Chapter 15

Materials, aesthetics and industrial design

15.1 Introduction and synopsis

Good design works. Excellent design also gives pleasure.

Pleasure derives from form, colour, texture, feel, and the associations that these invoke. Pleasing design says something about itself; generally speaking, honest statements are more satisfying than deception, although eccentric or humorous designs can be appealing too.

Materials play a central role in this. A major reason for introducing new materials is the greater freedom of design that they allow. Metals, in the past century, allowed structures which could not have been built before: cast iron, the Crystal Palace; wrought iron, the Eiffel Tower; drawn steel, the Golden Gate Bridge, all undeniably beautiful. Polymers lend themselves to bright colours, satisfying textures and great freedom of form; they have opened new styles of design, of which some of the best examples are found in the household appliance sector: kitchen equipment, radio and CD-players, hair dryers, telephones and vacuum cleaners make extensive and imaginative use of materials to allow styling, weight, feel and form which give pleasure.

Those who concern themselves with this aesthetic dimension of engineering are known, rather confusingly, as 'industrial designers'. This chapter introduces some of the ideas of industrial design, emphasizing the role of materials. It ends with two illustrative case studies. But first a word of caution.

Previous chapters have dealt with systematic ways of choosing material and processes. 'Systematic' means that if *you* do it and *I* do it we will get the same result, and that the result, next year, will be the same as it is today. Industrial design is not, in this sense, systematic. Success, here, involves sensitivity to fashion, custom and educational background, and is influenced (manipulated, even) by advertising and association. The views of this chapter are partly those of writers who seem to me to say sensible things, and partly my own. You may not agree with them, but if they make you think about designing to give pleasure, the chapter has done what it should.

15.2 Aesthetics and industrial design

We have discussed the mechanical design of a product. But what of its appearance, its feel, its balance, its shape? Is it pleasing to look at? To handle? What associations does it suggest? In short, what of its *aesthetics?*

There are many books on the subject of Industrial Design (see Further reading at the end of this chapter). You will find — it may surprise you — that they hardly mention the issues of functionality and efficiency that have concerned us so far. They focus instead on qualities that cannot be measured: form, texture, proportion and style; and on subtler things: creative vision, historic perspective, honesty to the qualities of materials.

There is a view — one held by engineers as different as Brunel and Barnes-Wallis — that a design which is functional is automatically beautiful. When a thing is well made and well suited to its purpose, it is also pleasing to the eye. Its proponents cite the undeniable appeal of a beautiful bridge or of a modern aircraft. The craftsman Eric Gill (noted — among other things — for the elegant typefaces he designed) expresses it on a higher plane, saying: 'Look after goodness and truth in design and beauty will care of herself.' But there also exists a different and widely held view that design is an art, or if not that, then a craft with its basis in art, not in engineering. Its supporters — and they have included many distinguished designers — argue that the practice of fine arts and drawing must form the basis of the training of designers. Only this can give an appreciation of form, colour, line and quality, and the sensitivity to the possibilities of their right relationship.

Both views are extreme. The first argument is the one most likely to appeal to the engineer: that a functionally efficient machine is, of itself, aesthetically satisfying; it is the basis of what is called a 'machine aesthetic'. But something is obviously missing. It is part of the purpose of the machine to be *operated*, and the design is incomplete if the satisfaction of the operator is ignored. The missing elements include the ergonomics — the man–machine interface — and they include the idea of visual enjoyment and aesthetic pleasure for its own sake. It is as if eating had been reduced to the intake of measured quantities of carbohydrate and protein, depriving it of all gastronomic pleasure.

Empty decoration, on the other hand, is equally unsatisfying. Styling can give pleasure, but the pleasure is diminished if the appearance of the product bears no relationship to its function. The pleasure is transitory; you quickly grow tired of it; it is like living on a diet of chocolate and puff-pastry. The outside of a product should reflect the purpose and function of what is inside. Successful industrial design tells you what the product is and how to use it, *and* it gives pleasure.

