the bifocal display a user can be reading or composing a letter displayed in the central region, yet be aware of the appearance in an outer region of a message from his or her boss, perhaps because of its distinctive colour or vertical position. That message cannot of course be deciphered in the distorted region, but that is not the point: the user has *noticed* the important message (necessarily in the form of a thin rectangle) and has the option to scroll the information space so that the message moves smoothly and continuously into the central, non-distorted region, expanding as it does so and becoming readable. An early illustration of the bifocal display technique is shown in Figure 4.9.

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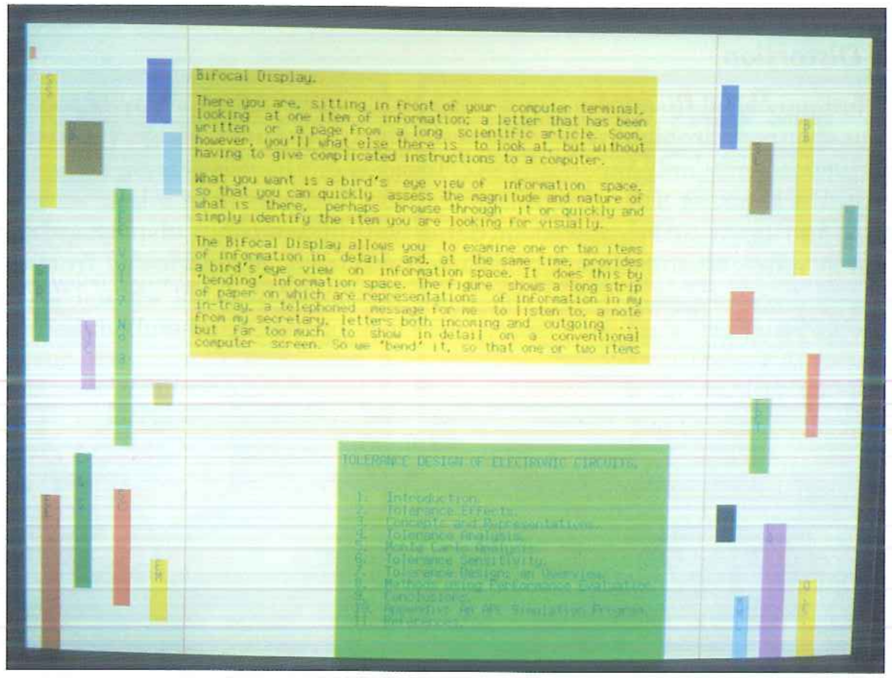

The bifocal display embodies a number of important features. A principal one is *distortion*, allowing available display area to be allocated to two different regions we may call the focus (undistorted) and context (distorted) regions. Another is the fact that an information item moves *smoothly* and *continuously* from context to focus during the scrolling action and, even without scrolling, embodies both geometric and (to some degree) encoding continuity between the regions. A third feature is the opportunity that the display affords for representation. Since the original information space (Figure 4.8) was two-dimensional, there is the opportunity to use those two dimensions to encode two attributes of the information items. Time or date of receipt might be assigned to the horizontal axis and type of item (e.g. in-email, out-email, manuscript, timetable) to the Y-axis. There is also an opportunity for further encoding, for example by colour or shape, to additionally distinguish the information items. The issue of representation also arises from the fact that an item can usefully be represented in a different way in the two regions. In the focus region the premium is on readability and interaction; in the distorted regions readability is not the main purpose – the essential feature is that of *awareness* and *identification*. In a distorted region, text and other detail would normally be *suppressed* and a representation chosen for the information item which, while supporting awareness and identification, will nevertheless not be so different from the representation in the focal region that transition from one region to another is disruptive.

Another important feature of the bifocal display is its *manual control* by a user. As originally proposed, the scrolling action would be achieved via a touch screen, making use of the visio-motor ability of the human being: in other words, the user can continuously monitor, simply by visual observation, how close the desired item is to the focus region and adjust finger movement and hence the associated scrolling action accordingly.

