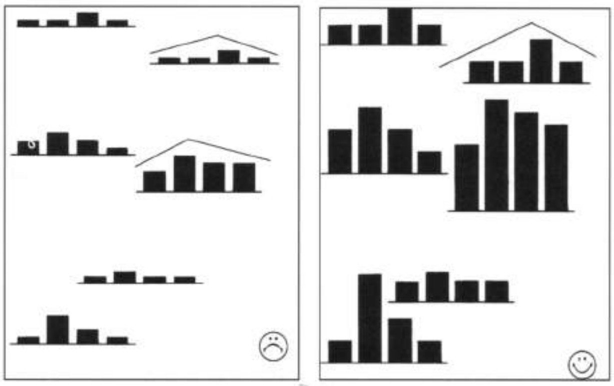


Fig. 2.117 Bar graphs must be scaled to produce an accentuated silhouette

2.17.1 Line textures in a digital production mode

Dotted and pecked lines are standard options within most digital production systems. Individual line widths and intervals can be selected when the symbol library is created. However, as a consequence of what was stipulated above, slightly modified intervals ought to be made possible for each line string. The pattern of the pecks should be arranged so that a line element is left on either end of the string. Some programmes allow for a proportional shift of the distribution of the pecks in order to obey to this rule. But what about 'fragile' areas along narrow bends, short vertices and rugged geometry, as, e.g., in Fig. 2.118? So far no available programme takes care of these rules. It would have first to analyse the geometry of every line string, and then be prepared to solve the distribution of dots and pecks for an almost countless number of cases. The intermediate solution is to interrupt the line interactively by using orthogonal strokes which mask out the intervals. Similarly dots have to be placed individually. Such a technique was applied and is illustrated by Fig. 2.119. The areas in light grey are to be seen as the opaquing mask needed to obtain an improved image for all the dashed lines. The effect at publication size may be verified by comparing the two reduced images in Fig. 2.120.

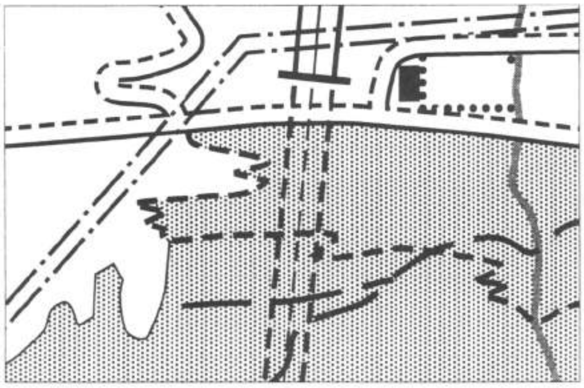


Fig. 2.118 Line patterns applied automatically using an available function of a digital mapping system

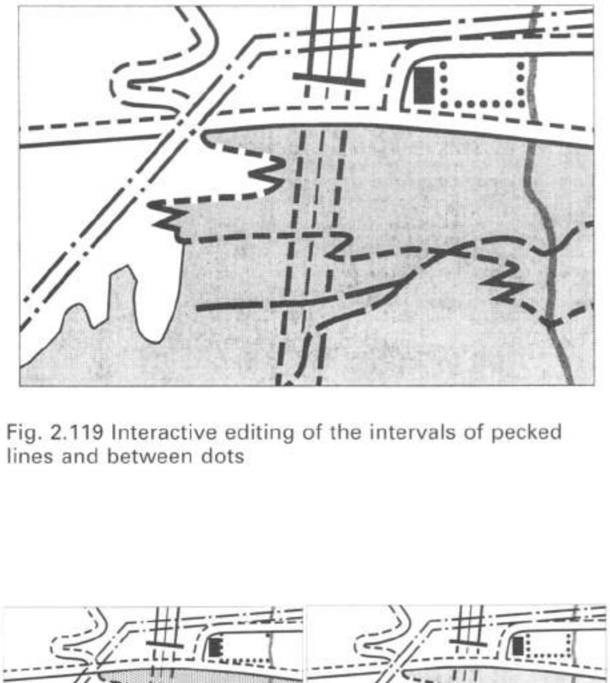


Fig. 2.119 Interactive editing of the intervals of pecked lines and between dots

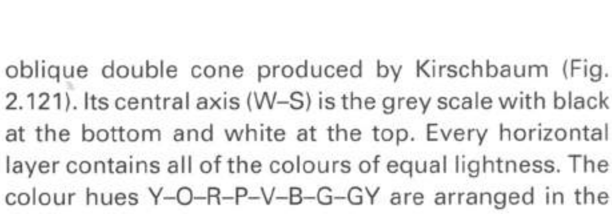


Fig. 2.120 Figures above at publication scale

2.18 Colour selection and application

2.18.1 Colour terminology

Colours can be differentiated in terms of their hue, lightness (or value) and saturation.

Hues	Y	yellow
	O	orange
	R	red
	P	purple
	V	violet
	B	blue
	G	green
Lightness	W	white
	L	light colour
	D	dark colour
	S	black
Saturation		pure colour
		desaturated colour
	GY	neutral grey

2.18.2 Colour-appearance systems

Each of the three characteristics of colour varies continuously, and all colours can therefore be arranged as a three-dimensional *colour-appearance system* for use in tint identification. A number of these have been developed – for example, those proposed by Munsell, Ostwald, and the Commission International de l'Eclairage (CIE). The system described here is the oblique double cone produced by Kirschbaum (Fig. 2.121). Its central axis (W–S) is the grey scale with black at the bottom and white at the top. Every horizontal layer contains all of the colours of equal lightness. The colour hues Y–O–R–P–V–B–G–GY are arranged in the form of an oblique diameter, also called a colour circle, with each vertical plane comprised of all the tints and shades of a particular hue. Within this model colours may vary continuously, but may also be split up into steps so that each colour sample differs from its neighbours by a noticeable amount.

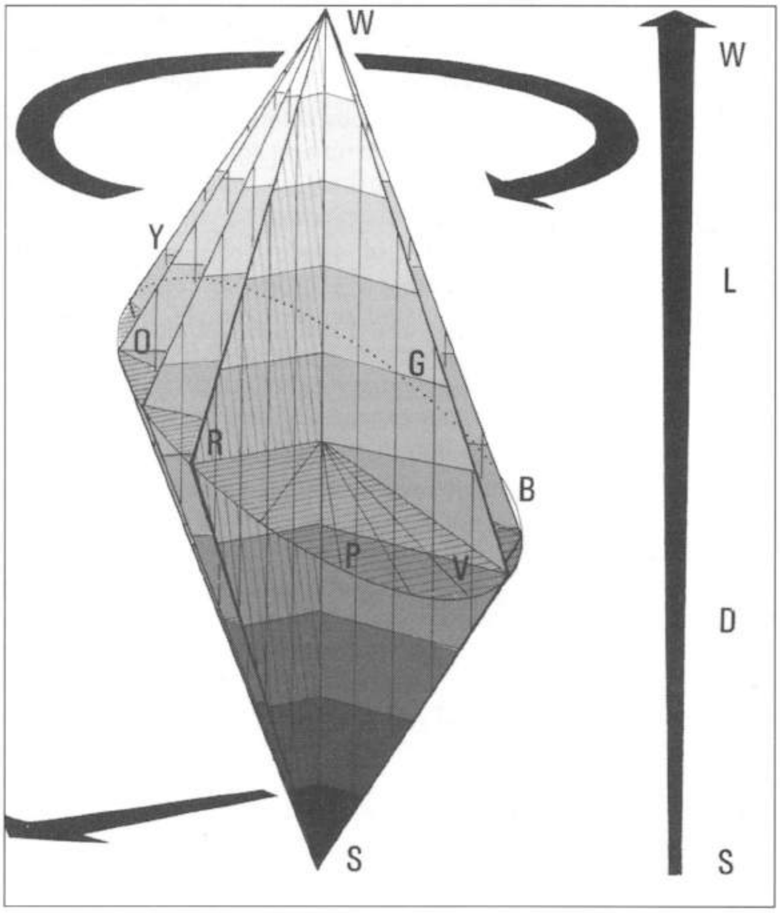


Fig. 2.121 Kirschbaum's 'colour appearance system'

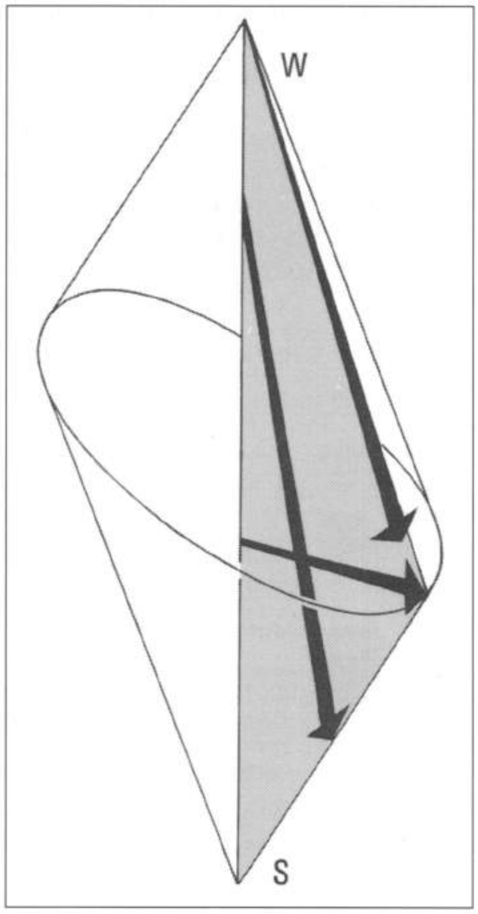


Fig. 2.122 Colour triangle of the same hue

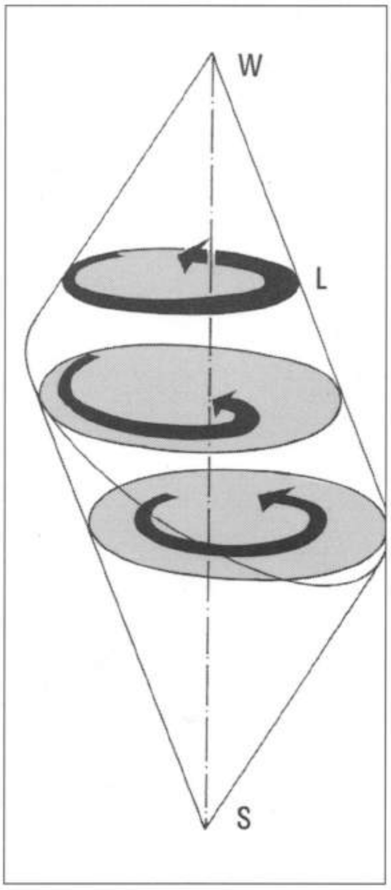


Fig. 2.123 Different hue of equal lightness

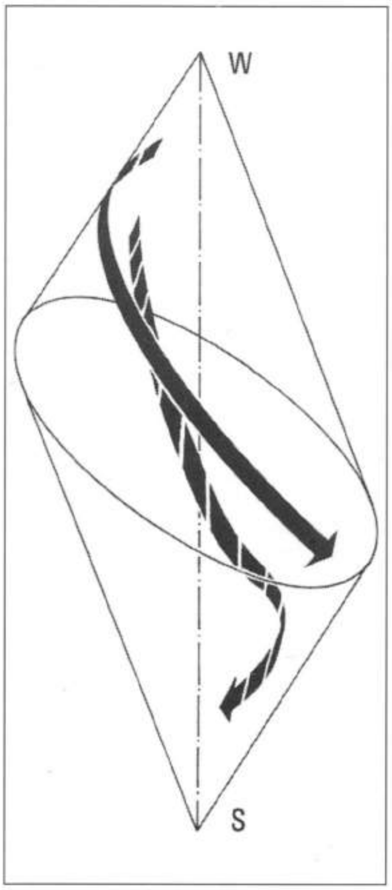


Fig. 2.124 Pure colours of different lightness and hue but equal saturation

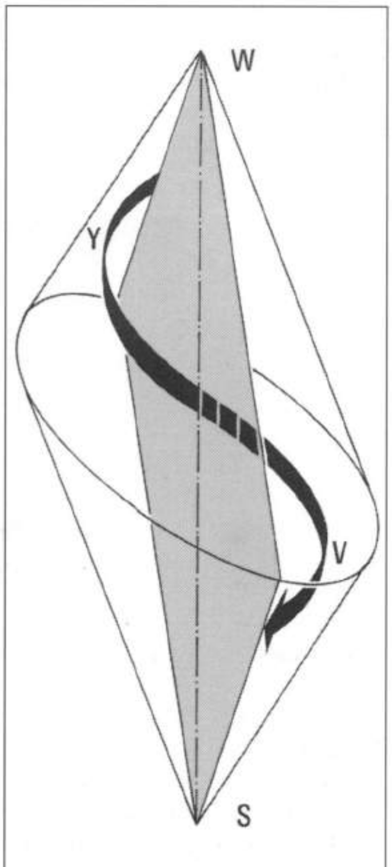


Fig. 2.125 'Faux-camaïeu'

2.18.3 Line colour selection

The smaller the area to be coloured the more contrast is necessary to enable clear differentiation between two or more hues. Therefore relatively dark colours must be used for point and line symbols, unless negative devices are to be applied. The following colours may be used for lines and small symbols on a white background:

black
brown
violet
blue
green blue
green
red
orange

2.18.4 Area colour selection

An initial decision has to be made as to whether a range of colours should consist of either:

- a continuous colour scale with scarcely noticeable steps;
- a continuous colour scale with noticeable steps; or
- a contrasting colour scale with prominent differences.

Required colours can be specified with reference to the colour-appearance system (Fig. 2.121). Aesthetically pleasing, harmonious compositions can be obtained by obeying one of the following rules (Figs 2.122–2.124) and using:

1. A range of tints of one and the same pure colour (violet (V)) – a straight line on the surface of the model (W–LV–V) (Fig. 2.122).
2. A range of shades of one and the same hue, from grey (GY) to violet (V) or dark violet (DV), in the vertical colour triangle (called 'camaïeu' in French) (Fig. 2.122).
3. A range of tints of the same lightness and of different hues (horizontal planes) (Fig. 2.123).
4. A range of shades of different lightness and hue, but pure colours only (LY–DP), following a curve along the surface or a curve of equal saturation (Fig. 2.124).
5. A range of shades of different lightness and hue, connecting two complementary hues LY–GY–DV (a curve through the interior of the model), called 'faux-camaïeu' in French (Fig. 2.125).
6. To achieve a maximum of contrast between hues, complementary colours which are evenly distributed over the whole colour circle should be used. However, care must be taken to avoid a predominance of yellow areas. Small symbols of one colour distributed over a large area of its complementary colour gain in brightness and increase colour contrast.
7. If non-harmonious colour combinations are to be avoided, the natural lightness of hues must not be completely reversed (e.g. no light violets and dark yellows).
8. The range of shades chosen should not concentrate on a group of colours that are closely related as, for example, being bluish, brownish, yellowish, greyish or pure reds.
9. A range of pure area colours should, normally, be neither excessively dark or light.
10. The amount of yellow on a map should not dominate significantly over blue or violet.

A number of other rules may apply in specific cases and, furthermore, the effects of the 'juxtapositioning' of colours in a particular map arrangement must be considered.

2.18.5 Ordinal colour scales for area tints

Ordinal scales typically show the variation of only one component. Logically the graphic solution is a variation of the intensity or lightness of one and the same hue. Depending on the chosen hue, between four and seven steps of intensity are possible. If more steps are needed the intensity scale is combined with slight changes of the hue as illustrated in Fig. 2.126. A special case is the representation of increase and decrease by two diverging ordinal scales showing a variation in the intensity of two contrasting colours (Fig. 2.127), starting from a neutral colour for the message 'practically no change'.

There may be a superposition of two ordinal scale components that create all kinds of mixtures. As an example we can think of more or less precipitation combined with a longer or shorter vegetation period. In this case two ordinal colour scales may be crossed, resulting in a number of intermediate tints that reveal

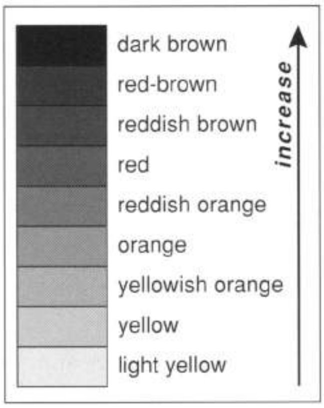


Fig. 2.126 Relatively long ordinal colour scale

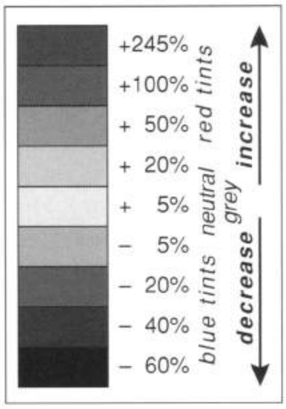


Fig. 2.127 Twofold ordinal colour scale

the relationship between the two components. Variation of blue for precipitation and yellow for the duration of the vegetation period may suit the purpose in this case (Fig. 2.128).

2.19 Selection of printing colours and screens

In offset lithography, with but a few exceptions, area colours can be printed by using the *three standard, subtractive primary printing colours: Yellow (Y), Cyan (C), Magenta (M) and Black (S).*

Each of the three solids (Y, C and M) is broken down by screens into a range of tints that gradually allow more reflection from the white of the paper. The 'percentage' indicates the amount of paper that is covered by the respective dot or line screen. *Colour charts* (Fig. 2.130) are produced by overprinting the three colour scales in all possible combinations, and can be cut up and used for the composition of colour ranges. Dark colours should normally be selected for point symbols and small areas, and light ones for more extensive areas (Fig. 2.129).