So what is excellent design? It is the imaginative attempt to solve the problem in all its aspects: the use to which the article will be put, its proper working, the suitability of the materials of which it is made, its method of production, the quality of the workmanship, how it will be sold and packaged and serviced, and — by no means least important — the pleasure it will give the user. It seldom costs more to use a good shape than a bad one, good texture instead of bad.

But how are we to decide what is 'excellent'? That requires the development of an aesthetic sense. There are, in any country, exhibitions of industrial design (Table 15.1). Some are permanent, illustrating the way in which products have evolved; others are brought together to display current products. Visit these; examine the designs; ask yourself why they have survived or evolved or developed, and observe how the use of new materials has enabled their evolution. Browse through the books on industrial design listed at the end of this chapter. Don't expect them to explain how to design well — ideas of aesthetic design cannot be expressed as equations, or set down as procedures. Try, instead, to see how forms have evolved which are both functional and beautiful, that perform well and use materials in a way that exploits their natural texture and qualities, and that build, in a creative way, on the past. Case studies of the evolution of a product give a good way of developing an aesthetic sense (there are three later in this chapter). Examine, particularly, long-lived designs; things that are still pleasing long after they were made and have survived changes in taste and fashion: the Parthenon, St Paul's Cathedral, the Eiffel Tower, the Chippendale chair, the Victorian pillar-box, the XK 120 Jaguar, the 'tulip' telephone; the shape of a jug, a wine bottle, of candlesticks, certain cutlery — these have influence, and give satisfaction long after the designer has died.

Table 15.1 Design museums

Country	*Design museum*
Britain	• The Design Museum at Butlers Wharf, S. Thames Street, London SE1 • The Victoria and Albert Museum (V & A) and the Science Museum, both in South Kensington, London
Czechoslovakia	• Musée National des Techniques, Prague
Denmark	• Musée des Arts Decoratifs, Copenhagen
France	• Musée Nationale des Techniques, CNAM, Paris • Musée des Arts Décoratifs, 107 Rue de Rivoli, Paris • Musée Natianal d'Art Modern, Centre George Pompidou, Paris • The Musée d'Orsay, Quai d'Orsay, Paris • Fondation National d'Art Contemporain, Ministère de Culture de la Francophonie
Germany	• Das Deutsche Museum, Munchen • Vitra Design Museum, Weil am Rhein
Holland	• The Stedljk Museeum, Amsterdam • The Booymans van Beumijen Museeum, Rotterdam
Switzerland	• Design Collection, Museum für Gestaltung, Zurich
USA	• The Smithsonian Museum, Washington DC • Industrial Design Collection of the Museum of Modern Art (MOMA), New York • The Museum of Fine Arts, Boston

One might consider the following approach to the design process. The quotation is from Misha Black, a Royal Designer for Industry (The Design Council, 1986):

> We should approach each new problem on the basis of practicality — how can it most economically be made, how will it function most effectively, how can maintenance be simplified, how can the use of scarce materials be minimised? An absolute concern with practicalities will produce new formal solutions as technology constantly develops; when alternatives present themselves during the design process, the aesthetic sensitivity of the designer will determine his selective design.

So, when you look at an object (or, more important, when you design one) ask yourself the following questions. What is its NATURE — workaday or ornamental, useful or fun? What is its FUNCTION — does it achieve what it sets out to do? What is its STRUCTURE — well and appropriately made, too heavy or too light, made honestly or with unworthy tricks of concealment? How does it FEEL — are the weight and balance right? Its SCALE — is it the right size, and right for its use? What of its DECORATION and TEXTURE — is the colour attractive, the detailed design pleasing, harmonious, and giving delight? Is it GENUINE in its detail — is the decoration related to the structure and function, or is it coincidental or deceptive? Has the MATERIAL been used well, making the most of its properties and potential? And what ASSOCIATIONS does it suggest — speed? comfort? affluence? the past? the future? frugality? youth? culture and discernment? a bright awareness of latest trends? In short, does it have an appealing PERSONALITY? Why — if you do — do you like it? Why did you notice it at all?