Application

Applications of the distortion technique are to be found in many domains. An example is provided by the field of bioinformatics which, broadly speaking, is the application of information technology to the analysis of biological data. Of primary importance are sequences, for example the nucleic acids in the familiar DNA molecule, and the amino acids comprising a protein molecule which encode life. One such sequence of amino acids is shown in Figure 4.10: each letter refers to an amino acid and the background colours denote what might loosely be termed the 'charge' on the amino acid. Because the one-dimensional sequences encode three-dimensional information, the sequences are long. Therefore, because an investigator needs to be aware of the complete sequence when associating it with other representations of a protein, some distortion may have to be introduced, as shown in Figure 4.10. Note, however, that the distortion is generated without any discontinuities – in other words, there is no point at which the sequence suddenly 'bends' as it does in Figure 4.8 – since a discontinuity would be an artifact of the display itself and would detract from the real information about the protein.

FIGURE 4.10
A sequence of amino acids within a protein
(Courtesy of Tom Oldfield)

Another example, and one which demonstrates the possibility of multiple focus regions, is provided by the table lens (Figure 4.11), a means of presenting information which has the advantage that many people are familiar with tables (Rao and Card, 1994). The table of Figure 4.11(a) contains details of around 300 baseball players, each normally assigned to such a thin row that their name cannot be discerned, though associated thin bars (providing a histogram) usefully encode attributes such as a player's position in the field and his or her number of 'hits'. A powerful feature is that rows can be reordered according to a selected attribute simply by a mouse movement down the corresponding column. The table lens supports a focus+context view in that one or more rows can be expanded to reveal names, as shown in Figure 4.11(b).

Generalization

The simple but powerful distortion concept can usefully be generalized (Leung and Apperley, 1994). For example, whereas the distortion illustrated in Figure 4.8 might be called X-distortion (Figure 4.12), it is possible to introduce

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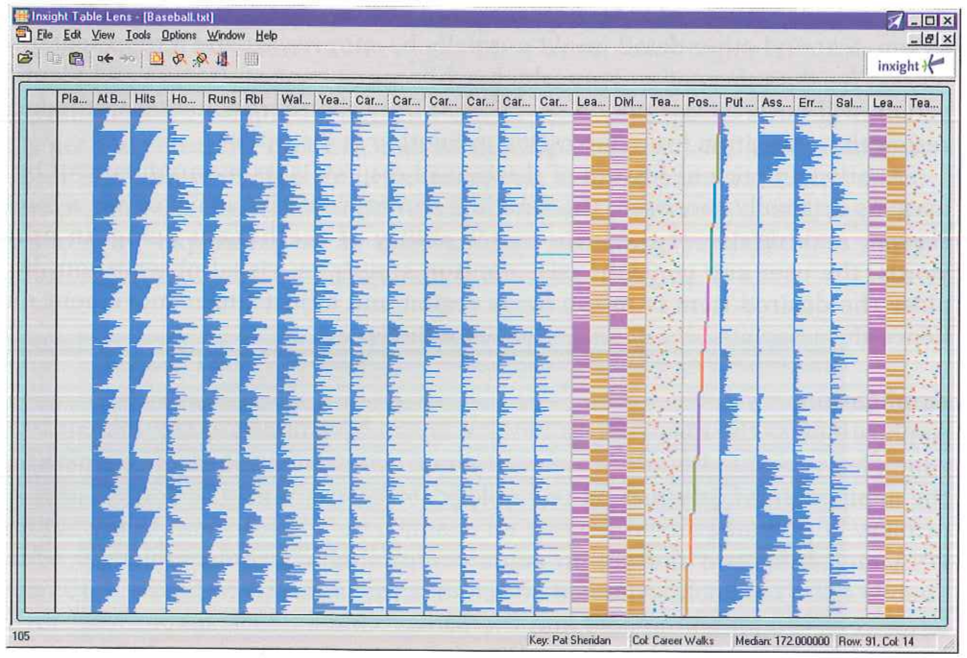
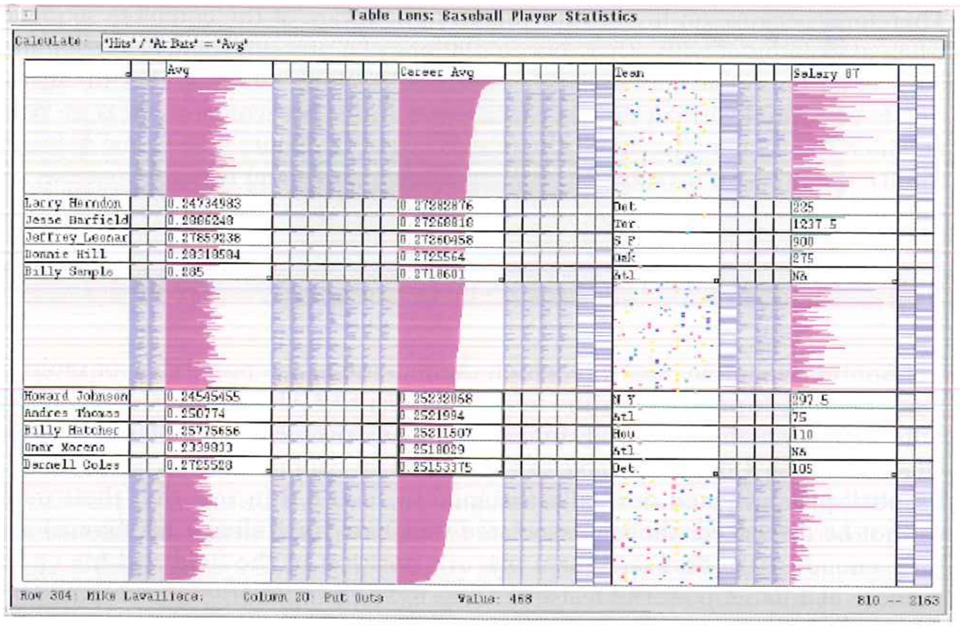