The smaller the area to be coloured the greater the contrast necessary to differentiate between two or more colours. In consequence, relatively dark colours must be used for point and line symbols unless negative versions are employed (Figs 2.131 and 2.132). Fine lines must not be screened and can be composed of two or more of the three standard colours printed as solids. If this practice is not

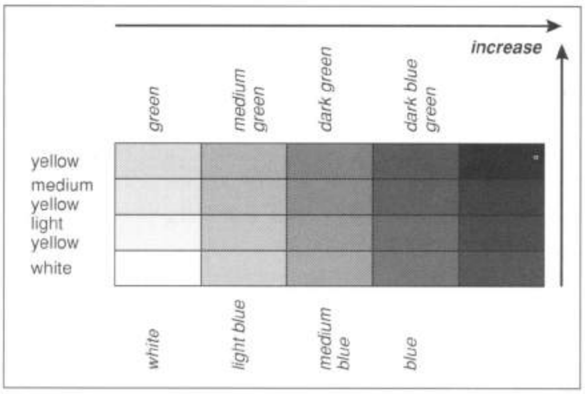


Fig. 2.128 Crosswise mixtures of two ordinal colour scales

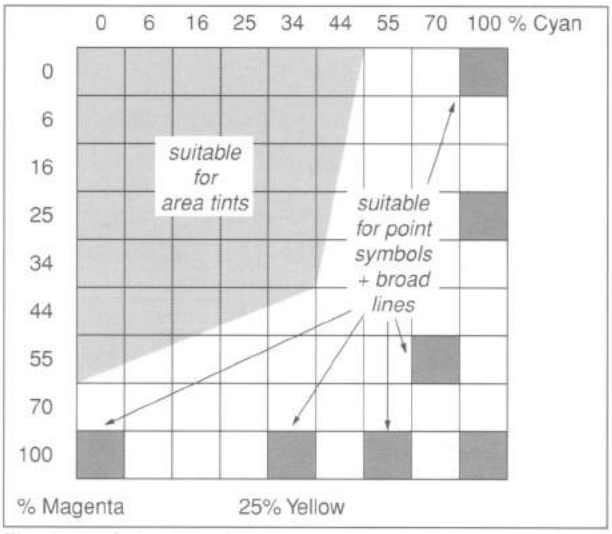


Fig. 2.129 Selection of light area tints and dark line and point symbol colours on one of the colour charts

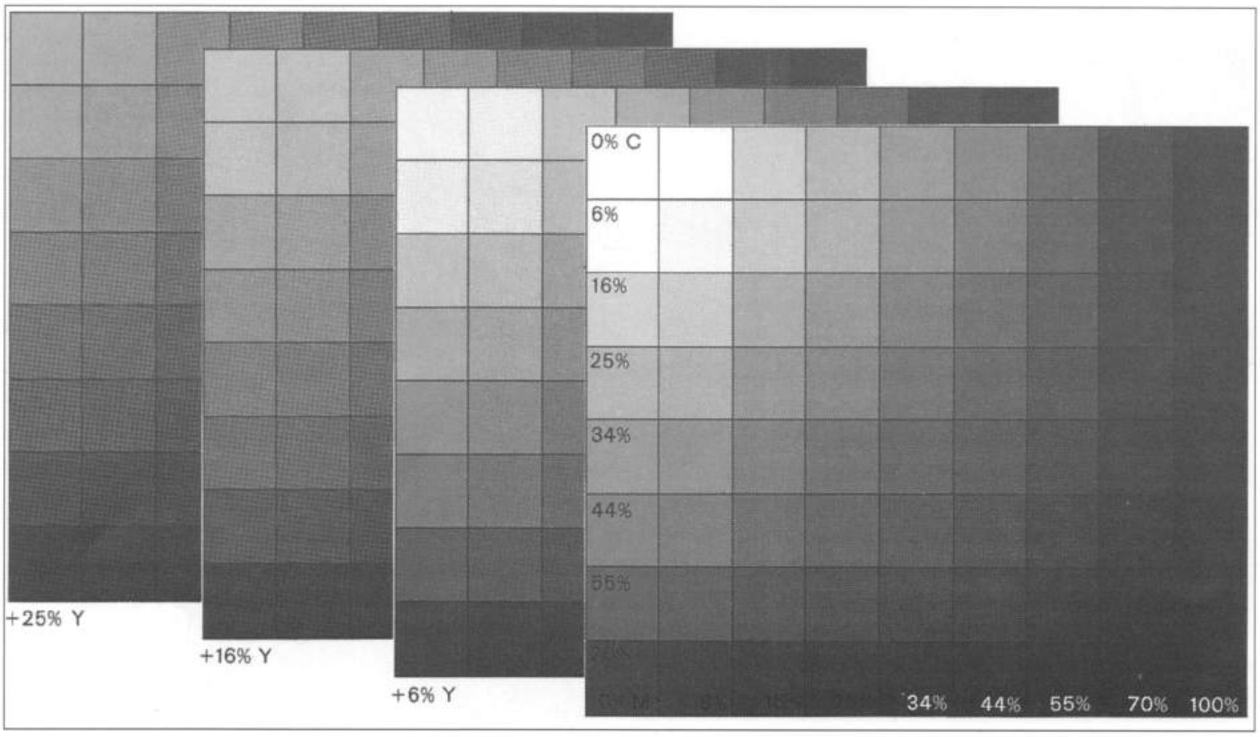


Fig. 2.130 Colour charts employing the three primary colours (Y, C and M) and showing the application of a predetermined series of screens

followed a brown contour line, probably no more than 0.10 mm wide, might have to be produced by the overprinting of a 50% Yellow, 30% Cyan and 50% Magenta dot screen (Fig. 2.133) – an impossible task to register precisely during the print run! Figure 2.134 demonstrates the extent to which monochrome lines may be screened (44% and 60 dots per cm at an angle of 45°).

When selecting a continuous range of colours from a chart, it may be helpful to obey some kind of a progressive construction scheme for the overlap of the three colours (Fig. 2.135). In order to ensure that lightness decreases in even steps one can check, approximately, whether the sum of the percentages of the two dark colours (C and M) follows a continuous progression.

2.19.1 Screen angles for multicolour halftone tints and the moiré effect

Most of the screens in normal use for copying the final films ready for print consist of regular, repetitive patterns of a given periodicity. When two screens are superimposed at an acute angle a combined pattern may appear in the middle of the intersection. This is known as the *moiré effect* and can be visually disturbing (see Figs 2.142 and 2.144), especially if the two screens intersect at small angles (Fig. 2.140).

Whenever possible screens should be arranged to intersect at 30° in order to avoid coarse moiré patterning. As each dot screen has two directions a special arrangement has to be made for the four colour process: Yellow (the lightest of the four), intersects Magenta and Cyan at an angle of only 15° (Fig. 2.139). Black, or grey, is usually placed at 45°, as is any additional pattern, such as, e.g., hachures, when combined with the three primaries (Fig. 2.141). Irregular patterns do not produce a moiré when combined with a regular one (Fig. 2.143).

Most copy screens are amplitude modulated. This means that they show dots at a regular interval of, e.g., 0.016 mm (60 dots per cm or 150 dpi). In order to create all tints appearing on a colour chart the dots are of variable size within a set of screens.

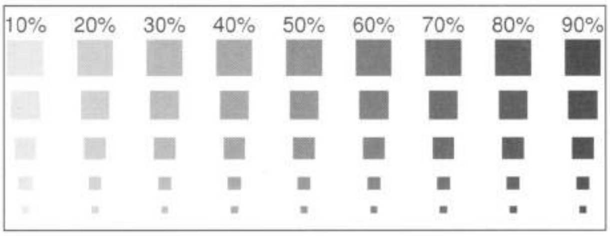


Fig. 2.131 The smaller the point symbols the more difficult it is to distinguish between different percentages

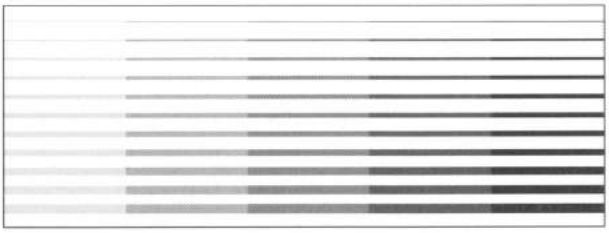


Fig. 2.132 The narrower the line symbols the harder it is to distinguish between different percentages

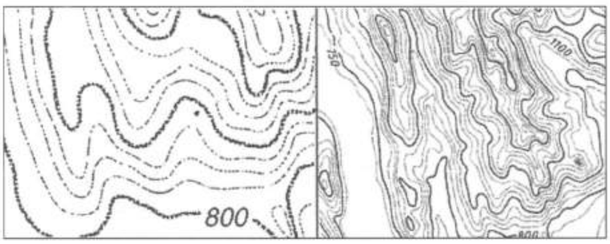


Fig. 2.133 Fine lines composed of three differently coloured and screened lines cause registration problems

Fig. 2.134 Screened monochrome contours (44% and 60 dots per cm at 45°)

Y 90°	6%	10%	10%	10%	10%	6%		
M 15°	25%	16%	10%	6%	6%	6%		
C 75°	70%	55%	44%	34%	25%	16%	16%	6%
Y +M +C	95%	70%	54%	40%	30%	22%	16%	6%

Fig. 2.135 Progressive overlap of colour screens to create a continuous range of colours

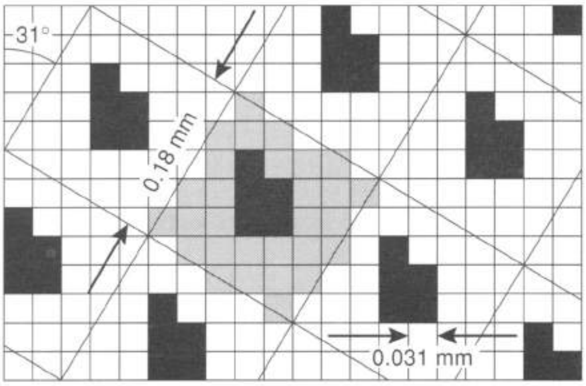


Fig. 2.136 A 19% yellow tint rasterised with 0.031 mm resolution by rational screening at an angle of 3:5, corresponding to approx. 31°

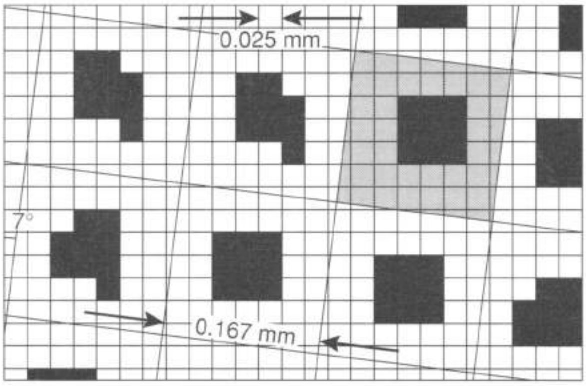


Fig. 2.137 A 20% yellow tint rasterised with 0.025 mm resolution by irrational screening at an angle of 7°

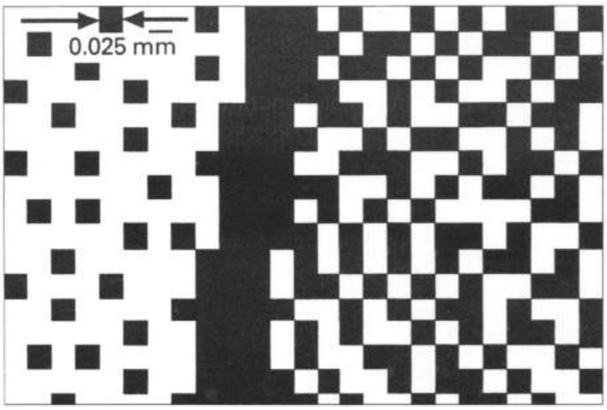


Fig. 2.138 Frequency modulated screening; simulated film extract 130 times enlarged, with a 20% tint to the left and 50% tint to the right of the line

The screens produced on film by a *rasterplotter* may look, under a magnifying glass, like Figs 2.136 to 2.138.

Amplitude modulated (AM) screening simulates the copy screens. Dots of different size are formed by groups of basic picture elements (pixels). Their size is determined by the plotter resolution. The percentage of paper covered by dots determines the tint. In order to be able to make use of a wide range of tints, and to ensure high quality of line-work and text, a rather fine resolution is needed with pixels of approx. 0.025 mm corresponding to 1000 dpi or better.

There are two main solutions to the obtaining of such a result. When the groups of pixels have the same form one speaks of *rational screening* because the groups are placed at equal horizontal and vertical intervals resulting in rational screen angles as, e.g., 1:5 in Fig. 2.136.

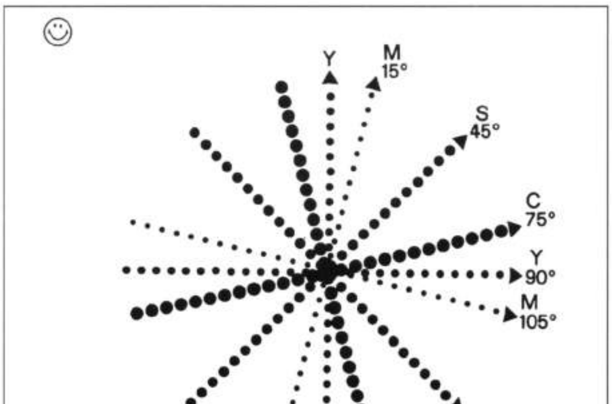


Fig. 2.139 Screen angles employed in four-colour printing process

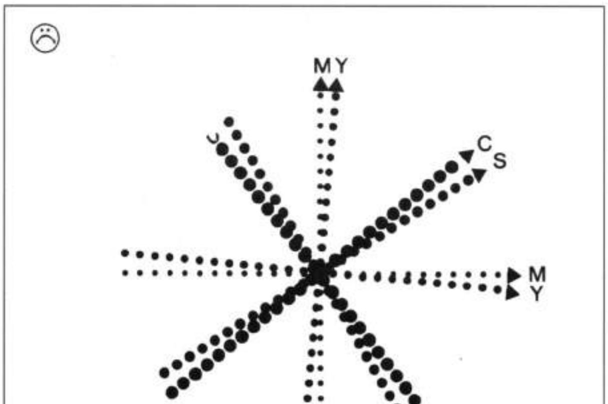


Fig. 2.140 Small angle intersections between two-colour screens lead to generation of a moiré effect

The second approach, so-called *irrational screening*, consists of retaining in principle the usual screen angles employed in the four colour printing process (Fig. 2.137), overlaying the dot meshes on the basic resolution grid and forming the group of dots out of the central pixels. In order to avoid the so-called auto-moiré of the basic plotter grid, the usual screen directions are, however, rotated by 7°.

Frequency modulated (FM) screens (Fig. 2.138) have become available with the advent of laserplotters. They operate with only one size of dots equal to the basic resolution. The tint is also determined by the percentage of paper covered by dots. As the dots are randomly distributed on the surface to be tinted, overprints with FM screens are free of moiré patterning. The pattern of the dot distribution is calculated by software. The neat printing of such fine dots is another technical problem for the press operator.

In the images below the plotter resolution grids and raster cells are indicated just for clarification. Of course, the printing dots will appear in black on the exposed film.

2.20 Selection of area patterns

Similar rules to those established with regard to Area Colour Selection should also guide the cartographer's choice of area patterns and shadings. The absence of visually similar properties within chosen patterns can create an atmosphere of chaos! This point is well illustrated in Figs 2.145 and 2.152 where all the potential variables change from one area shading to the next.

The ideal solution is, therefore, to keep one graphic variable equal or constant and to modify the

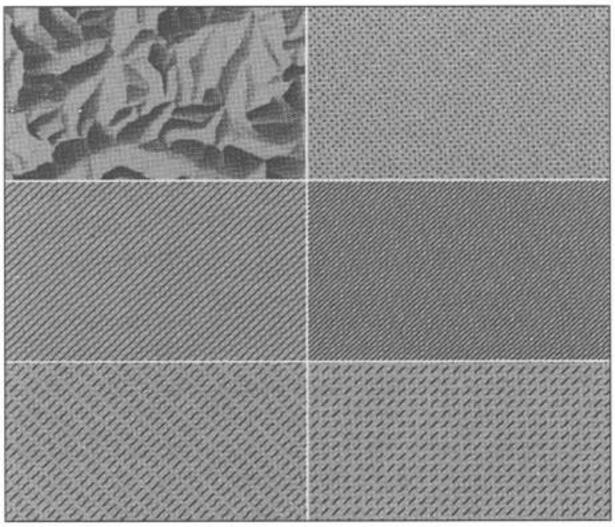


Fig. 2.141 Combination of black/grey screen angled at 45°, and additional patterns, with the three primaries