We have seen, in the preceding chapters, that materials selection is intricately interwoven with the design process. A good design exploits the special properties of the materials used for each of its parts. Innovative design frequently does this in a new way, which either results in a cheaper product, or a product with better performance in some other sense (it is lighter, delivers more power, is easier to handle, more pleasing to look at and use). Much design is evolutionary, that is to say, the function and the basic scheme of achieving it does not change, but the details of shape, texture, and material do. Important markets are won in this way. The successful designer is, often, the one who exploits the potential of a new material more effectively than do his competitors.

Much can be learnt by examining the evolution of products in which the function has remained unchanged but the mode of achieving it has evolved with time. We now examine three such products: the telephone, the hand-held hair-dryer and the dinner fork. Lest they strike you as trivial, remember that all three are found in almost every household; their sales in Europe run to at least ten million units, or £200 m ($360 m), per year. You may disagree with the judgements I present here — aesthetics, as we have said, is a subjective and personal matter. But that means you have to decide what you like, or what your customer will like, and be able to express why. If you *do* disagree, see if you can formulate and express an alternative. But before that, something short and to the point: designing to please.

15.3 Why tolerate ugliness? The bar code

Few things are more functional, more information-intensive, than the bar code (Figure 15.1). And few are uglier. Their ugliness causes designers of book jackets, of wine labels, of food packages — of almost everything — to make them small and hide them at the bottom, round the back. And even there they are ugly.

Is that necessary? Could they not give, in some small degree, pleasure? Bar codes are read by a horizontal sweep; no information is contained vertically. Those in Figure 15.1 come from a pharmaceutical product and from the end of a bobbin of thread. Why not, at least, acknowledge this?

One response is shown in Figure 15.2. These are designs from the Ecole Supèrieure des Arts Graphiques in Paris, commissioned by the US firm Intermec which markets the most widely used coding system. They succeed at two levels. They are novel — other bar codes are not like this — and because they are novel, they entertain, they turn dullness into interest, they please. And because they are to-be-seen, not to-be-hidden, the designer can make them bigger and display them prominently where they can be scanned easily.

And making this change has cost nothing at all*. It is no more expensive to print a bar code which appeals as an abstract design, or as a caricature, or has humour, or conveys visual information (the examples of Figure 15.2 do all these things) than it is to print an ugly one. So why not? Designing

A1234

3123 4560

Fig. 15.1 Bar codes. The first is from a pharmaceutical product, the second from a bobbin of thread.

* A disingenuous statement. It cost the design time.

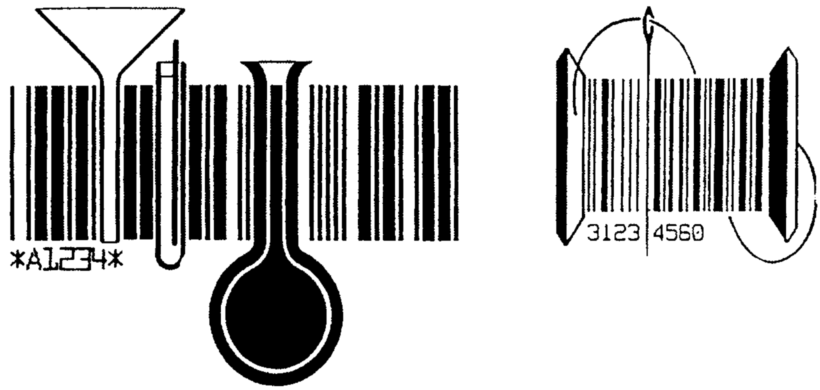

Fig. 15.2 The same bar codes, redesigned.

for pleasure as well as functionality is a worthy goal. The case studies which follow illustrate successes and failures in this, and the way in which materials have contributed.