(a)



(b)

distortion in both X and Y directions (Figure 4.13). The latter combination of distortions is well suited to the display of the London Underground map (Leung *et al.*, 1995). Outside a movable focus region (Figure 4.14), station names are suppressed in view of the limited space available, but there is valuable *continuity* of railway lines at the boundary of the focus region, allowing easy comprehension.

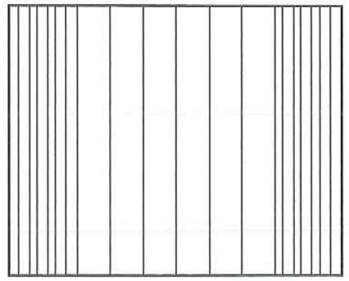


FIGURE 4.12 Schematic representation of X-distortion

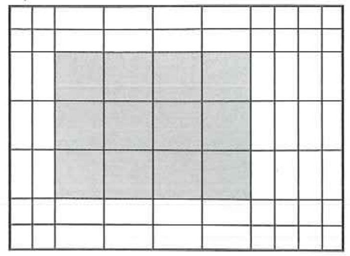


FIGURE 4.13 Schematic representation of combined X- and Y-distortion

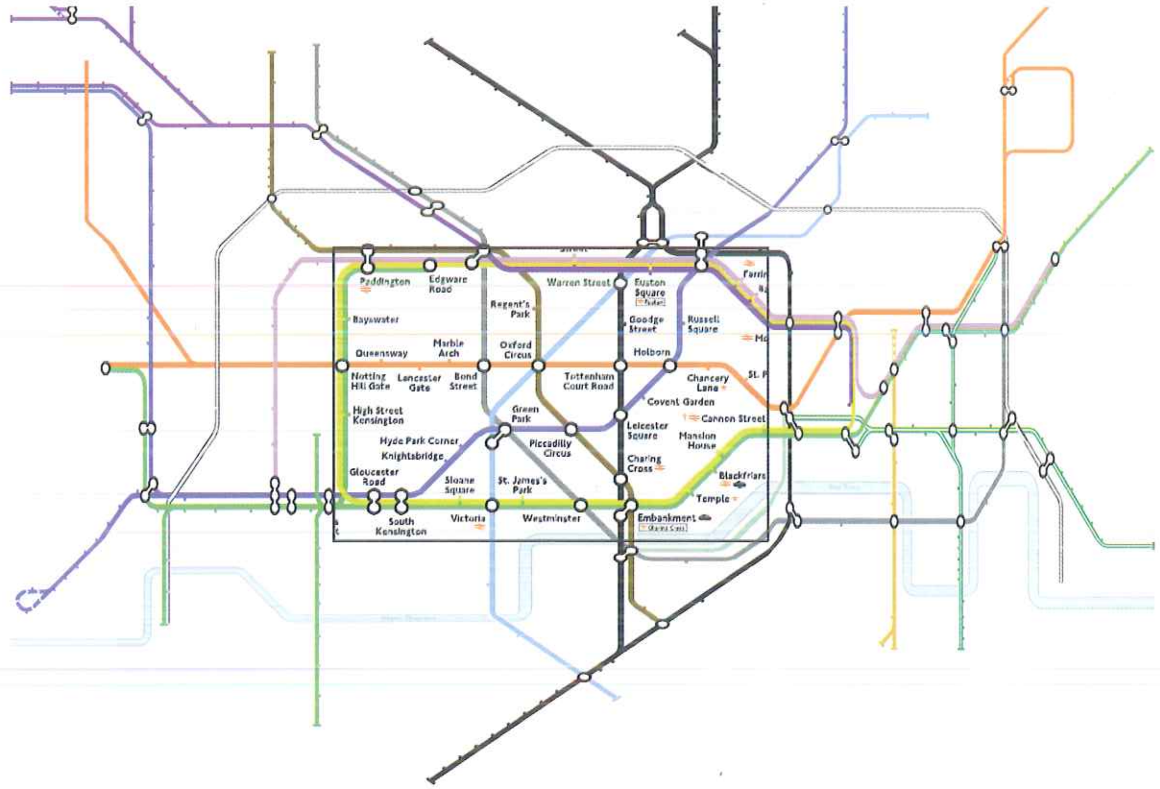