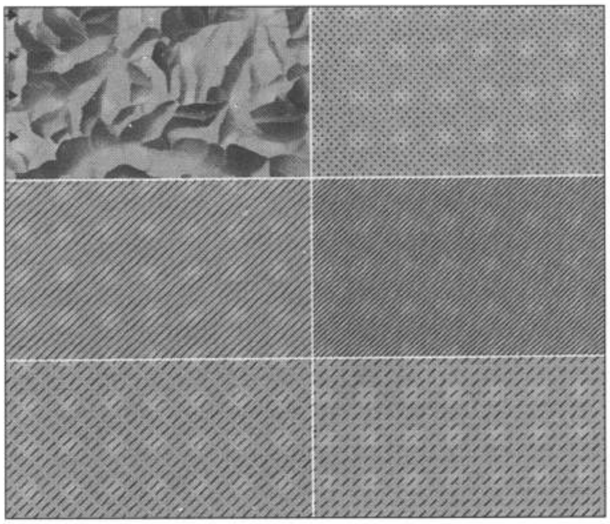


Fig. 2.142 Incorrectly angled screens result in a moiré effect

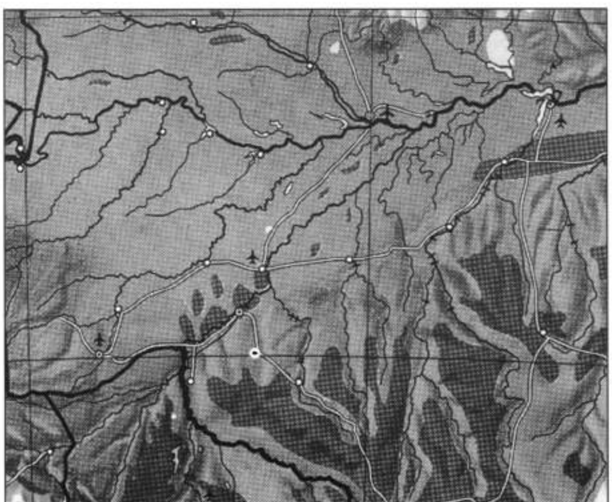


Fig. 2.143 Correct screen angles used in producing a four-colour map

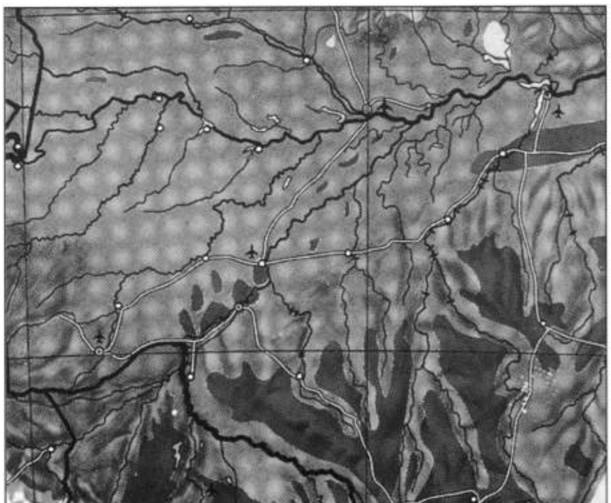


Fig. 2.144 Wrongly angled screens create visual disturbance and a moiré effect

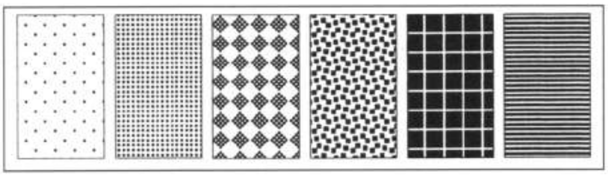


Fig. 2.145 Chaotic selection of patterns

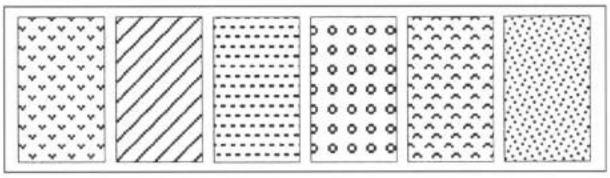


Fig. 2.146 Nominal scale with pattern of equal value

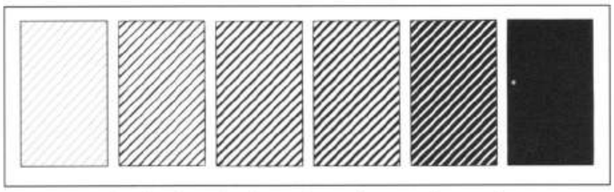


Fig. 2.147 Ordinal scale based on decreasing values only

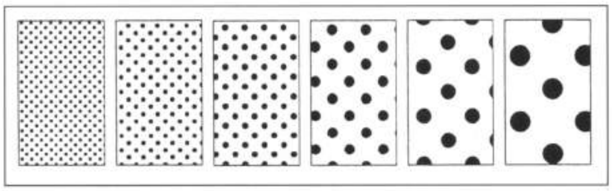


Fig. 2.148 Dot patterns forming an ordinal scale based on spacing only

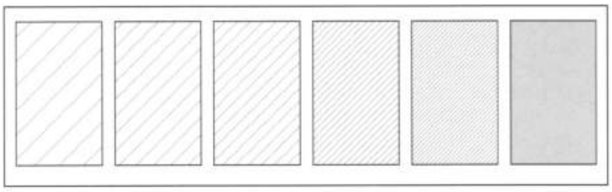


Fig. 2.149 Ordinal scale based on spacing only

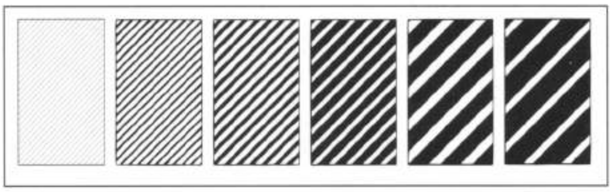


Fig. 2.150 Stepwise increase of spacing combined with a decrease of value improves the pattern identification and emphasises the effect of order

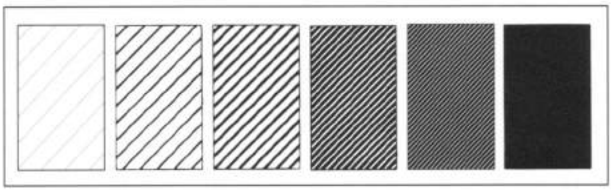


Fig. 2.151 Stepwise reduction of spacing combined with an increase of value improves the identification and strengthens the effect of order

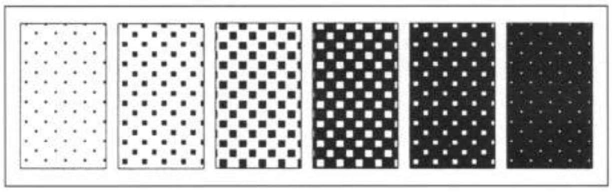


Fig. 2.152 Ordinal scale composed of 1, 4 and 9 pixels

others. However, it depends on each specific case as to which should be maintained. If it is necessary that the visual level of the patterns used in a particular map should be the same for all areas then the value of all shadings, and eventually the spacing, must be equal (Figs 2.146, 2.155 and 2.156).

For the easier discrimination of detail all other variables may be changed and combined. If only one graphic variable is modified the result may be somewhat monotonous (Figs 2.147 and 2.155), and cause problems in interpretation.

The design of a graded scale for ordered area shadings is primarily based on a sequence of different values or lightness (Fig. 2.147). To a certain degree a series of decreasing or increasing spacings can also produce an ordinal scale (Figs 2.148, 2.149 and 2.157).

Values can be combined with different spacings to improve differentiation (Figs 2.150 and 2.151). But any combination of these patterns with different shapes or forms reduces the impression of such a visual-order relationship (Fig. 2.157).

Software for graphic design often lacks functionalities that allow following of the above rules precisely, as it is illustrated by Fig. 2.145. Figure 2.152, showing six steps of an ordinal scale, is a rare exception.

The selection of pattern orientation is influenced by psychological factors. Figures 2.159 and 2.160 show a similar arrangement of area patterns. In Fig. 2.159 some hachures are vertically oriented, or are steeply inclined from top left to bottom right. These patterns are more visually disturbing than those which have been used to replace them in Fig. 2.160. Horizontal

Discordant patterns

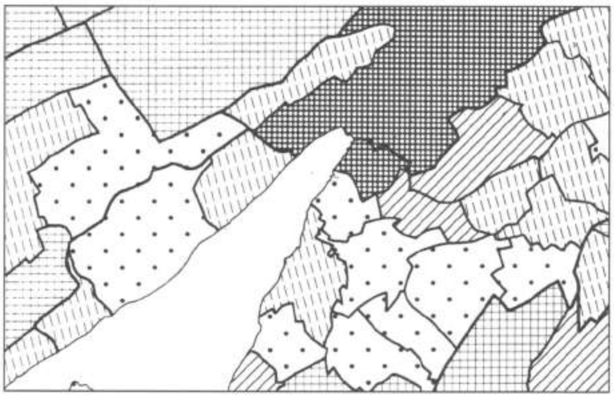


Fig. 2.153 Chaos: no order and all variables difference

Fig. 2.155 Different spacing but equal form, orientation and value resulting in monotony

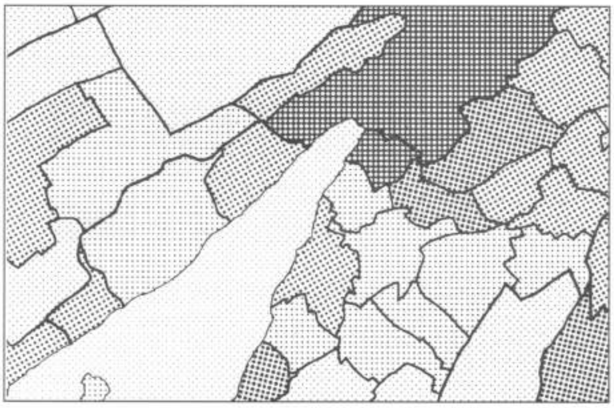


Fig. 2.157 Equal spacing and form but different orientation and values

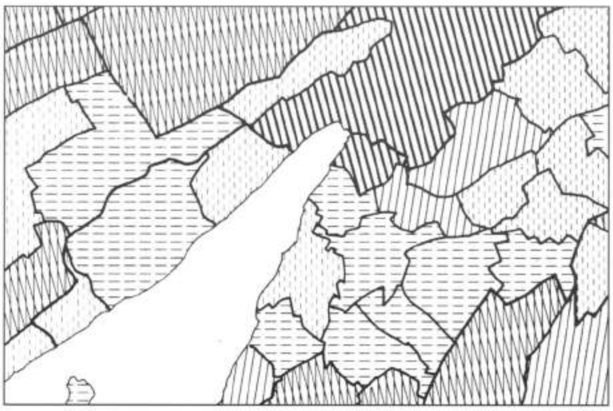


Fig. 2.159 Disturbing patterns resulting from the arrangement of steep hachures

Harmonious patterns

Fig. 2.154 Equal orientation and spacing achieved by using different forms and values

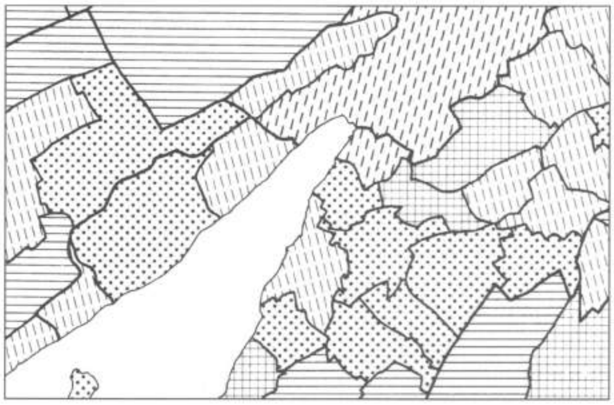


Fig. 2.156 Equal spacing and values but different forms and orientation

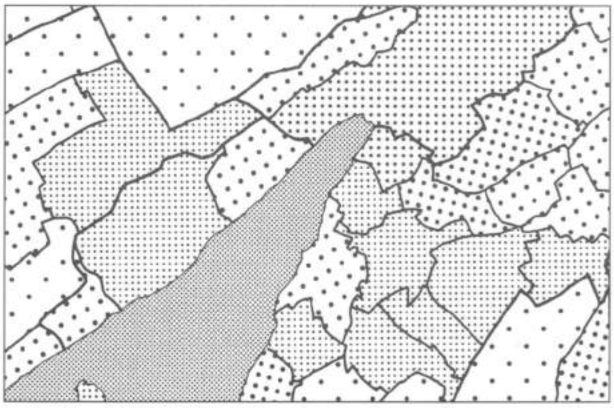


Fig. 2.158 Different spacing, value and orientation but equal form

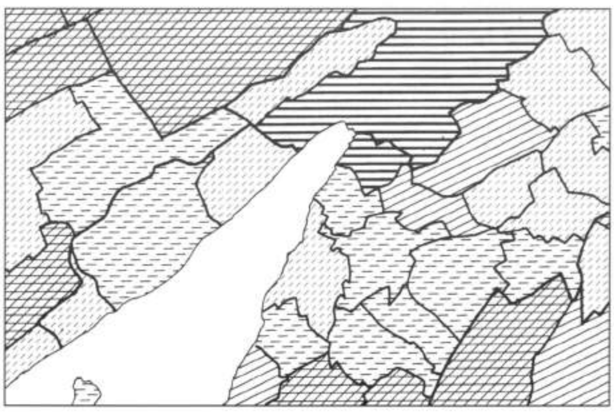


Fig. 2.160 Arrangement of patterns to minimise disturbing effects (no steep hachures)

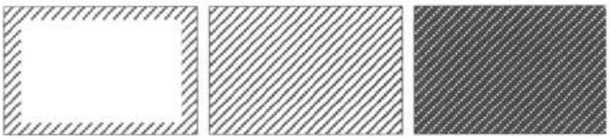


Fig. 2.161 Series of patterns with increasing certainty

shadings and hachures that are slightly inclined, and oriented from top right to bottom left, create a less 'noisy' impression. Selection of patterns can, therefore, be made according to the intended effect.

Area patterns may be used to express variable degrees of certainty as is illustrated by Fig. 2.161.

An area pattern can be organised on a regular grid basis, or have an irregular distribution.

In Fig. 2.162 three different grids have been selected for regular patterns. They are based on a square, a rhomboid and a 'comb' structure. For each type of pattern symbol a rectangular box is provided, which will include the symbol. Starting from such basic structures, in Fig. 2.163 irregular patterns have been incorporated. The latter may be essential in illustrating natural features and can give these areas a more life-like feeling.

The irregular pattern is created by a computer program. A random generator calculates, for each box, a small amount of shift around its position in the regular grid. The maximum amount of shift can be selected by a parameter, a given percentage of the regular grid interval.

If an area pattern is produced by conventional techniques using an 'open window' mask, or within a polygon in digital production, some incomplete symbols may be left as remnants along the edges (Fig. 2.166). These blemishes should be deleted (Fig. 2.167), or enclosed within an outline (Fig. 2.168), in order to avoid ambiguous map content. An ideal solution would be to distribute the symbols evenly over the area left for the pattern when sufficient hold-out is secured (Fig. 2.165).

The distribution of selected patterns must be adjusted to suit the complexity and fineness of area outlines (Fig. 2.169). Each indentation or projection of a boundary should be emphasised by at least two pattern elements so that every detail of the map content can be easily distinguished (Fig. 2.170), and in order that smoothed outlines allow the use of a coarser or darker shading on the other side of the line (Fig. 2.171).

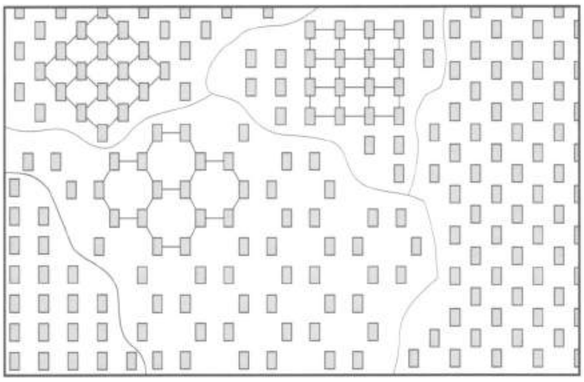


Fig. 2.162 Regular patterns based on three different grids

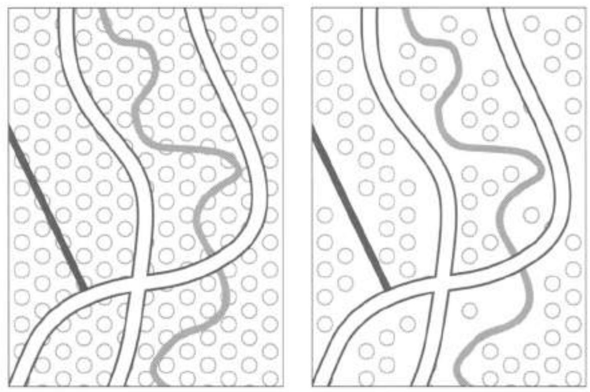


Fig. 2.164 Disturbing overlap of a regular tree pattern on minor road and river; symbols involved simply eliminated

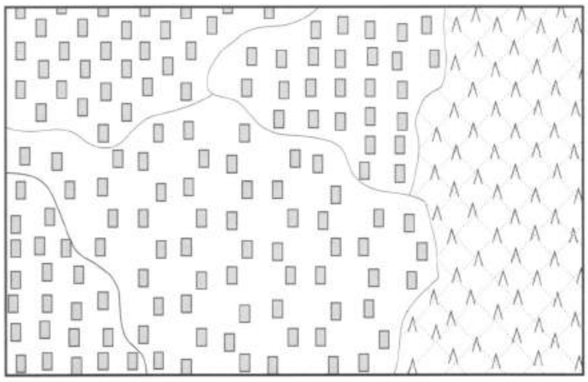


Fig. 2.163 Irregular patterns with moderate displacement of symbols

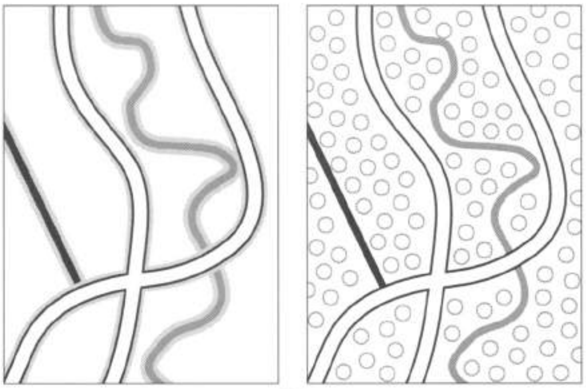


Fig. 2.165 Irregular patterns arranged within the areas that do not create conflicts

If grey tones can be allocated at will, small and regular areas should be shown by the darkest shadings (Fig. 2.172). The same is true for intricate or widely dispersed areal information (Fig. 2.173). Such a decision guarantees that these elements do not become lost within the larger surrounding areas, and that they can be perceived as a whole.

In a 'chorochromatic' map with a closed outline the small border areas, the most prominent parts within the boundary, should exhibit the darkest tones, whereas larger areas in the interior can be displayed with lighter shadings (Fig. 2.174).

2.21 Superimposition of images

Every component part of a map has its own image characteristics which relate to employed point symbols, linework, area patterns and tints, etc. If elements with similar qualities are superimposed this may result in problems of legibility. The use of identical graphic representation methods to illustrate two different items can lead to confusion as to which category a particular symbol belongs.

If a number of components are included in a map, special care must be taken to ensure that there is adequate graphic contrast between them. The best way to accomplish this is to employ different symbolisation for every category of information, so giving each its own specific image characteristics. Another method of differentiation involves the utilisation of dissimilar tonal intensities. Wherever possible these two techniques should be used in conjunction.

Experimentation has shown what normally no more than three components or images can be combined in a map without seriously affecting its readability. This rule has led to the creation of a 'model' relating to map detail superimposition. One of the components must occupy the foreground, a second the intermediate level, and the other the background. Another rule states that the most important information should always be located at the first level and in the foreground. However, this cannot be obeyed on every occasion because it may be in direct contradiction with one of the following graphic priorities:

- Dark symbols will always appear to be at the highest level and in the foreground.
- Coarse area patterns also appear dominant.
- Symbols with low colour intensities recede to lower levels.