15.4 The evolution of the telephone

The function of the telephone and the manner of achieving it has hardly changed since the days of Alexander Graham Bell (1847–1916). It consists of a device for turning electrical signals into sound, one for turning sound into electrical signals, and a system for sending digital information to the exchange.

Figure 15.3 shows how telephones have evolved. Note, first, materials; they follow the evolutionary pattern of Figure 1.1. The telephone of 1900, shown at (a), was largely made of wood; only the parts that had to conduct electricity or respond to a magnetic field are metallic. In the tulip phone (b), standard from 1901 to 1925, metal has replaced wood: a cast iron base supports a pressed steel cover from which rises a column of iron or brass, supporting the mouthpiece. The receiver, made of turned brass, is long and slender in order to accommodate the soft iron magnet. The whole thing is metal except for the bakelite mouthpiece and the rim of the ear-piece, but even these are turned and threaded, an inheritance from metal technology.

From here on the transition to polymers begins, although it takes 50 years to complete. Phone (c) of 1928–1970 (an Ericsson design of extraordinarily long life) has, technically speaking, only two significant changes. First, it uses magnets with a higher remenance and coercive force, allowing the ear-piece to be made smaller. Second, the body is moulded from bakelite — a polymer — but still with a metal base screwed to it. The 'metal design' mentality persists. Screw threads are cut or moulded into the mouthpiece and ear-piece, screw fasteners are widely used, and the only other major change — the shape and structure of the body — is designed much as one would design a metal die casting. There is a reduction in weight and, presumably, a saving in cost of manufacture, but the unique properties of the new material have not been exploited.

The later 'phones of 1970–1975 (Figure 15.3(d)) show some advances in the way the materials are used. Instead of the numerous fasteners, the case (made of acrylic) is held to the base (still metal) by a smaller number of screws and by moulded protrusions which locate in slots in the base. The full exploitation of the potential of polymers is found only in the 'phones of 1982 and later, like