FIGURE 4.14 Distorted presentation of the London Underground map, illustrating continuity across the boundary of the distorted region

A different combination of X- and Y-distortion finds useful application to calendars (Figure 4.15). Whereas in 1980 the implementation of such a calendar was impracticable (Spence and Apperley, 1982; Apperley *et al.*, 1982), the bifocal display principle underpins a modern PDA-based calendar (Bederson *et al.*, 2003, 2004), described in detail in a case study in Chapter 6. One advantage of simultaneous X- and Y- distortion is, of course, when the distortion factors are equal, whereupon recognizable miniatures can result. This advantage was exploited

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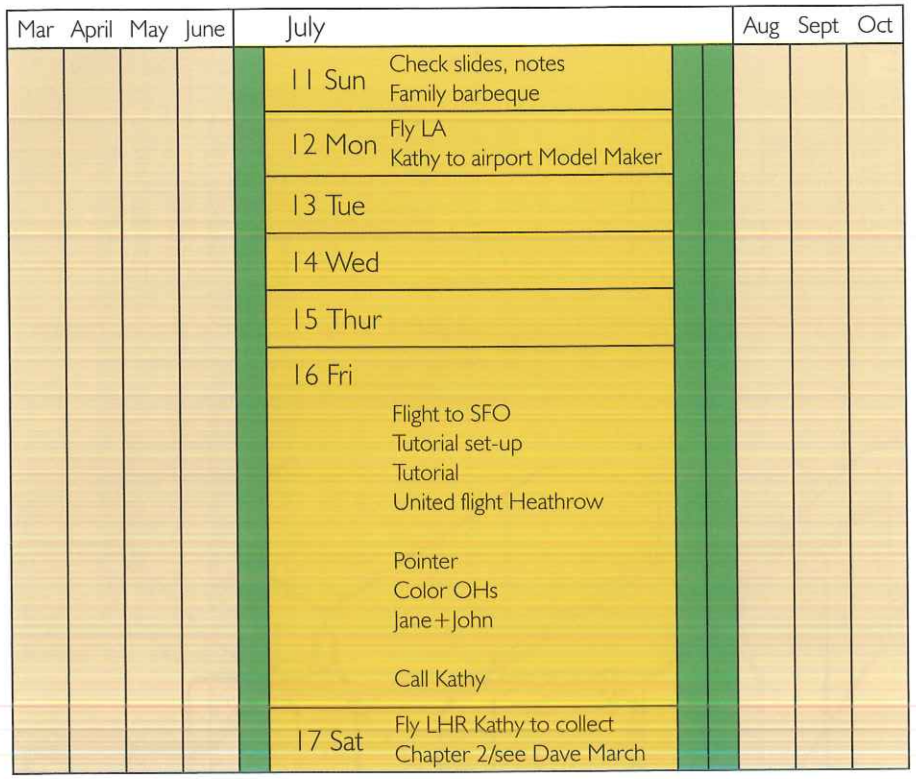