Based on these facts the following rules can be formulated:

- Never use dark area tints when these have to be combined with other cartographic elements.
- Light area tints are recommended and will normally form the map background.
- Point symbols should preferably be allocated dark colours so placing them at the highest level.
- A reversed version of the rules quoted above may involve the use of very light points symbols positioned over a medium- or dark-toned area background. Such a departure from standard graphic practice may create a surprising effect!
- Coarse line symbols always dominate over fine line networks.
- Generally dark, or at least medium-toned, colours must be used for linework which will otherwise recede into the background. As an exception the rather special case can be quoted in which three elements, all symbolised by lines, are superimposed. This situation is further discussed in the next section of this chapter.
- It is impossible to superimpose two areas which are tinted and to maintain their separate identities. The only solution to this problem is to tint one of the areas and to use a pattern to distinguish the other.
- Coarse area patterns always appear in the foreground.
- The foreground and the intermediate level must, to some extent, be 'transparent'. If the background is overlaid by patterns that cover more than 20%, it will be practically impossible to read it (Fig. 2.175).
- A legend frame pasted over the map is not transparent, however, but hides a part of the map and is therefore not to be regarded as one of the three levels.

Figures 2.176 to 2.180 illustrate typical cases involving the superimposition of map elements.

2.22 Superimposition of line networks

In some instances the recommendations made in the previous section concerning the superimposition of point symbols upon line symbols, and of both point and line symbols over light area tints, cannot be followed because of the actual nature of the features being represented. For instance a river system and a communications network can only be depicted by linear symbols, and there are many other similar examples. In consequence, the combination of line networks illustrating different classes of information commonly occurs on all types of maps.

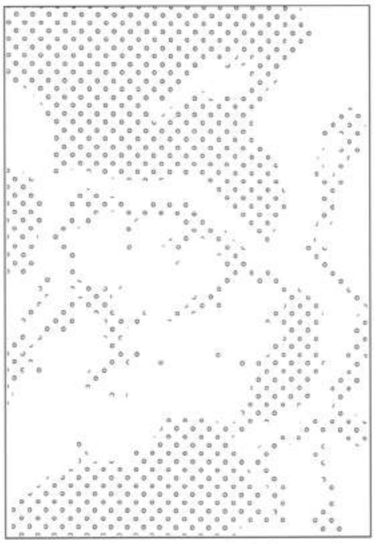


Fig. 2.166 Pattern copied through an open-window mask and leaving some incomplete symbols

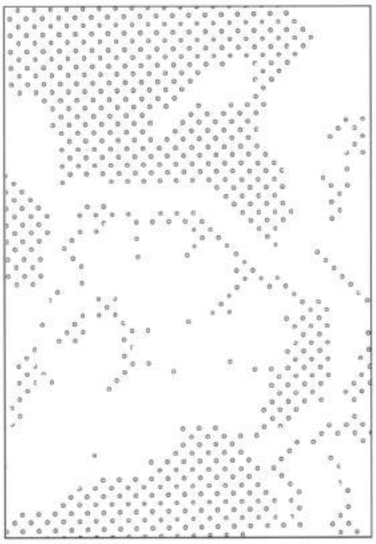


Fig. 2.167 Remnants removed during the copying process

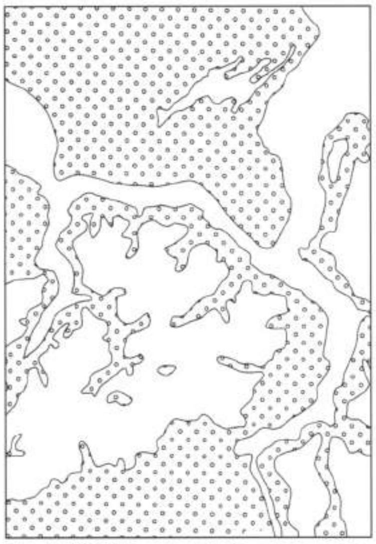


Fig. 2.168 No retouching necessary because of inclusion of area outline

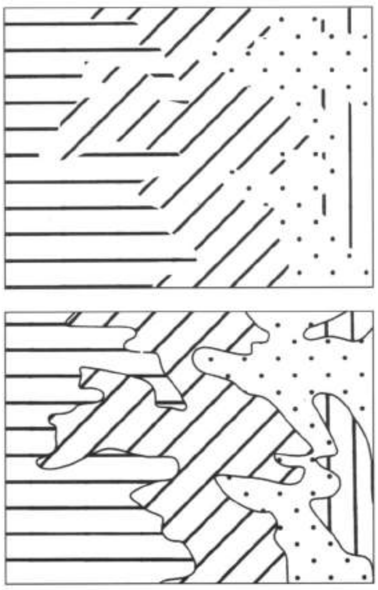


Fig. 2.169 Pattern spacing too wide for detailed outlines

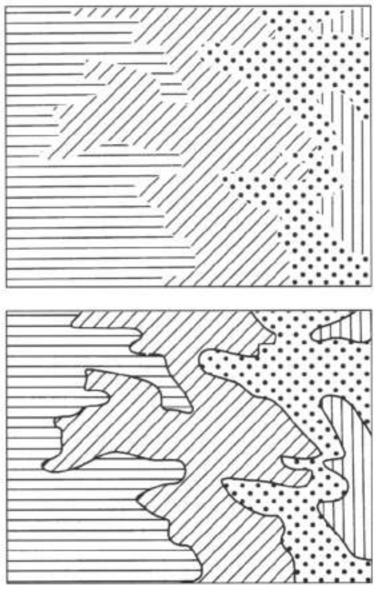


Fig. 2.170 Pattern spacing well suited to detail of outlines

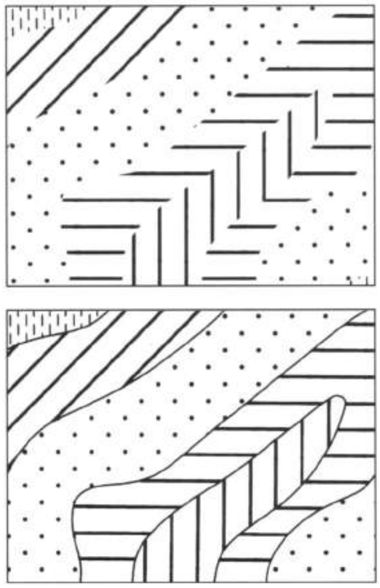


Fig. 2.171 Coarser patterning possible with smoothed outlines

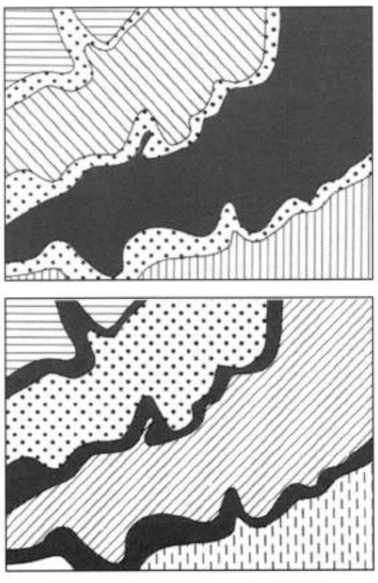


Fig. 2.172 A darker tone is recommended for small areas

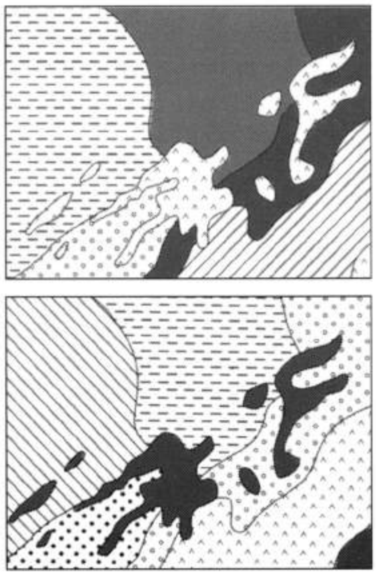


Fig. 2.173 Widely separated dark areas can be perceived as a whole

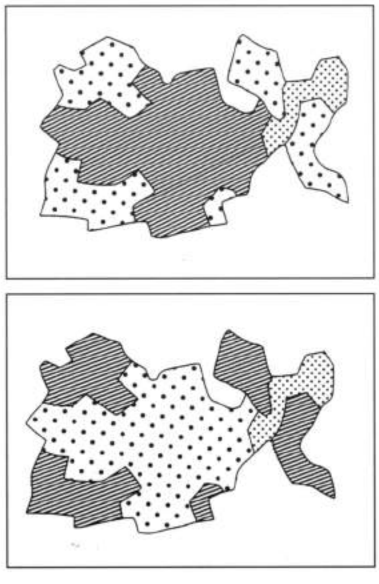


Fig. 2.174 Mosaic outline is emphasised by dark parts along border

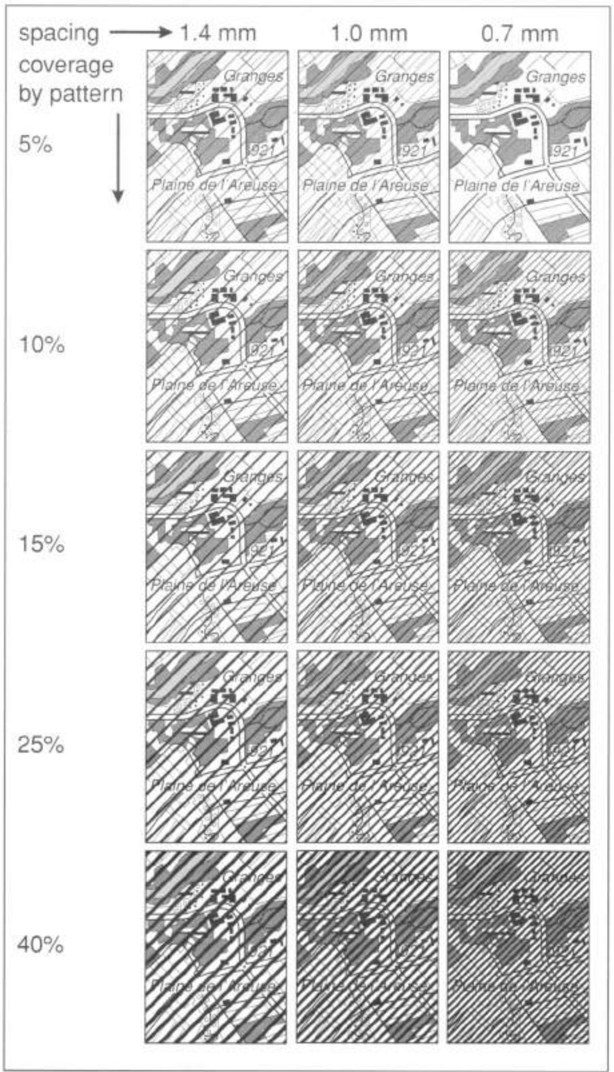


Fig. 2.175 Superimposed patterns must have enough transparency for the background image to be readable

If such symbols are superimposed they must be clearly distinguishable, one from another, or confusion can result (Fig. 2.181). The following techniques may be used to assist in the generation of contrast between lines which represent various phenomena:

- differences of width or weight (Fig. 2.182);
- use of different colours;
- variations in grey toning (lightness);
- changes in texture (Fig. 2.183).

In many cases dissimilarities in the characteristic structures exhibited by the complete line network create the desired contrasts. For example, such obvious differences between, on the one hand, an isoline pattern consisting of closed loops and with a degree of parallelism among the smooth lines and, on the other, the undulating and less regular structure assumed by a river system clearly result in visual variety in the symbolisation (Fig. 2.184). In order to make as much use as possible of these structural contrasts, the differences have to be emphasised rather than reduced or equalised when the individual elements are compiled.

If the superimposition of three different linear symbols is important, there is an alternative solution to the problem. One of the classes of information may be rendered by areal tints. To take an example – rather than using contour lines, hypsometric tints can be employed in association with the isolines representing other features. This technique is particularly appropriate if height information is included merely as an aid to orientation or as background detail (Fig. 2.185).

2.23 Topographic details at different levels

When two elements occupy the same position some confusion may be created. This is especially the case for boundaries that follow the midline of a river or a creek (Fig. 2.186). Depending on the map's purpose a decision has to be made as to which of the two elements priority should be given. When the boundaries are important the rivers are masked out. Overprinting is not recommended. On the other hand, the rivers can often function as a substitute for the boundaries. They are shown only as far as is necessary for a clear identification of the area surrounded by the boundary.

When two linear symbols cross, there is normally little space available for the inclusion of additional details. Consequently it is important that special attention is given to the representation of any such minor information. Having studied various examples, it would appear that the simplest solution is always the best!

As is illustrated in Fig. 2.187 the symbols used to show bridges can be used excessively. Bridge piers are given only for large bridges.

The depiction of crossings may become confusing to the map reader as a result of the inclusion of unnecessary information. In many instances the portrayal of too much intricate detail leads to problems during interpretation (Fig. 2.188).

The existence of a level-crossing is important, and the symbol used to represent it must not be confused with that for an underpass or overpass (Fig. 2.188). Straightforward solutions to these difficulties are illustrated in Fig. 2.189. No additional symbolisation is needed when two double line symbols cross. The underpass is masked out by the overpass.

As the cables of cable cars and chairlifts cross in the air over other map elements like paths, roads, etc., masking the latter out underneath is recommended. Skilifts may cross a road by means of a bridge (Fig. 2.190).

Three image levels: foreground — intermediate level — background

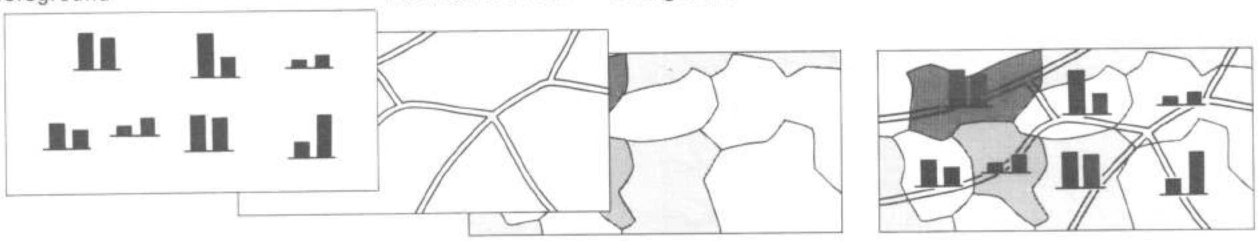


Fig. 2.176 Dark point symbols above — medium weight lines above — light area tints — Superimposition of all three levels

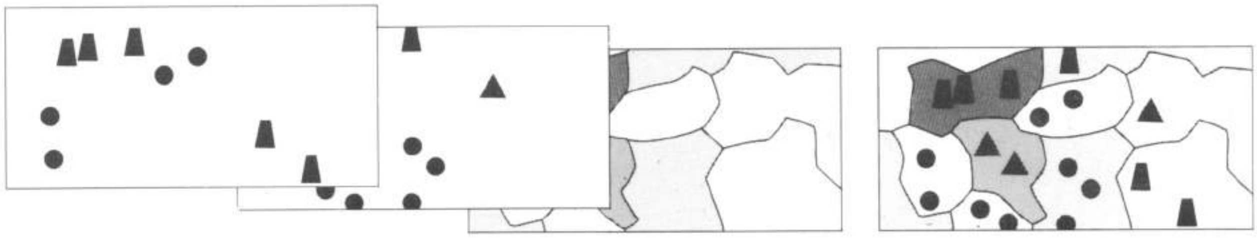


Fig. 2.177 Dark point symbols above — medium-toned point symbols above — light area tints — Superimposition of all three levels

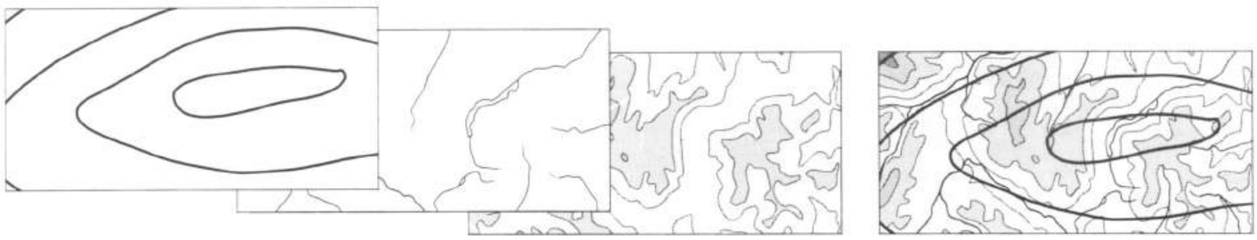


Fig. 2.178 Heavy weight lines above — a fine line network above — light area tints — Superimposition of all three levels

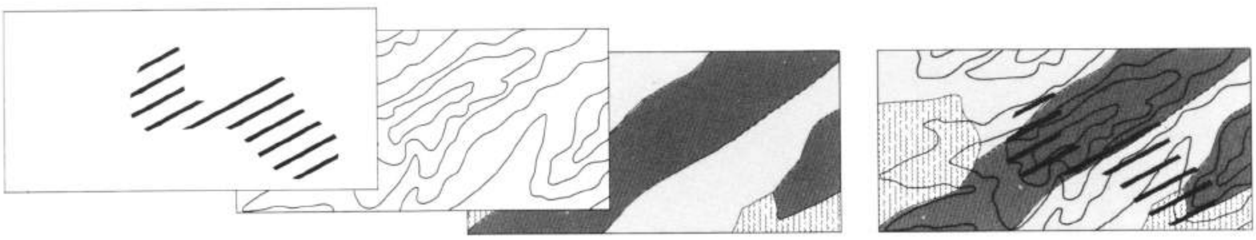


Fig. 2.179 Coarse area pattern above — a fine line network above — light area tints — Superimposition of all three levels

Fig. 2.180 Coarse area pattern above — light area pattern above — light areal tints — Superimposition of all three levels