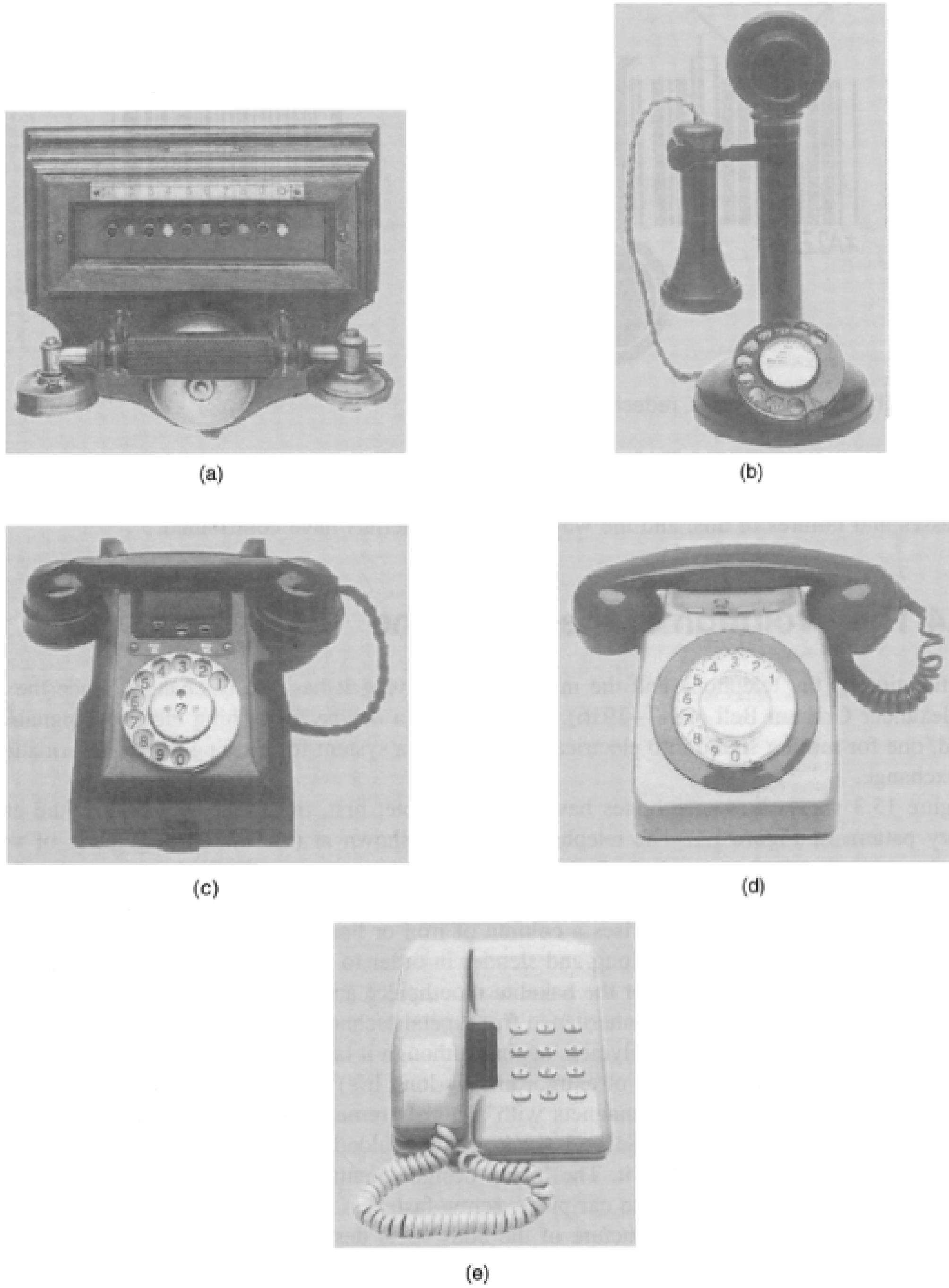

Fig. 15.3 Telephones: (a) a wall telephone, circa 1900; (b) a 'candlestick' or 'tulip' telephone of 1920-1 928; (c) the standard Ericsson telephone of 1928-1 970; (d) a telephone of the period 1970-1 980; (e) the telephone of 1982 to 1992, making good use of polymers, but unappealing in its form, weight and proportion,

that shown at (e). Here snap fasteners and moulded clips are used throughout and there are very few fasteners. Polymer properties are exploited in elastic hinges (replacing pivots) and in the bi-stable 'touch-sensitive' supports for the keys. Both the cover and the base are injection mouldings of ABS shaped to give good stiffness despite the low modulus of the polymer itself. The design has at last escaped from the 'metal technology' mind-set.

But at a different level, that of the aesthetics, it might be argued that the design has not improved. The early telephones (a) and (b) express their function well. The tulip 'phone, particularly, is pleasing to look at; there is no confusion about which bit you speak into and which you listen to; and the dial is well positioned and displayed; its one drawback is that two hands are needed to work it. Its successor, (c), overcomes this by combining mouth- and ear-piece in one, and it does so in a bold, sculpted design: it sits solidly on the desk, has pleasing angular lines and suggests — or did in its day — the power and success of technology. Both it and its 'tulip' predecessor had long lives; they influenced the designs which followed; and they are both sought after and reproduced today, some 60 years later. Those are the characteristics of a 'classic' design — one which successfully combines functionality with consumer satisfaction.

The subsequent period might be called the decadent era of telephone design. The model shown in (d) uses polymers more effectively, but lacks vigour; it has historical perspective, but dilutes rather than innovates. The rounded edges and pastel colours must have appealed to the consumer of the 1970s, but it lacks the lasting quality of (c).