URE 4.16
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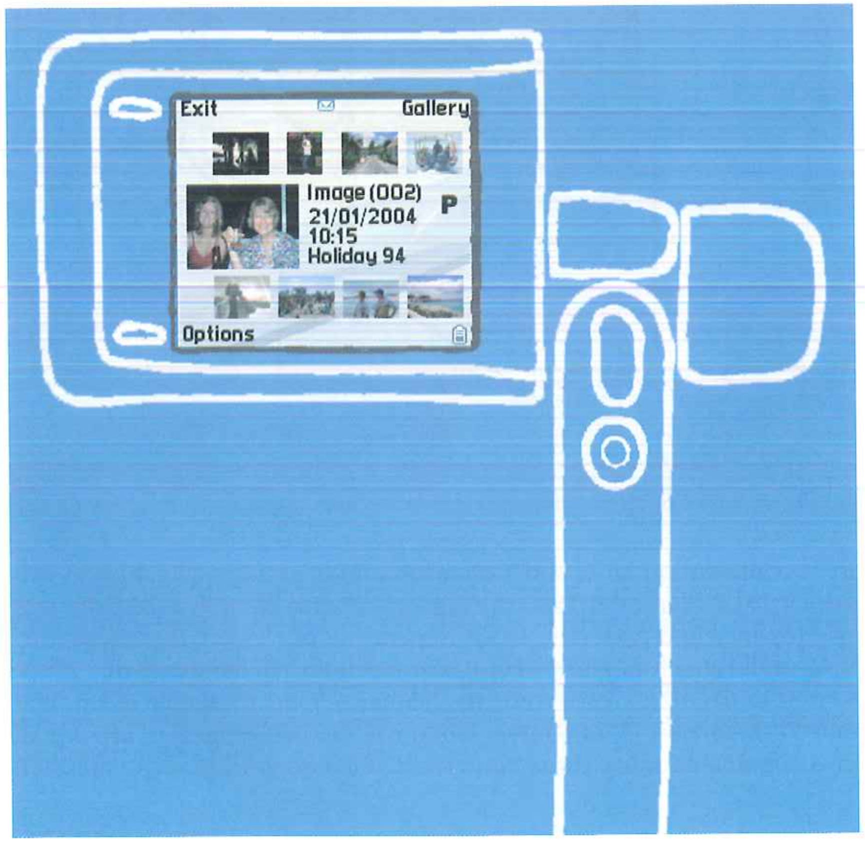

(Figure 4.16) in the flip-zoom technique (Holmquist, 1997). Originally demonstrated on a PDA where space is at a premium (Bjork *et al.*, 1999), it has recently been adopted to facilitate the browsing of photographs on a mobile phone: Figure 4.16 shows the original designer's sketch for this facility. Other recent exploitations of both X- and Y-distortion are to be found both in the presentation of route information in the small area of a PDA display (Figure 4.17) and, by contrast (Figure 4.18), in the presentation of geographical information for collaborative use on an interactive table of conventional size (Ryall *et al.*, 2005).

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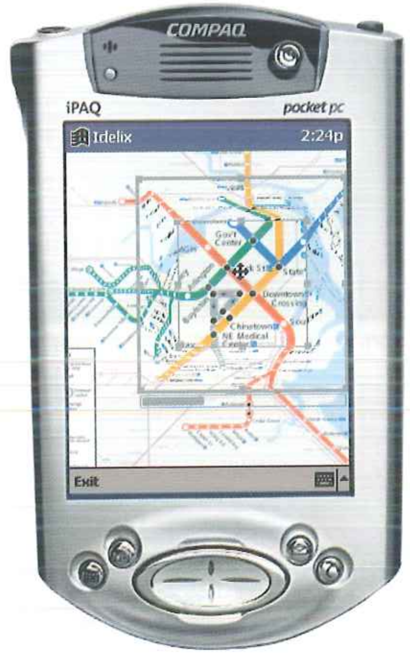

FIGURE 4.17
Distorted map on a PDA, showing the continuity of transportation links
(Courtesy David Baar, IDELIX Software Inc.)