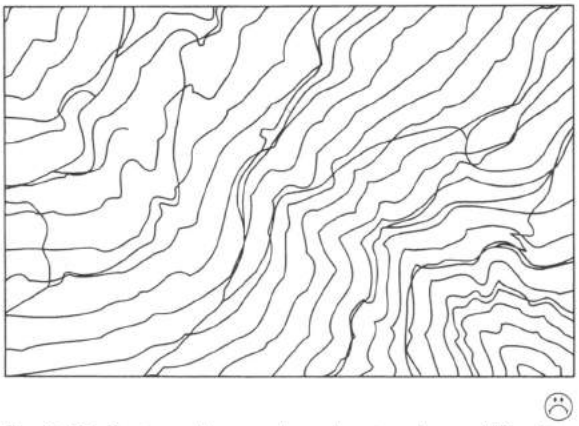


Fig. 2.181 Contour lines and road network are difficult to separate because of equal line widths

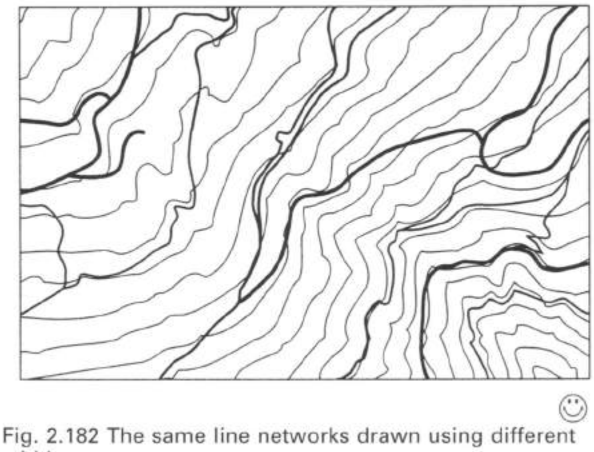


Fig. 2.182 The same line networks drawn using different widths

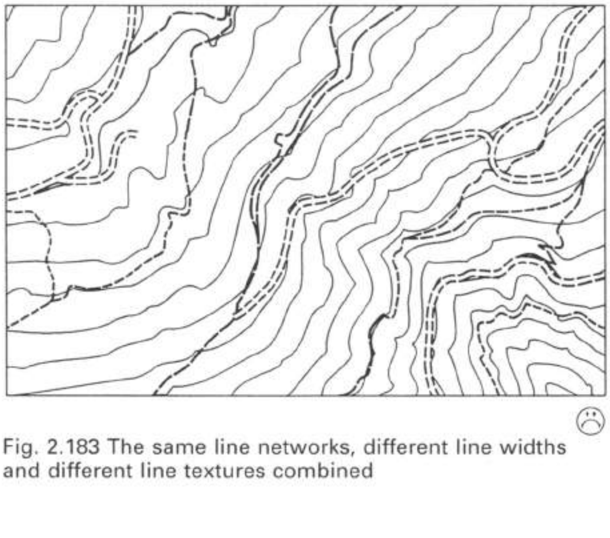


Fig. 2.183 The same line networks, different line widths and different line textures combined

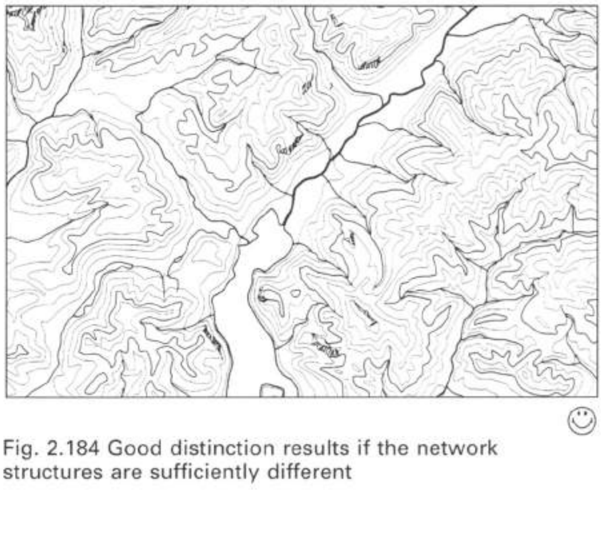


Fig. 2.184 Good distinction results if the network structures are sufficiently different

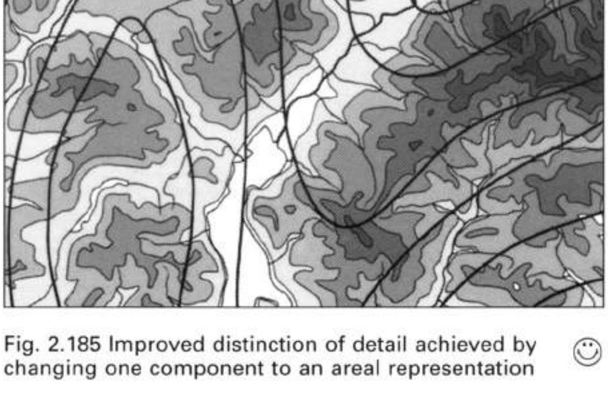


Fig. 2.185 Improved distinction of detail achieved by changing one component to an areal representation

2.24 Generation of image contrast

Map readers may often become confused as a result of the superimposition of identical, or similar, image structures: for example, the amalgamation of two sorts of dot symbols, crossing networks of lines, or contours superimposed upon an area pattern, etc. If the structures of the distributions of two separate features are relatively uniform, or if similar techniques are used to represent two or more phenomena, the resultant composite image can create an impenetrable jungle for the user (Fig. 2.191) as the individual details cannot be distinguished easily. However, the principles which are suggested below can help the cartographer avoid potentially disastrous results:

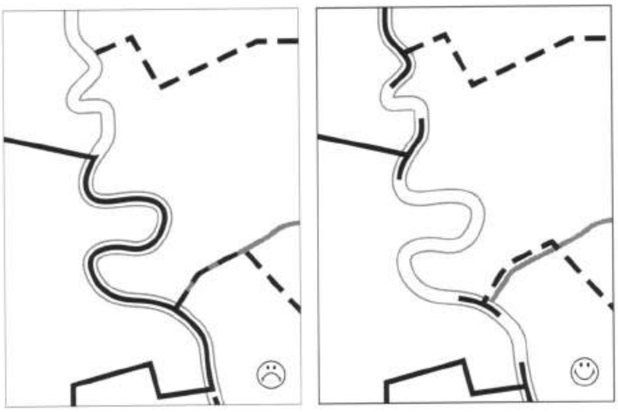


Fig. 2.186 Overlap of boundaries and rivers; often the river can function as a substitute for the boundary

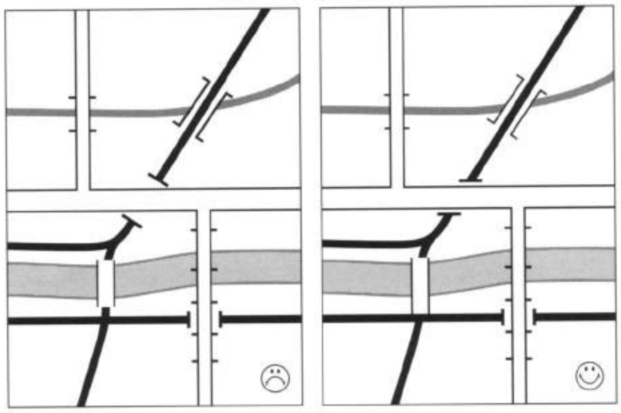


Fig. 2.187 Too much detail in connection with bridges and a solution with just the necessary minimum

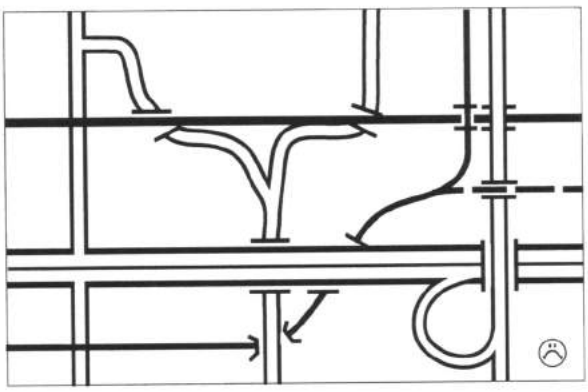


Fig. 2.188 Road and railway crossings at different levels; inspite of intricate details much uncertainty is left

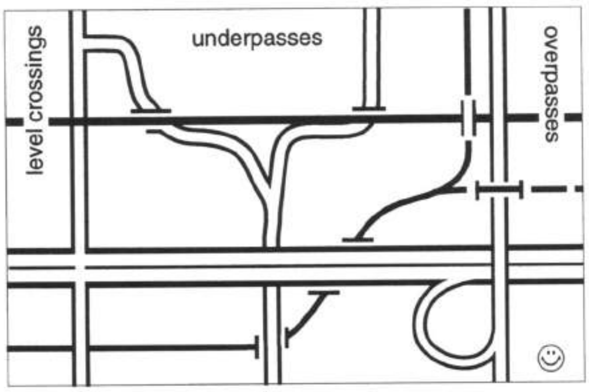


Fig. 2.189 Improved version with as few annexes as possible

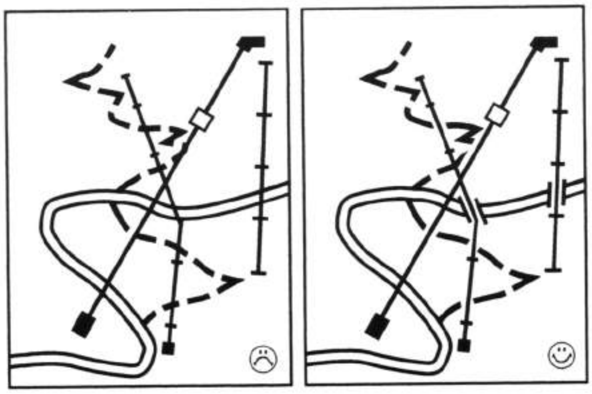


Fig. 2.190 Cable cars and skilifts crossing paths and roads; the element below is masked with a small gap

1. Every map component must be allocated to its own image level. The most important element should be shown at the highest level, and emphasised by the use of a relatively coarse texture. Less important details are made to appear as background by the use of softer screen patterns, finer lines and lighter tones.
2. The graphic techniques utilised must generate as much contrast as possible between the included details. This can be achieved by specifying distinct differences of line widths, tones and shapes, together with related complementary colours and textures.
3. Characteristic differences in the image structures must be emphasised. Thus the regular lines representing hydrography contrast favourably with the more uneven courses of boundary lines, and the simple geometry of diagrams.
4. Any disturbing superimpositions still remaining among the graphic elements must be graphically modified. For example, solid or dark coloured lines should be broken wherever they cross names or text, etc.

Figures 2.193 to 2.198 represent population changes over a ten year period. The effectiveness of the graphics has been increased by improving the contrast from figure to figure:

- In Fig. 2.193 the same line weight has been used to illustrate all details.

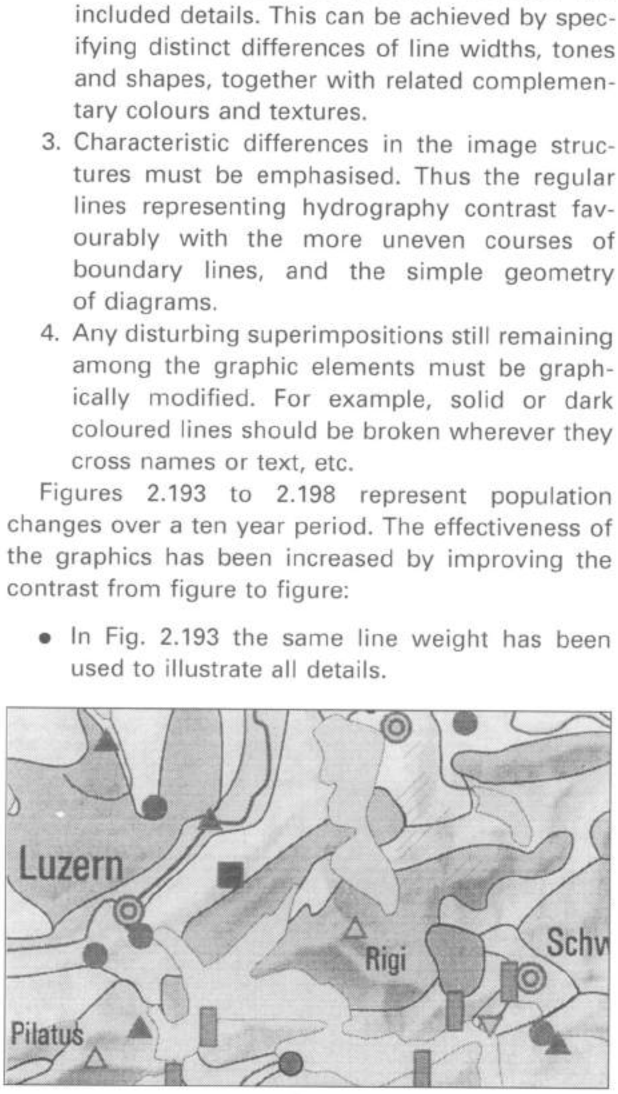


Fig. 2.191 Map images lacking contrast between the different elements

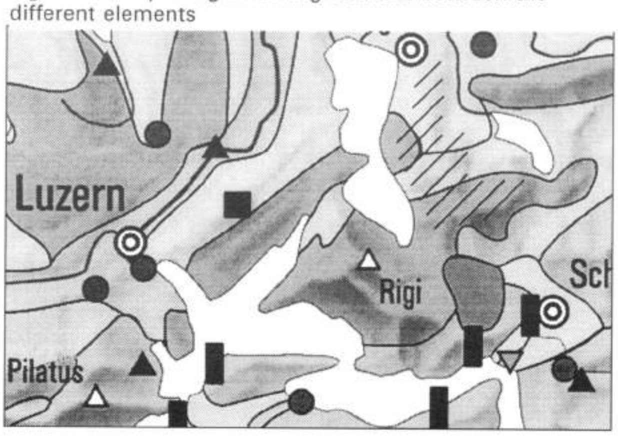


Fig. 2.192 The same map content, contrast considerably improved

- Legibility can be slightly improved by employing three different line weights (Fig. 2.194).
- Figure 2.195 demonstrates the establishment of strong tonal contrasts to illustrate the topic.
- The subduing of line symbols by using area shading improves the situation, but the patterns chosen are too similar (Fig. 2.196).
- Figure 2.197 employs black diagrams against a grey background. Lakes are left white, and different line thicknesses are used to show rivers and boundaries.
- In multicolour mapping it is easier to generate contrast and separate the various components and classes. For example, the use of solid blue for rivers; light blue for the lakes; brown for administrative boundaries; and a contrasting colour with easily discernible steps from light to dark for the classes of population information. If, as here no colour is available, variations of pattern must be used (Fig. 2.198).

2.25 Overlap of map symbols

In thematic mapping it is not uncommon for graduated symbols or diagrams to overlap one another in areas of heavy detail concentration. In order to overcome the resultant difficulties, it is first of all necessary to adjust the size of the symbols so that the map as a whole shows a balanced image density. According to Bertin, the percentage darkness created by the figures should amount to between 10% and 15% of that of the total map surface.

In high density areas there may be an abundance of symbols that have to be placed without ambiguity. An example of such a case is the extract of an economic atlas map (Figs 2.199 and 2.200). Whereas the line geometry allows only for minor moves, there is more flexibility for the point symbols. On a display they can be easily selected, moved and stacked.

The distribution of symbols within an area will vary considerably from map to map. It is therefore recommended that the compiler makes a decision concerning the visual optimisation of the scale of the figures based on a series of experiments. Computer-assisted editing techniques, employed in combination with a high-speed verification plotter, are particularly useful during this test phase.

Figures 2.201 to 2.208 demonstrate techniques by which the overlapping of symbols can be minimised to an acceptable degree. In Fig. 2.201 the available map space has not been fully exploited, and the symbol scale should certainly be increased. This computed image has not been edited before plotting. On the other hand, the scale used in Fig. 2.202 is much too large with the result that more than half of the map area is covered with symbols. In many instances the overlap of the diagrams is so complicated that individual symbols can scarcely be visually separated.