Still, it is much better than the last phone of all, (e). This design has none of the directness and elegance of the earlier ones. It ignores its past; historical perspective, visible in each of the earlier phones, is absent here. The keys are too small for ordinary fingers and it is so light that it slides away from you when they are pressed. Its gooey, lava-like shape in no way suggests its function; nor does it suggest any other satisfying image. The phone works, but it provides very little of the further pleasure that is inherent in really good design.

15.5 The design of hair dryers

Electric hair dryers first became available about 1925. As with telephones, there has been very little change in the way their function is achieved: an electric motor drives a fan which propels air through heating elements whence it is directed by a nozzle onto the hair (Figure 15.4). But the materials of which hair dryers are made, and the consumer appeal which has been created by these materials, has evolved steadily.

Early hair dryers (Figure 15.4(a)) had a power of barely 100 watts. They made from pressed steel or zinc die castings, and they were bulky and heavy. Their engineering was dominated by the 'metal mentality': parts which could be easily cast or machined were held together by numerous fasteners. Metals conduct both electricity and heat, so internal insulation was necessary to prevent the dryee getting electrocuted or roasted. This, together with inefficient motors and fans, made for a bulky product, the casing of which, typically, was made up of five or more parts held together by numerous fasteners (Table 15.2).

The emergence of polymers led to hair dryers which at first used bakelite, then other polymeric materials, for the casing and handle (Figure 15.4(b), (c), (d) and (e)). The early versions are plastic imitations of their metal counterparts; the bakelite model shown at (b) has the same shape, the same number of parts, and even more fasteners than the metal one shown at (a). Polymers were at first attractive because of the freedom of decorative moulding they allowed. Dryers (c) and (d) have lost some of the machine-tool look of (a); they were aimed at a fashion-conscious public;