Equal distortion factors are employed in the distortion exhibited by the 'dock' of the MacOSX system (Figure 4.19), a technique that has also found application in the rapid browsing of photographs (see Section 4.2) (McGuffin and Balakrishnan, 2002). In 1991, Mackinlay *et al.* (1991) showed an implementation of the bifocal display technique in which a 3D effect was introduced (Figure 4.20) and features such as the stretching of the focal region were made possible; the result was called the perspective wall. Distortion can also be applied to hierarchical data (Stasko and Zhang, 2000).

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4.1.4 Suppression

Another presentation technique having a similar goal to that of distortion is **suppression**. Furnas (1981, 1986) made the point that it is often necessary to provide a balance of local detail and global context, and identified the useful analogy of the famous Steinberg poster entitled 'View of the World from 9th

FIGURE 4.18 Distorted map on a table *(Courtesy IDELIX Software Inc. and Mitsubishi)*

FIGURE 4.19 Equal X- and Y-distortion centred around a manually chosen location in the Macintosh OSX 'dock'

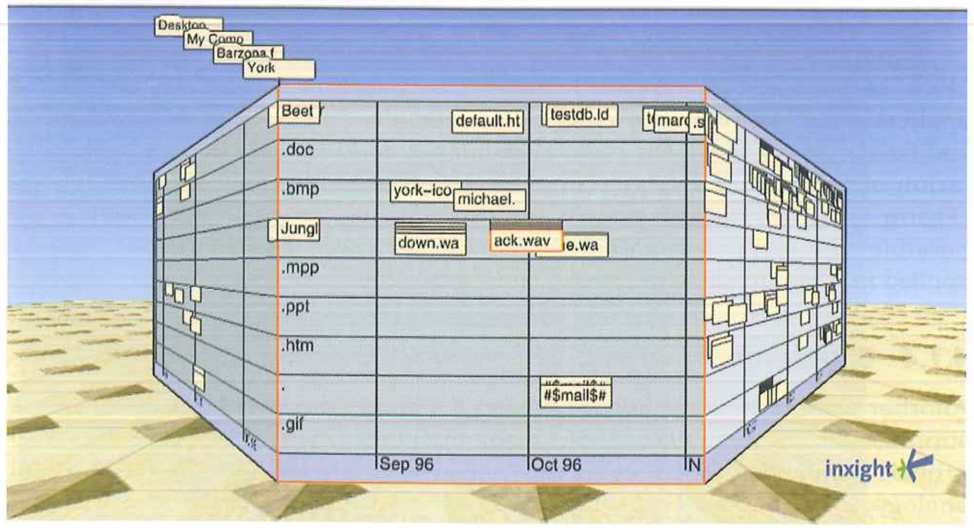


FIGURE 4.20 The perspective wall applies a 3D effect to the bifocal display

Avenue'. For the centre of Manhattan the poster shows the postbox, the subway entrance and the corner shop which are of far greater interest to a local resident than the entire landmass of Australia, which is therefore given token display as a mound somewhere out to sea. Furnas found it useful to identify a *degree of interest* to determine which data should be represented and presented and which should not. Like the bifocal display, Steinberg's poster map of the USA is distorted as well as modifed to suppress details considered irrelevant.

Furnas placed the concept of suppression on an intuitively attractive formal basis. The *degree of interest* (DoI) of any item of data is expressed as a function of two quantities. One is that item's *a priori importance* (API) and the other is some measure of the *'distance'* (D) between that item and whichever item is currently the *focus* of a user's interest.

Both concepts – API and D – can be illustrated by reference to the organization tree of a company (Figure 4.21). We first consider the concept of distance D. Let us suppose that we have a query about the production activities of that company and therefore wish to focus our attention on the person P who is in charge of production. We could, of course, simply click on some representation of P and be presented with information about that person. However, in view of the general nature of our enquiry it may be useful, while *focusing* on P, to be aware of the *context* in which he operates. His immediate superior S might well be relevant, as might the three people K, M and N responsible to P for day-to-day activity. It is less likely that we need concern ourselves with F and G who report to N; it is also unlikely – at least initially – that the president of the company will be relevant to our concerns. We can formalize these considerations through the concept of the *distance* between the focus (P) and any other person, by assigning a value of unity to the distance between two directly connected nodes. In that way each node in Figure 4.21 is assigned a value indicating its distance from the focus (P) (Figure 4.22). In view of the nature of our enquiry we might first place an upper threshold of unity to define the scope of interest (Figure 4.23) and, thereby, the nature of any display of the information we require (Figure 4.24).