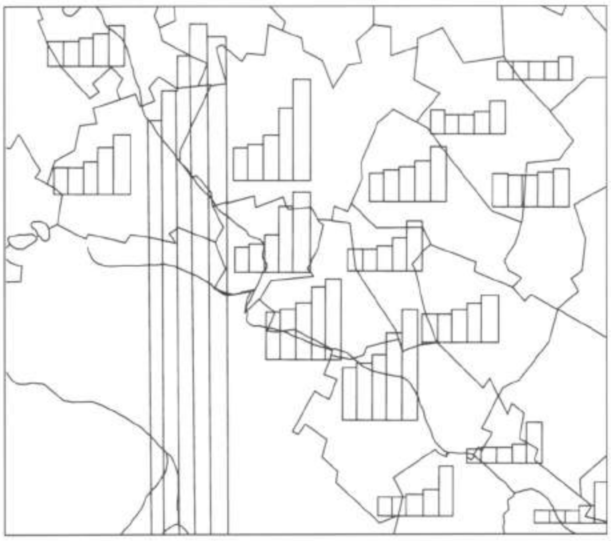


Fig. 2.193 User of a standard line weight, and complete overlap of all three components

Fig. 2.194 Contrast improved by using different line weights

Fig. 2.195 Bar graphs emphasised and raised above the background

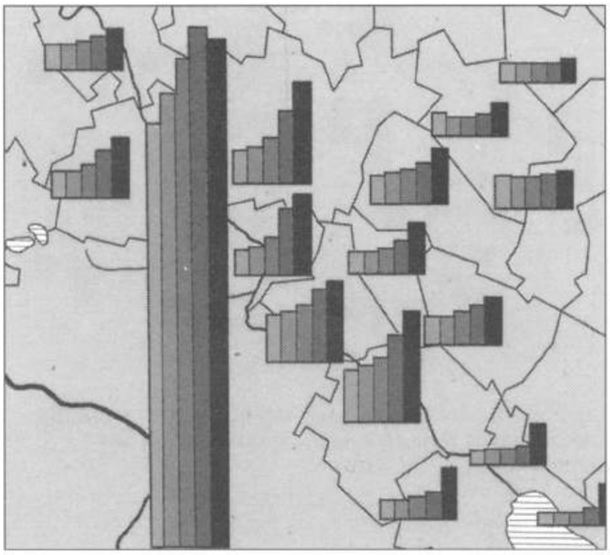


Fig. 2.196 Comparison of individual bars easier. The three components are at different levels

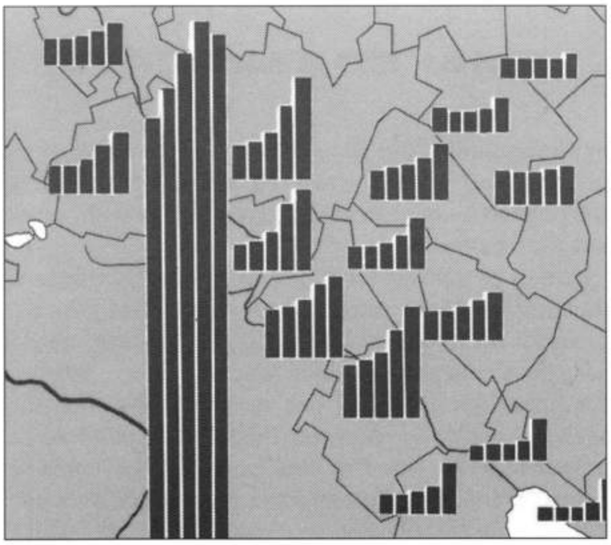


Fig. 2.197 Use of black graphs to achieve maximum contrast with the background

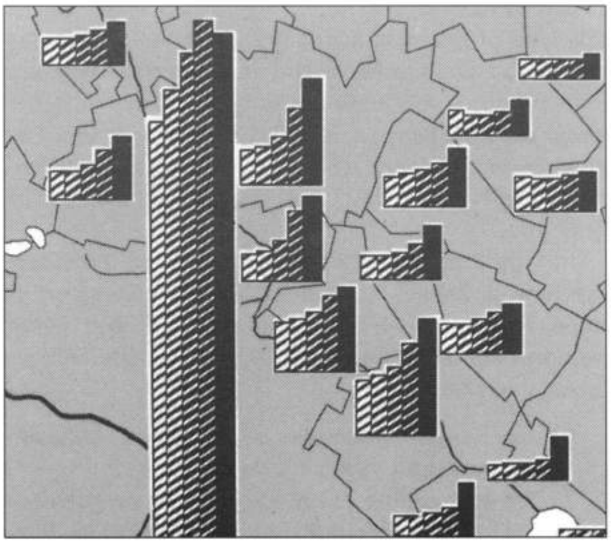


Fig. 2.198 Coarse patterns, or a relatively dark range of colours, used to emphasise graphs in the foreground

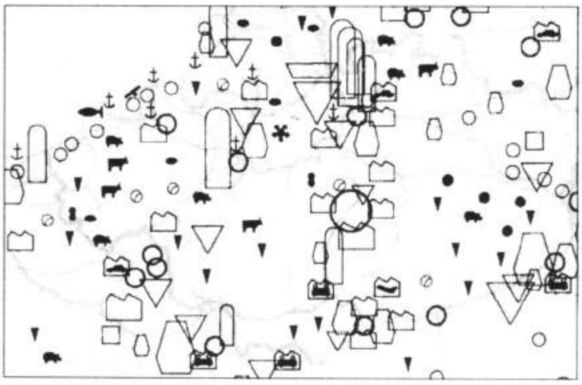


Fig. 2.199 Overlapping line and point symbols on a draft for an economic map. The symbols have to be moved to ensure identification of each symbol

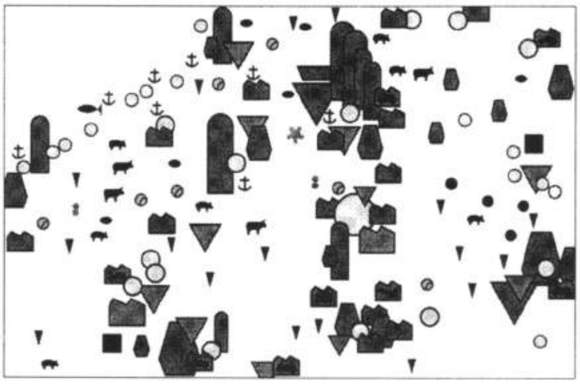


Fig. 2.200 Symbols have been slightly shifted, regrouped and overlayed to enable easier discrimination and identification

A well-balanced symbol scale has been used in plotting (Fig. 2.203, but there are still a number of awkward overlaps. A normative rule employed in this type of situation states that the smallest devices should be positioned in the foreground. They are then progressively underlayed by symbols of larger sizes, with the biggest forming the background. For illustrative purposes these priorities are demonstrated in Fig. 2.204 by using decreasing densities of grey tone.

In Figs 2.201 to 2.205 the location of individual symbols is always consistent and their neighbourhood configuration is, in consequence, somewhat random. As a result a number of details remain unsatisfactory:

1. Very small intervals or overlaps between symbols are graphically bad.
2. The butt-joining of outlines should be avoided.
3. The relative positions of some symbols may often be slightly modified without causing problems of orientation.
4. Complete series of overlapping symbols should be arranged in the same order.
5. Excessively large symbols may ultimately be represented by using a lighter tone.

In Fig. 2.206 the necessary steps have been taken to improve the overlap situation and to remedy the defects quoted above. The devices have been graphically separated by superimposing a heavier outline positive on the open window mask for the symbols. Hidden sections are mentally completed and the figures seen as a whole.

The pie diagrams shown in Fig. 2.207 overlap in such a way that their most essential segments are partly hidden. First, priority must be given to creating an order that allows the precise identification or estimation of the size and character of a symbol (Fig. 2.208).

2.26 Superimposition of map lettering

It is essential that all of the names included on a map should be completely legible, and that there should be no question as to the way in which they are spelt. Individual letters must be easily distinguishable, although certain characters are very susceptible to interference from neighbouring details which can affect their readability.

Diacritical marks such as accents and hyphens are especially vulnerable in this respect, as are also the letters 'o' and 'l' which can easily become confused with other map symbols.

At this point it is necessary to reiterate an important graphic rule – that words are read with particular reference to the shapes of the upper elements of their composing letters:

In consequence, the shapes of the upper parts of all geographical names must be especially carefully maintained and protected from overlap with other included symbols.

When producing town plan it frequently happens that names come into contact with street casings, possibly on both sides (Fig. 2.211). Because, in the case of a relatively straight road, an interruption of the linear symbol does not seriously influence the reader's ability to interpret detail, it is possible to emphasise the name of the feature. Thus lettering can be clarified by deleting linework detail. This can be achieved by using a 'stop-out' mask which involves the employment of the reprographic technique described below.

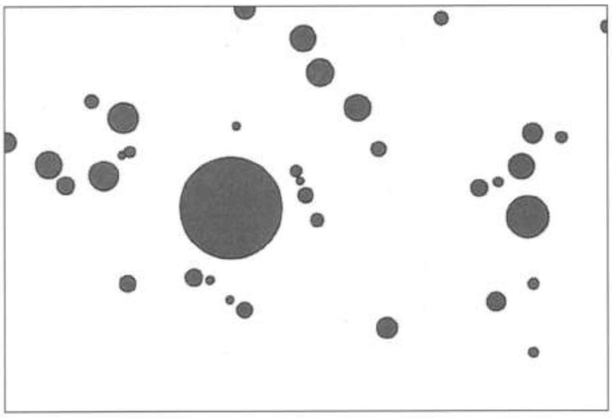


Fig. 2.201 Symbol scale for graduated circles too small ☹

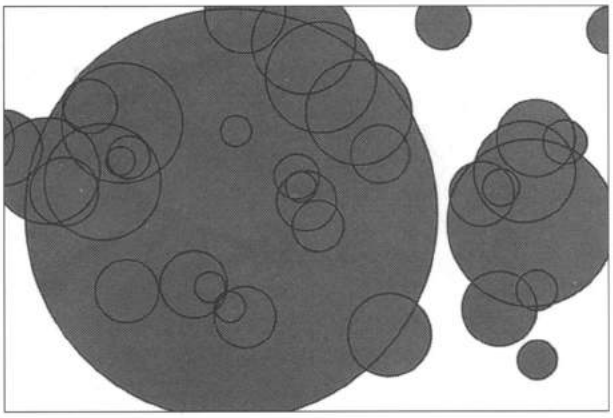


Fig. 2.202 Symbol scale too large resulting in many overlaps ☹

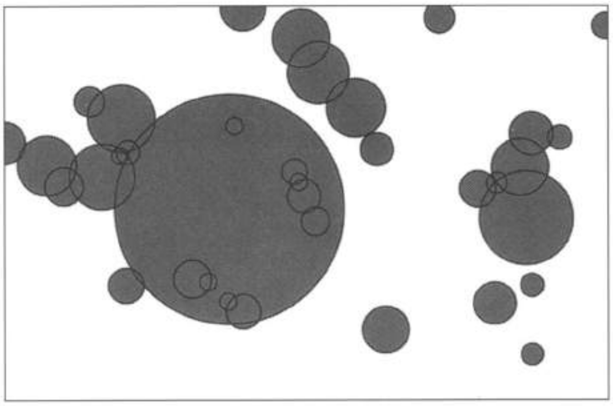


Fig. 2.203 Well-balanced scale, but some overlap problems remaining ☹

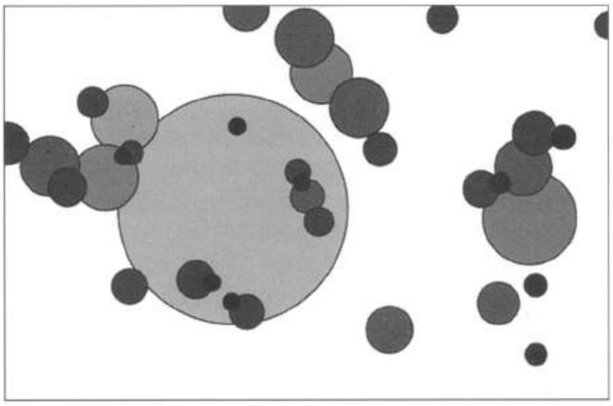


Fig. 2.204 Visual priority given to smaller symbols ☹

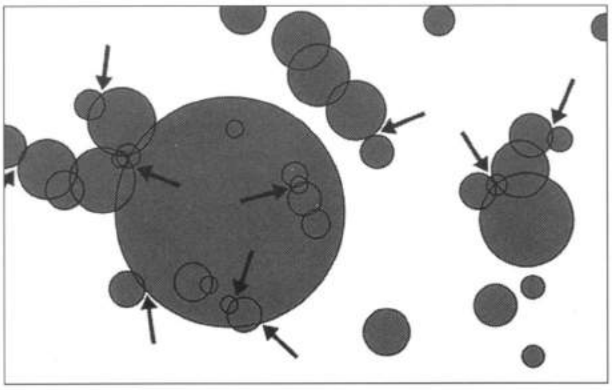


Fig. 2.205 Areas demonstrating problems of interpretation ☹

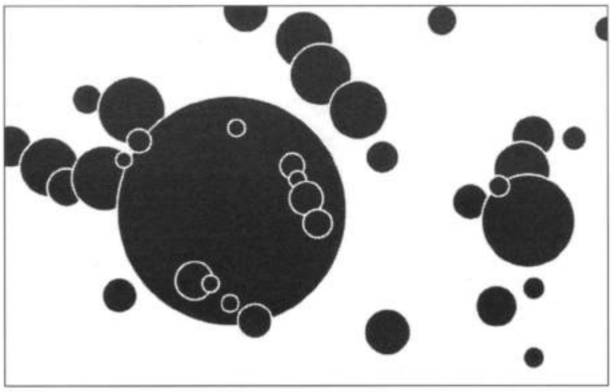


Fig. 2.206 Difficulties overcome by repositioning of symbols and ordered overlaps ☺

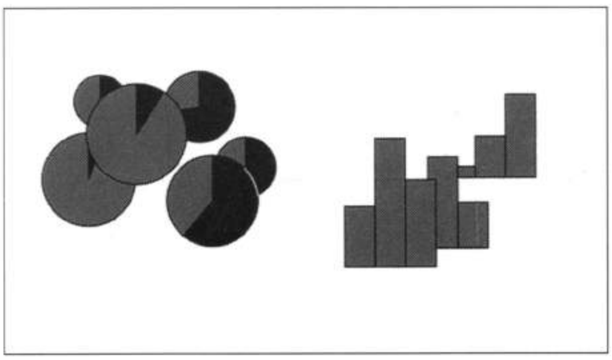


Fig. 2.207 Pie diagrams and bar charts which are liable to misinterpretation ☹

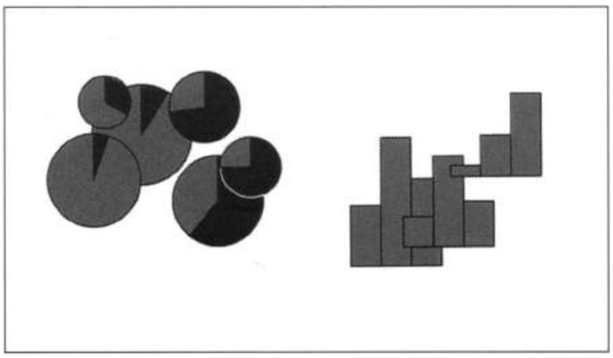


Fig. 2.208 Modified overlap priorities allowing unambiguous interpretation ☺

Fig. 2.209 Photomap overlayed with black names is partly illegible

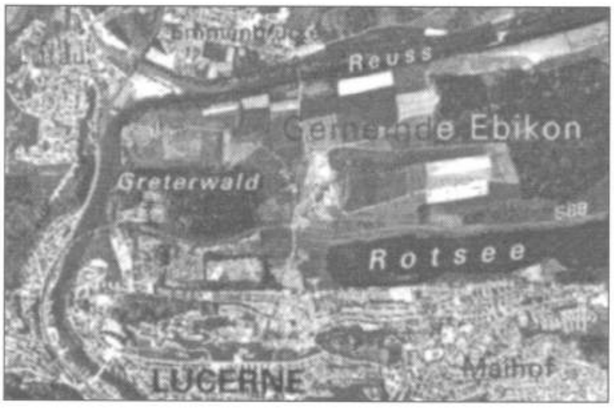


Fig. 2.210 Same photomap with negative names or white outlines

Using the nameplate positive (Fig. 2.212) an in-contact negative is produced. A positive is made form this by employing a diffuser to scatter the light between the negative and a new piece of film. This results in the production of a thickened positive of the names (Fig. 2.214), which can be used as a stop-out mask for the planimetric detail (Fig. 2.213). There are several such masking functions also available in digital techniques.

The positioning of geographical names must be related to specific locations as is described in the rules concerning placement described in the next section of this chapter. However, there is a certain amount of tolerance within which a name may be located with respect to its theoretically ideal situation. This degree of freedom must be employed to optimise the overlapping of other map details.

Fig. 2.211 Overlap of type and street casings affects name legibility ☹

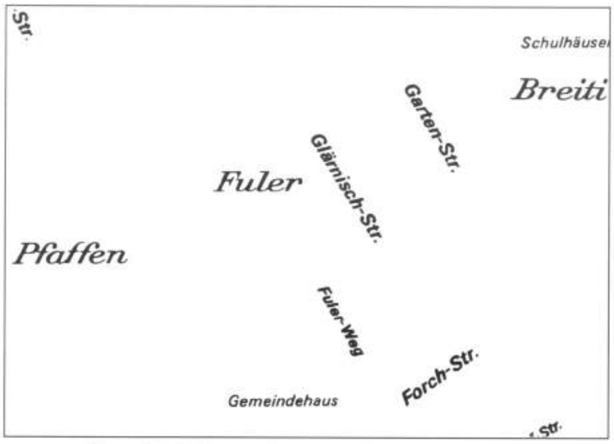


Fig. 2.212 Nameplate positive of this map

Fig. 2.213 Planimetric details deleted under names to enhance their legibility ☺

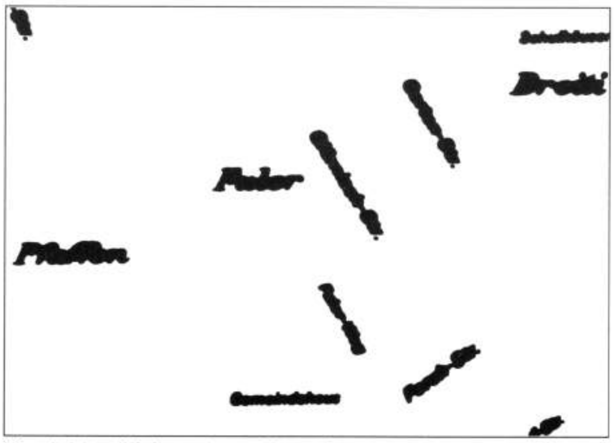


Fig. 2.214 Thickened positive of nameplate for use as a stop-out mask

In Fig. 2.215, names have been positioned merely with regard to the rules of placement that ensure that non-controversial referencing is guaranteed. As a result there are undesirable type overlaps with roads, rivers and railways which render some of the names virtually illegible. This is particularly evident if the positioning of a name results in the intersection of characters with an acutely angled thick line, so creating a situation in which a number of letters are interrupted. In Fig. 2.216 an improved name placement has been attempted in order that, wherever possible, lettering crosses linework perpendicularly and has an appropriate offset from neighbouring elements. Details have deliberately been placed at an optimum distance from related symbols, and names have been positioned in order not to follow lines, but rather to be above or below them.

Considerations cited above become less important if names are to be printed in black, or another dark colour, especially if other map elements are to appear in light- or medium-toned colours. In this case an adequate contrast is created between names and all other included details (Fig. 2.217).

Figure 2.218 illustrates how names can be incorporated with very dense map detail which is of an equivalent level of greyness. Spot heights and mountain names have been directly rotated to graphic relief depiction.

Special problems arise with lettering on photomaps as is illustrated by Figs 2.209 and 2.210. Aerial photographs should be shown with as much contrast as possible; dark tones for hydrographic features and woodland and light ones for roads and fallow land. Black colour used for the names is therefore hidden by the dark parts of the image. An occasional change to white is problematic, and white outlines do not really provide a solution.

2.27 Name placement

The appropriate positioning of names is essential to ensure the unambiguous identification of all of the labelled map elements. In consequence, the production of the lettering manuscript must be undertaken with great care. The subsequently listed rules

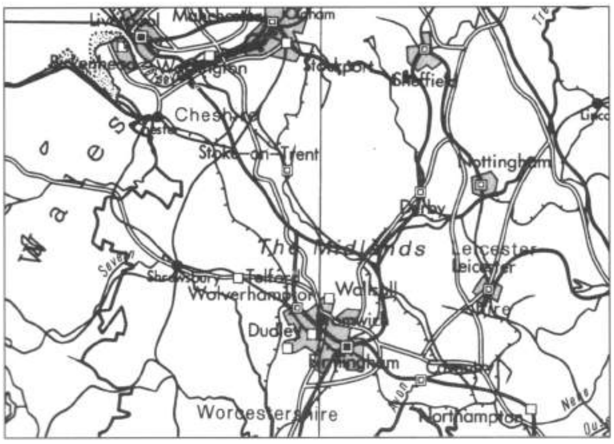


Fig. 2.215 Excessive overlap of names and line

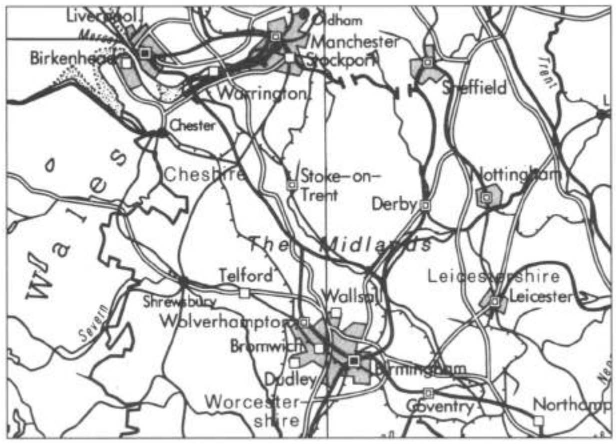


Fig. 2.216 Improved positioning of names to avoid

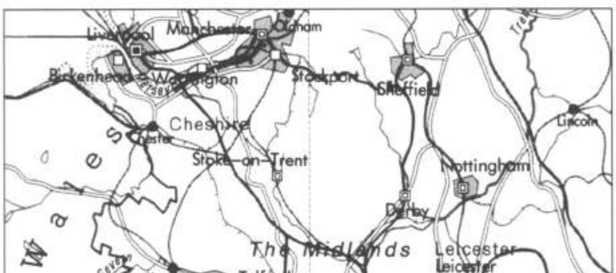


Fig. 2.217 Overlaps are less of a problem if black names are superimposed on medium-toned colours or screened detail

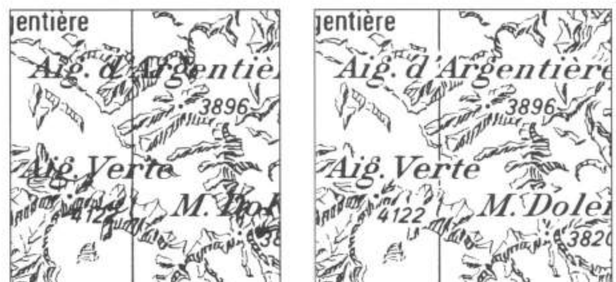


Fig. 2.218 Lettering used in areas with a high symbol density must be carefully integrated

relate to the principal factors which should be considered by the map editor in the compilation of the names manuscript, and by the cartographic draughtsperson during the eventual patch-down of the type. Figure 2.219 illustrates some of the most common mistakes, and the included numbers relate to the comments made below. In Fig. 2.220 the considered placement of names has been organised according to rules relating to the optimisation of positioning.

Comments on the various factors necessarily considered:

1. This name has been positioned with respect to an approximately horizontal straight line – this is graphically undesirable! Wherever possible names should follow genuinely horizontal lines accurately, as the human eye is aware of even slight deviations. The use of a regular grid is recommended as a guide.
2. The name is located with insufficient space being allowed between it and the related symbol. It is advisable that there should be the equivalent of a least half an upper case character space between a name and a symbol.
3. Placement has ignored the potential usefulness of the silhouette of the name because of the employment of lower case lettering.
4. Reference between the symbol and its associated name is ambiguous.
5. The ideal position of a name referring to a point symbol is on its right, but not on the same horizontal line.
6. This type has not been positioned in the area to which the names pertain. Wherever possible names should be located within the territory to which they refer, or on the appropriate side of a river or boundary line.
7. These names have been placed directly on top of the line to which they relate. This interrupts the letters and makes them difficult to read. Sufficient space, at least half of the size of a lower case letter, should be allowed between the bottom of a name and its associated line symbol.
8. Names and numbers must not be positioned on sharp curves, but rather where the shape of a feature is relatively smooth.
9. Words incorporating characters which reach below the normal base line (for example, g, p, q and j) should be positioned where bends in a line symbol make their placement appropriate, or alternatively be placed below the line. This is especially important in the case of straight lines.
10. In areas which are congested with quantities of names and symbols, particular care must be taken to ensure unambiguous identification. This is best accomplished by arranging names around the highly detailed area rather than attempting to incorporate them in it.
11. Names in this part of the map have not been adequately centred, and consequently do not extend over the full area to which they should refer. Whenever possible such names should stretch over approximately two-thirds of the territory to which they relate, and serve as a central axis for the region.
12. The use of curved type is unnecessary in these areas. Names referring to areas should normally be placed horizontally in order to simplify their reading.
13. The spacing of the letters comprising these names does not relate naturally to the size of the individual characters. It is essential that the letters forming a name or title can be read and appreciated as a whole. If necessary the size of the type must be increased to enable this to occur.
14. These names have not been positioned with respect to a regularly curved base line. The user's eye will experience difficulties in attempting to reassemble the complete words. Curved lettering, whether or not it is spaced, should always be arranged along a regular base line. This can be experimentally sketched onto the manuscript before the characters are positioned.
15. The intersection of names at narrow angles always results in confusion for the reader. When, of necessity, two names have to cross they should be at as near to a right angle as possible.
16. Type relating to an area, and having a straight base line, should never be positioned at an oblique angle. Horizontal placement, or the curving of lettering, is always preferable.
17. These names have been unnecessarily hyphenated and displayed on separate lines. In consequence it becomes difficult to read the name as a whole.
18. Wherever possible names should read from the middle of the bottom edge of a map, and not be oriented towards the other edges.

Digital techniques have alleviated name placement difficulties considerably. Once the name is composed, according to the desired font and size, it can be moved around quite easily and located in the optimum position. Specialised software even allows scaling of the length of the name and its bending along a curved base line.

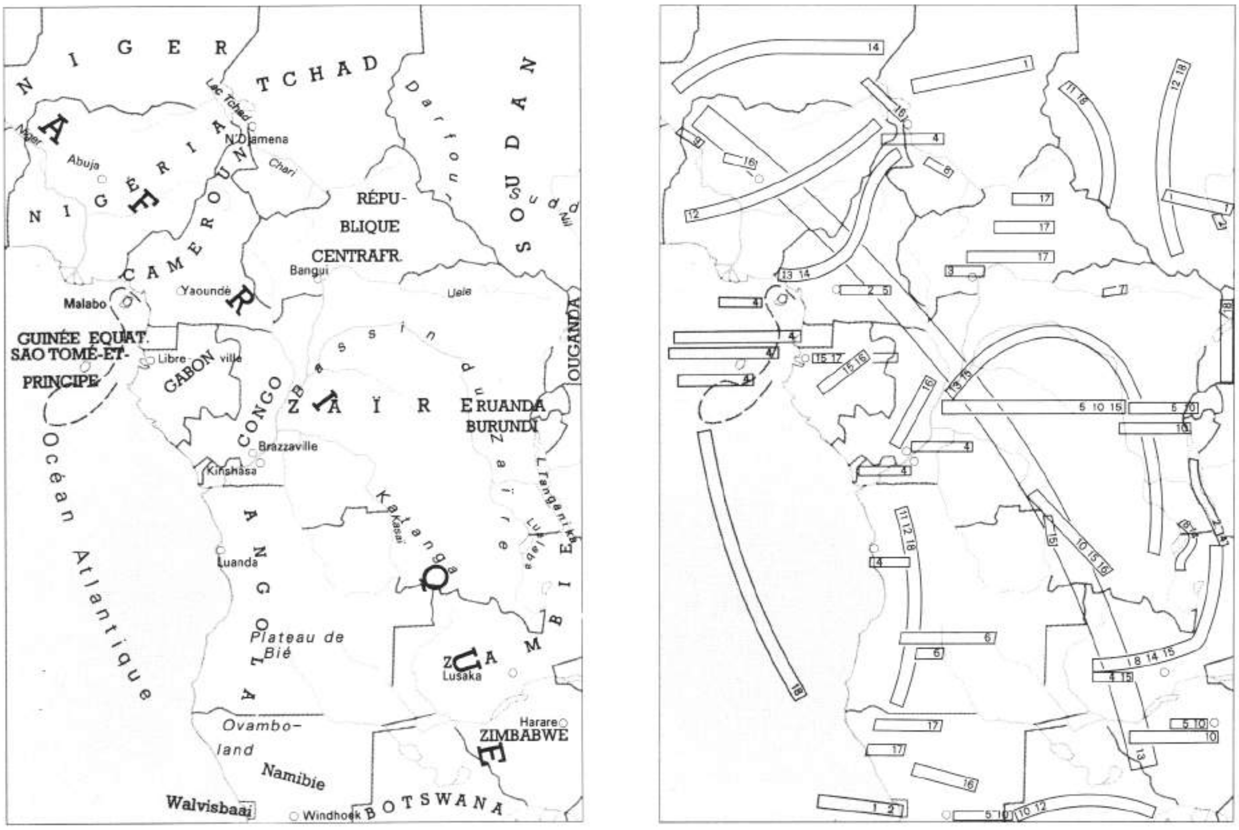


Fig. 2.219 Examples of poor name placement. Included numbers refer to the corresponding comments in the associated text

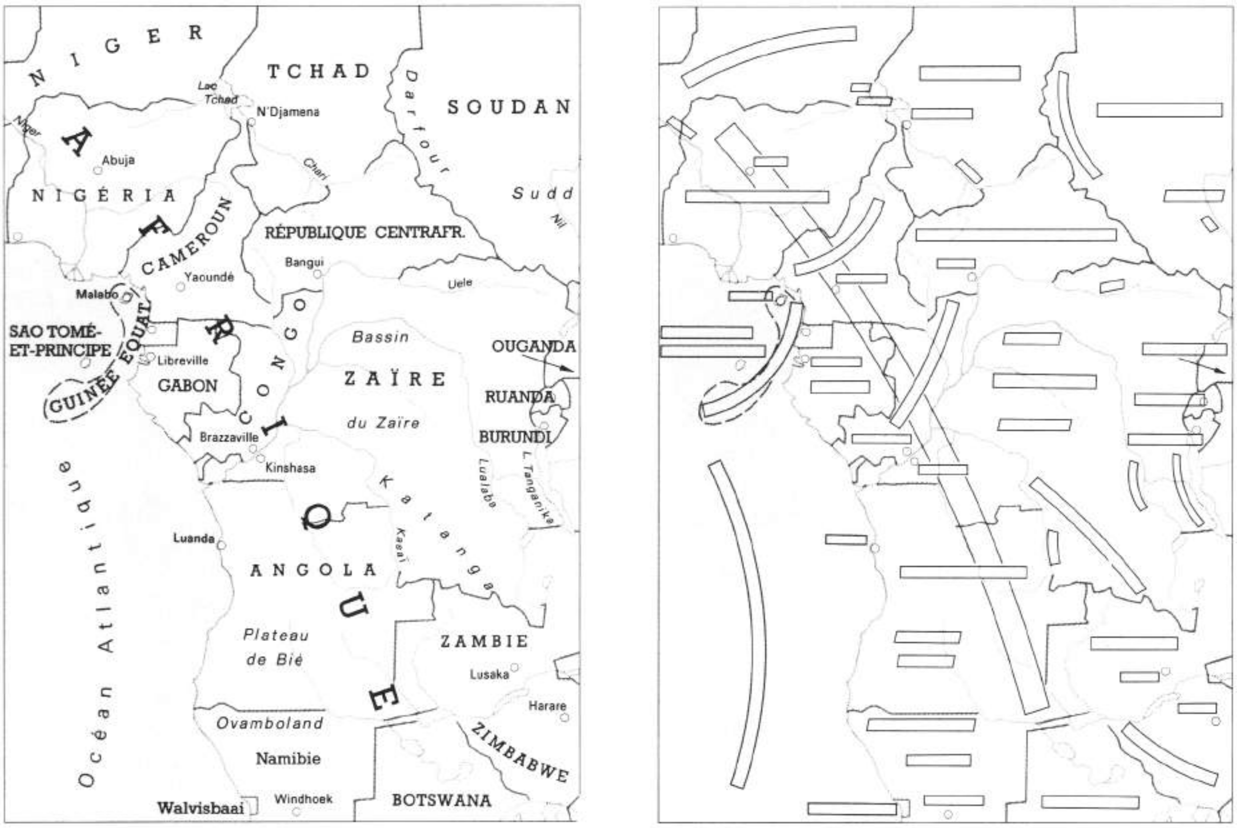


Fig. 2.220 Improved name placements

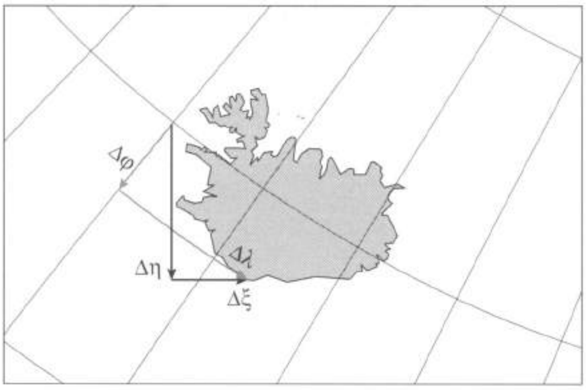


Fig. 2.221 Rectangular coordinates of the detail in the source map are the basis for the transformation

Fig. 2.222 Database with transformed data in latitude and longitude units

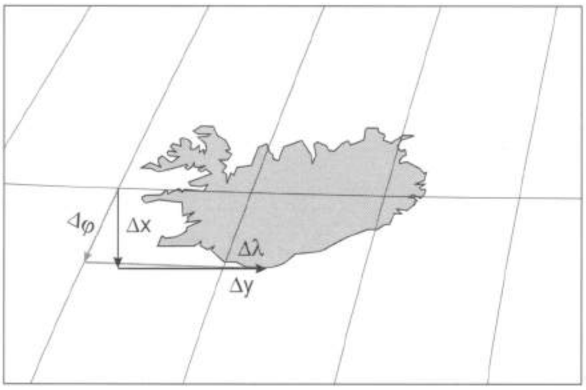


Fig. 2.223 Above data transformed onto another projection

2.28 Map projection transformation

In small-scale mapping the compilation of detail onto a specified projection may prove both difficult and time consuming, particularly when source data presented on other projections have to be incorporated. Not only the scales but also the graticules may be quite different from that of the compilation, thus making simple scale reduction and mosaicking impossible.

The conventional approach to the transformation task involves the subdivision of both map graticules by the overlaying of a much finer working grid. Details are then manually redrawn on the compilation manuscript according to their respective positions on the source map. The technique is illustrated in Fig. 2.224.

Computer-assisted techniques have significantly affected this compilation task, not least by shortening the time involved in these conversion processes. The computational element is characterised by a great amount of data that have quite often to be treated with algorithms which vary locally. If the compilation is based on existing maps two methods can be distinguished depending on the type of source data.

2.28.1 Transformation of vector coordinates

If the base consists of line and point symbols (Fig. 2.221) it may be advantageous to vectorise the source map as a first step. With two-dimensional interpolation methods, based on graticule intersections with known coordinates, geographical coordinates are recompiled as an intermediate step (Fig. 2.222). The vector database established in this way allows for transformation into any other projection (Fig. 2.223).

Figures 2.225 and 2.226 illustrate two different documents which are to be used as source material for the compilation of a new map. The latter contains bathymetric contours and is constructed on a Mercator projection; the other depicts the tectonic features on an equal-area projection. These details have to be plotted onto an azimuthal equal area projection consisting of curved meridians and parallels. Initially details relating to the two original projects have to be digitised, and are then subsequently mathematically transformed into geographical latitude and longitude. The resultant coordinates are then used to calculate and plot detail conforming to the projection and scale of the new map (Fig. 2.227).

2.28.2 Transformation of raster data

If vectorisation is not envisaged or possible, the source map (Fig. 2.228) is scanned. This image is then warped to match the projection of the map being compiled. For this purpose a number of control points must be selected, usually graticule intersections, whose rectangular coordinates are known for the source map and also the new projection. Using two-dimensional interpolation algorithms the original pixels of the scan are resampled to fit on the new projection. This method is especially useful for producing a background image from a source map as a base for the construction of a new graphic on another projection.