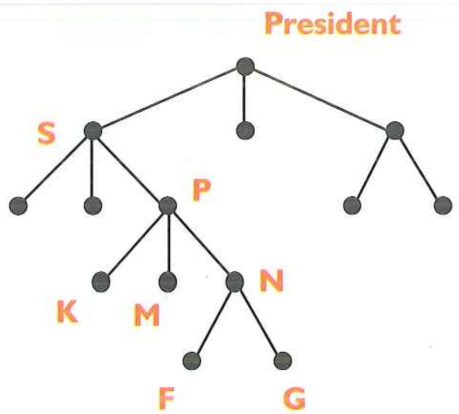


FIGURE 4.21 The organization tree of a company

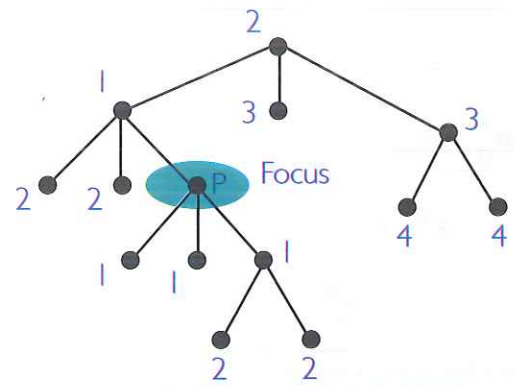
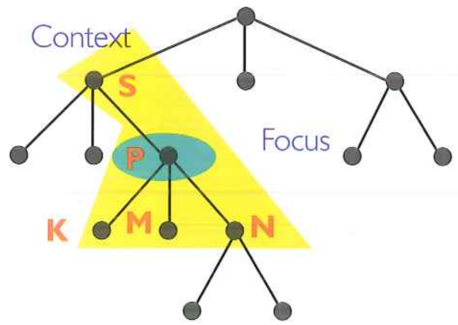


FIGURE 4.22 Showing the 'distance' of each node from the focus of attention



URE 4.23 The context defined by setting an
er threshold of unity for distance from a focus

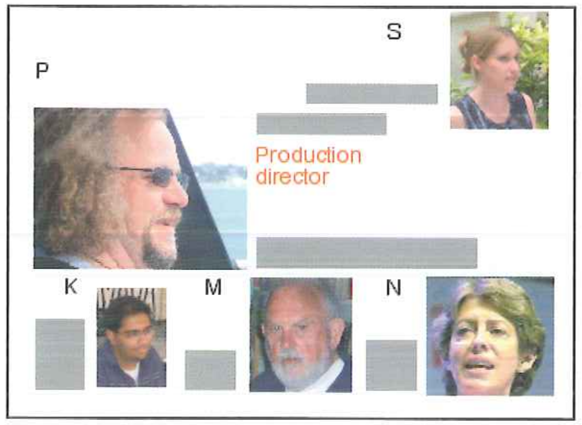
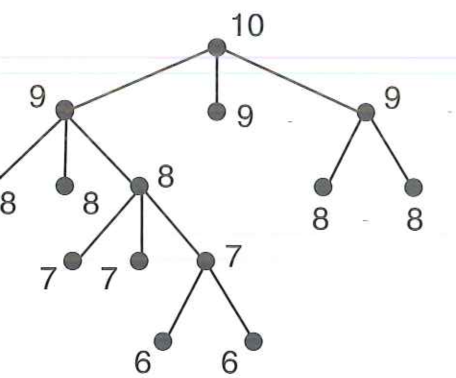


FIGURE 4.24 Example of a display that might be associated with the focus and context defined in Figure 4.23

The second concept, that of API, can be introduced by assigning an API value – representing intrinsic importance – to every node in the tree quite independently of the intended focus. It would be appropriate to assign the highest value of (say) 10 to the president, with values of API decreasing by unity as one goes down the company hierarchy (Figure 4.25). The difference between the API value for any node and its distance D from the focus (see Figure 4.26) is called the degree of interest of that node: the values of DoI for our example are shown in Figure 4.26. Now, if a lower threshold of 6 is imposed to define relevance, the focus and context are defined as shown in Figure 4.26 and the display of information will be composed accordingly. Clearly the implication, inherent in the assigned API values, that the president is the most important in the organization has biased the context towards the more senior people in the organization.