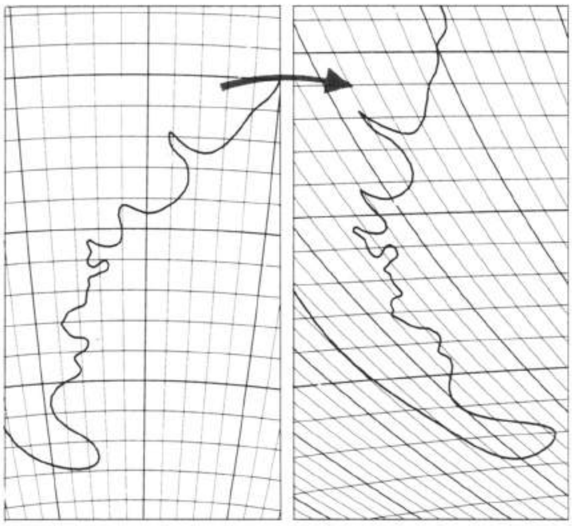


Fig. 2.224 Conventional method of detail transfer using a fine working grid

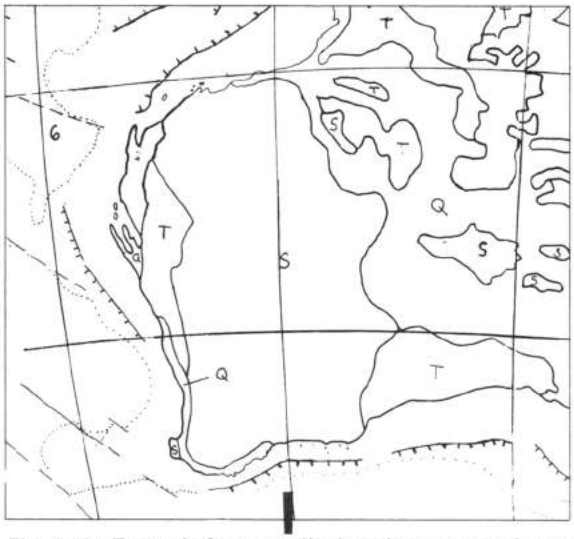


Fig. 2.225 Tectonic features displayed on an equal-area projection

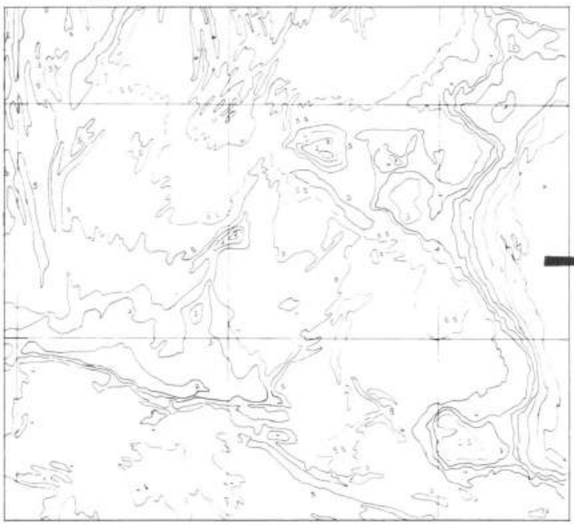


Fig. 2.226 Bathymetric contours on a Mercator projection

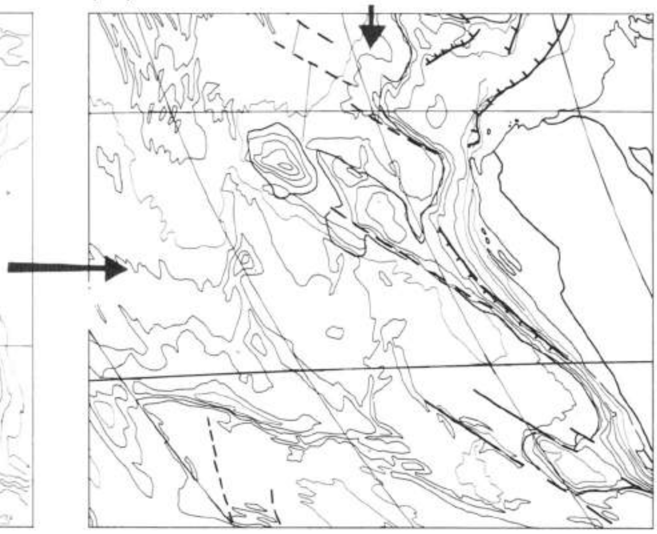


Fig. 2.227 Details from Figs 2.225 and 2.226 transformed into an azimuthal equal-area projection

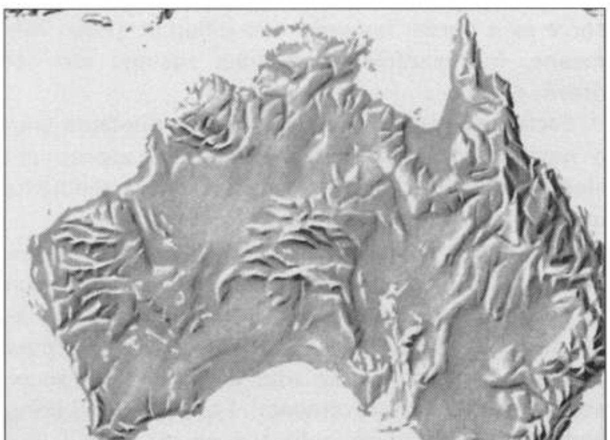


Fig. 2.228 Original hill shading on a conic projection

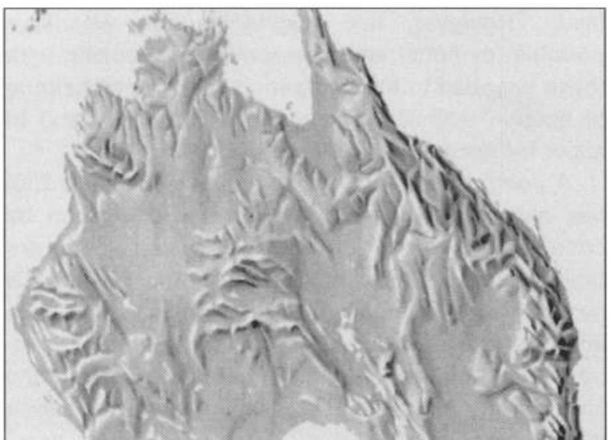


Fig. 2.229 The same hill shading transferred onto an azimuthal equal-area projection centred in the Pacific

As it is not possible to digitise modulated area tones, the warping technique is also used for the transformation of hill shading of the type shown in Fig. 2.228. In Fig. 2.229 this detail has been warped onto the new projection.

Within defined limits of scale and distortion, this method allows the use of the same hill shading originals for maps on different projections. It must be noted that the problem of generalisation, heightened in all cases by considerable distortion during the transformation, remains to be solved.

2.29 The map compilation manuscript

2.29.1 Conventional map production

In conventional map production the preparation of a compilation manuscript is fundamental in most cases. It contains all of the details necessary for the preparation of final drawings by the cartographer.

It is essential that the compilation is complete and geometrically accurate. It must be an unambiguous draft of the whole content, with the significance of each line or symbol being clearly understandable and the final form and dimension of every element being correctly specified.

It is recommended that the *working scale* is larger than that of the intended publication – an enlargement to 150% or 200% is usually adequate. Working at 1:1 may be inappropriate because it is not normally possible to produce an accurate draft with a less precise tool than that which will subsequently be used by the cartographer. An alternative working scale may be chosen, depending on those of the maps used as base material.

When working at a larger scale, line quality is not of such immediate importance, and progress will be faster. However, line widths should, whenever possible, demonstrate their correct relationship with those intended in the final representation, so helping to reserve sufficient space for each symbol and to allow for necessary displacements.

A composite compilation manuscript (Fig. 2.230) has only one advantage – that everything can be coordinated in one drawing. However, there are major disadvantages in the fact that unambiguous symbolisation is impossible. The significance of each line element is not clear and, in consequence, misunderstanding may result. Therefore, except in the case of very simple drafts, a composite compilation is not recommended.

Separated compilation manuscripts should be used to facilitate handling and minimise possible ambiguity. An example of such a series is illustrated in Figs 2.231–2.237, where individual overlays have been provided for:

- layout and grid lines (Fig. 2.231);
- hydrography (Fig. 2.232);
- contour lines (Fig. 2.233);
- roads and railways (Fig. 2.234);
- point symbols (Fig. 2.235);
- the outlines of area colours or patterns (Fig. 2.236);
- names (Fig. 2.237).

The overlay demonstrating the geometrically correct position of the grid lines may also be used as the layout for the whole map. By using this system the sheet can be correctly formatted. The map delineations are precisely indicated, and the title and legend are appropriately arranged.

The layout is punched and provided with at least two register marks outside the diagonal of the map frame. All subsequent sheets are also punched, and have the equivalent register marks mounted on them. The latter will allow the precise registration of the separated documents after their reduction to publication scale.

The three sheets incorporating *linear elements* (rivers, contours, roads, etc.) are compiled, in register, one after another and as transparent overlays. This serves to guarantee a precise match between each of them. As long as line widths are approximately correct, their textures can be quite different from those used on the final map. At the manuscript stage they are chosen to facilitate and speed the compilation process whilst allowing the maintenance of a clear distinction between the different composing elements.

Similarly, *point symbols* used at the manuscript stage will not be identical to those appearing on the final map. What is required is an alternative symbol which is easy to draw and takes up an equivalent amount of space to that of the intended final version (Fig. 2.235).

Outlines of area colours and superimposed area patterns (Fig. 2.236) are usually separated onto two sheets. Outlines are drawn where no other lines can serve as a border between two different areas. This means, for example, that street casings are not drawn twice.

Each area surrounded by a line is annotated with a number or letter that refers to an appropriate element contained in the legend, so guaranteeing its unambiguous identification.

The *names layout* (Fig. 2.237) contains all names, figures and text material intended for inclusion on the map. All texts and words are positioned as precisely as possible, so that the final placement of the type has to take into account only minor adjustments or improvements. Type styles, spacing and size may also be indicated on the layout, but usually a special *names manuscript* will be produced. This is a list of all the names, text and other information needing to be typeset.

A compilation manuscript, whether it be produced on separate sheets or as a composite, requires the

Fig. 2.230 Composite compilation exhibiting many problems relating to the identification of details

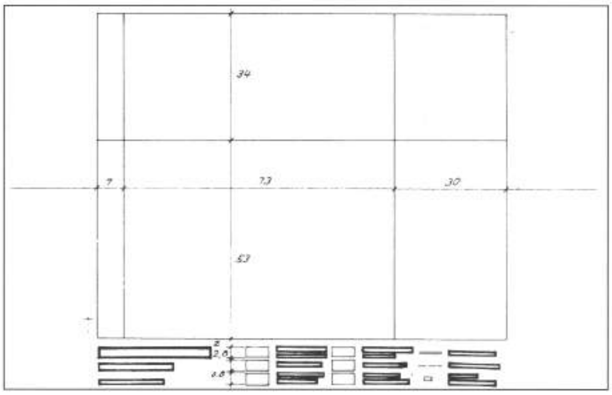


Fig. 2.231 Separate layout sheet including graticule and marks for the registration of detail overlays

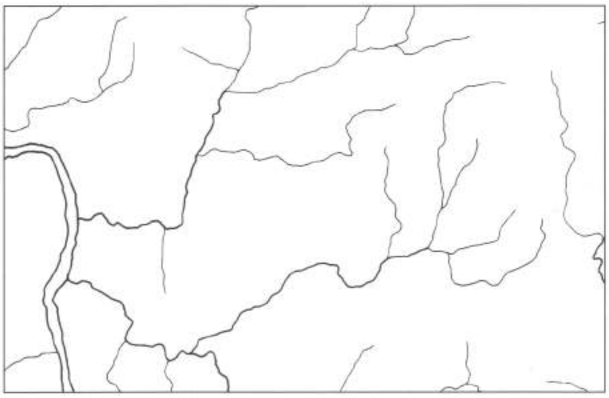


Fig. 2.232 Hydrography overlay

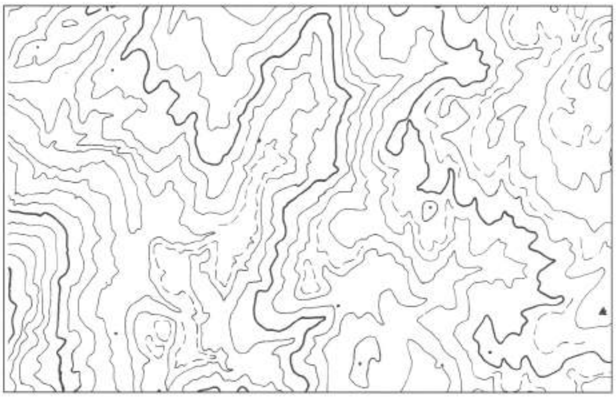


Fig. 2.233 Contour overlay

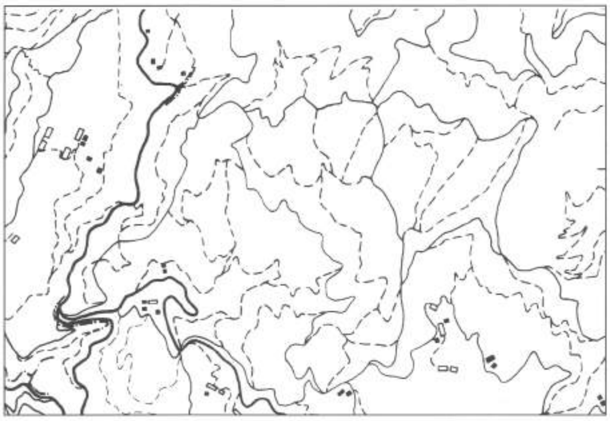


Fig. 2.234 Communications overlay

Fig. 2.235 Point symbol overlay

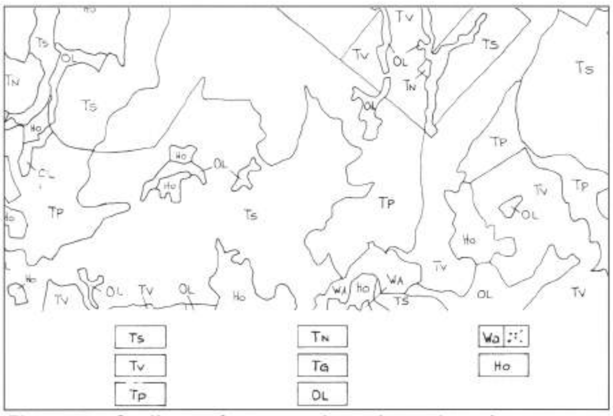


Fig. 2.236 Outlines of areas to be coloured, and associated legend boxes

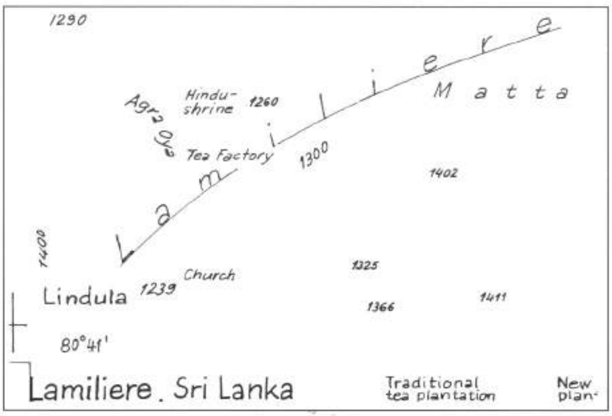


Fig. 2.237 Names manuscript incorporating spot heights and graticule numbers

attachment of further information in the form of a *specifications list* which is prepared by a map editor for the cartographer. This contains a description of items included on each of the compilation sheets that cannot be otherwise explained.

As was stated in section 2.10, 'Map legend specification', a first requirement is the classification of the precise form and dimensions of each of the symbols used on the map (Figs 2.48 to 2.51). The colour to be allocated to each device is indicated on a *colour screen table* which lists the features as one set of entries and the relevant printing colours as another (Fig. 2.52). All of these components – the compilation and type manuscript, the specifications and colour screen table – comprise what may be termed the map compilation. When these have been produced the map is then ready for production by the cartographer.

2.30 Compilation in digital map production

In digital production the compilation procedure is quite different. In many cases there is hardly any compilation at all, because the digital editing techniques allow for a graphic quality of every detail which already meets the needs of the final product. Furthermore one can make use of the great advantage that most specifications can easily be changed at a later stage, for example after the inspection of a preproof copy.

The source materials for the compilation are of a variety of types but now include digital databases. The conventional procedure described above may also be followed for the compilation stage. In this case the digital data have to be plotted to the scale of the other bases. The drawn set of compilation overlays has to be scanned or digitised thereafter for the final cartographic production.

In many cases *compilation and production go hand in hand*. At first all analogue source maps are scanned and assembled for display on the screen, together with ultimately available digital databases. As a result, advantage can be taken of the facility to store, display and edit different elements as separate layers. The calculated map graticule or grid serves as a compilation base, onto which the other components needed for map construction are scaled, warped and registered. Allowance must be made for some transparency, if several layers are superimposed. The zoom function is very important in the editing phase, as the screen resolution would be much too coarse at publication scale for precise editing and matching.

The *editing process* follows along the same lines as the preparation of overlays in conventional compilation, the only difference being that almost every 'fair drawn' detail is rendered in its final form. The standard sequence of operations presented in Figs 2.231 to 2.237 can also be followed in digital production. New linework may be created by overlay or heads-up digitising on the source base map, which is zoomed up to 1600% for this purpose. This may present some problems as it needs considerable experience to judge the likely graphic effects on the end product. Frequent proof plots may assist in evaluating such editing work.

The concept of layers renders the compilation process quite flexible, in so far as they can be made invisible or their superimposition may be changed whenever necessary. Figure 2.238 is a screenshot of a map in the editing process.

Although it is also essential in digital production to start with precise map legend specifications, it is possible to change these at a later stage – normally after checking a final proof plot. Dimensions of line widths and symbols may be slightly modified and colours need only be specified at a very late stage.

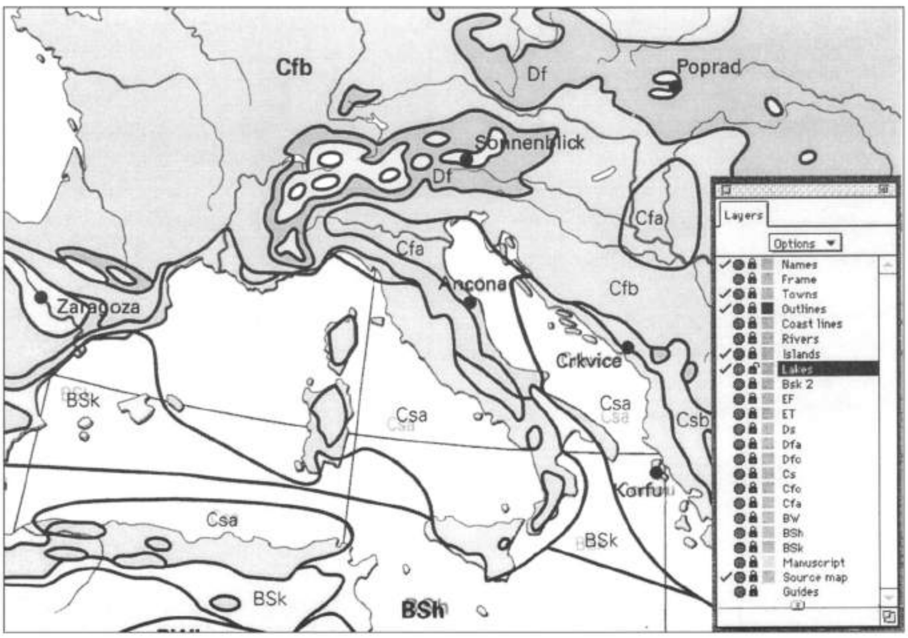


Fig. 2.238 Part of a screenshot of a map during the editing process