URE 4.25 Each node in the organization tree
een assigned an *a priori* importance (API)

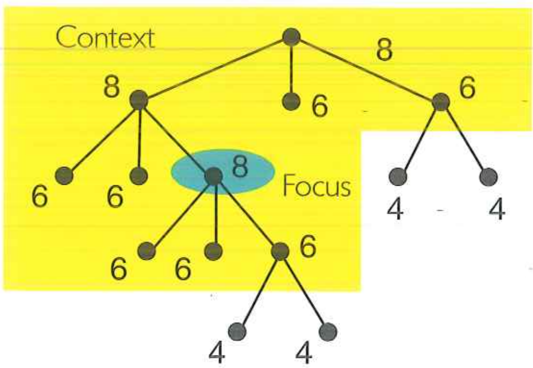


FIGURE 4.26 Nodal values of degree of interest (=API – D). Setting a lower limit of 6 for DoI identifies the nodes within the shaded region

The DoI concept enunciated by Furnas has wide application. Many examples arise from situations in which an understanding has to be acquired of the function of a small component part within a large structure. The location and correction of a fault in a mechanical system, for example, typically requires an expert to examine a very large diagram to see what (usually small) part of it might be relevant to the fault that has developed and hence to its repair. Such is the case with aircraft maintenance, a fact that prompted the US Air Force to develop a system in which, for example, the engineering drawing of Figure 4.27 is automatically replaced by that of Figure 4.28 once the function of interest has been defined (Mitta, 1990).

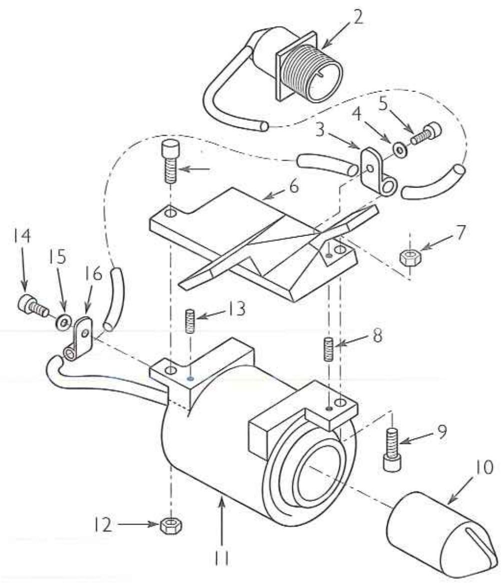


FIGURE 4.27 Part of an engineering drawing

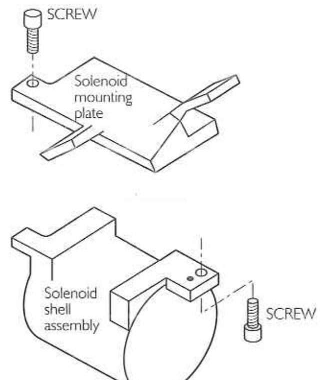


FIGURE 4.28 The engineering drawing simplified in the context of a suspected fault

The technique of suppression finds valuable application in the magic lens technique. An example is shown in Figure 4.29. In (a) we see a conventional geographical map of a district, showing roads, streets, a church, a railway line and a station. But a maintenance crew concerned with a fault in the gas supply to the area will need to know the location of underground gas pipes and their interconnections, the position of valves and other buried systems such as electrical and telephone cables that may affect digging to reveal a gas pipe (Figure 4.29(b)). But Figure 4.29(b) is of limited value since no geographical context is shown: what is far more valuable (c) is the display of gas pipes and electricity and telephone cables in a small area of interest within the geographical map, not least because the maintenance crew have got to get themselves and their equipment, as far as conveniently along available roads, as close to the problem as possible. The ability to examine a different 'layer' of data, and especially to do so