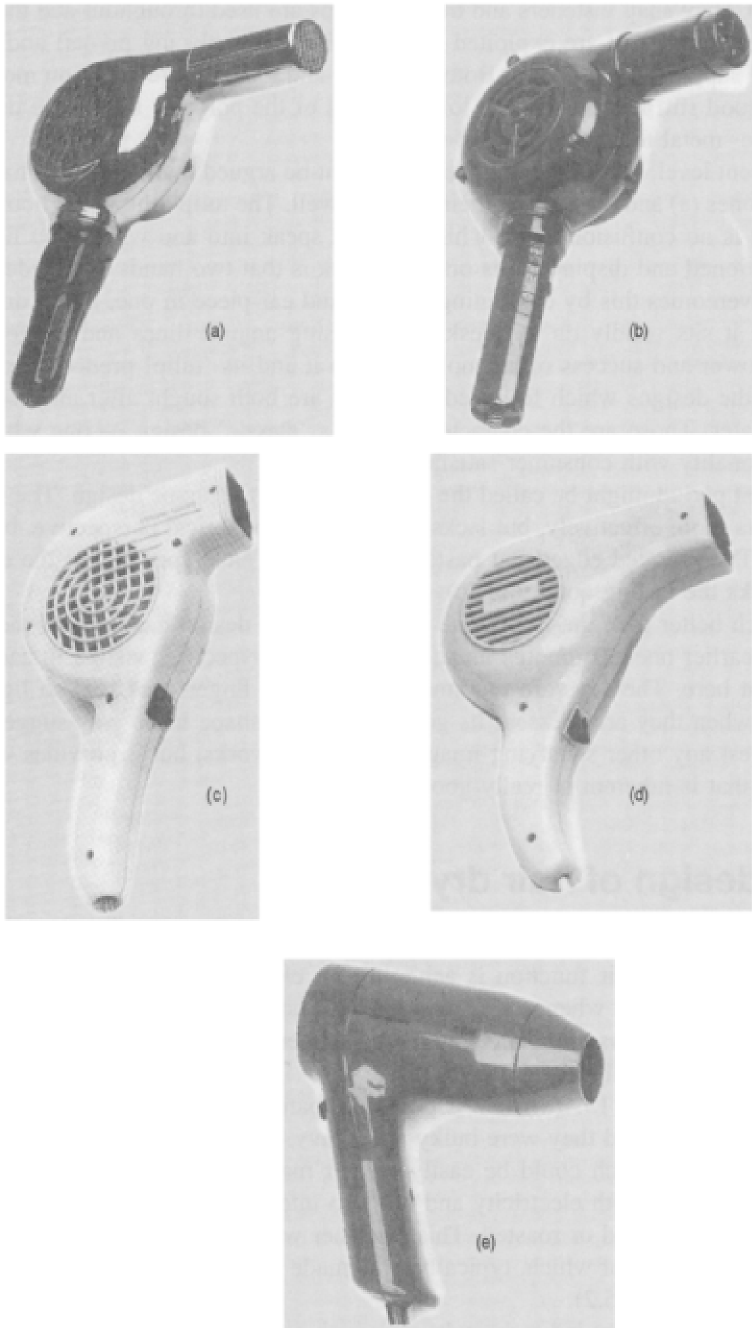

Fig. 15.4 Hair dryers: (a) a metal hair dryer of about 1950; (b) a bakelite dryer, almost identical in form to (a); (c) a plastic dryer of 1960, still influenced by 'metal' thinking, but with attractive moulding; (d) a dryer of 1965 – it has fewer fasteners than (c), but is undistinguished in design; (e) a hair dryer of 1986, exploiting fully and effectively the properties of polymers, and with a racy, youthful look. Their characteristics are given in Table 15.2.

Table 15.2 Characteristics of hair dryers and their casings

Model and date	*Power (W)*	*Weight (kg)*	*Parts*	*Fasteners*
Schott, 1940	300	1.0	5	7
Ormond, 1950	500	0.85	5	7
Morphy–Richards, 1960	400	0.82	3	6
Pifco, 1965	300	0.80	3	4
Braun, 1986	1200	0.27	3	1

they are boudoir-compatible. But their designers did not appreciate fully the advantages which could be gained from the use of the polymer: brighter colours, more complex mouldings which interlock, snap-fasteners for easy assembly and the like. There were some gains: the unit was a little lighter, and (because the thermal conductivity of polymers is low) it didn't get quite so hot. But if the fan stalled, the softening point of the polymer was quickly exceeded; most old hair dryers that survive today from this era are badly distorted by heat. Nonetheless, more efficient motors and better thermal design slowly pushed the power up and the weight down (Table 15.2 again).

The pace of change has been faster in the most recent decade than ever before. The modern hair dryer (Figure 15.4(e)), cheaper than any of its predecessors, sells for around £10 ($18) and delivers up to 1500 watts of heat. This is an enormous increase over the earlier designs, and from a unit which is smaller and lighter. This has been achieved in a number of ways, most of them relating to new materials. The fan is axial, not centrifugal. The motor is much smaller, and uses ceramic magnets and a ceramic frame to give a high power density. Sensors detect overheating and shut the unit down when necessary. The higher velocity of air-flow allows a heater of higher power density and reduces the need for insulation between the heating element and the casing. This casing is now designed in a way that exploits fully the attributes of polymers: it is moulded in two parts, with only one fastener. An adjustable nozzle can be removed by twisting it off; it is a snap-fit, exploiting the high strength/modulus ratio of plastics. The whole thing is youthfully attractive in appearance, light and extremely efficient. Any company left producing pressed-metal hair dryers when a unit like this becomes available finds that its market has disappeared.

15.6 The design of forks

The term 'cutlery' derives from the Latin cutelus, a knife; the word 'fork' from furka, a hay-fork. The cutlery industry, with a recorded history which dates back to the 12th century, was originally concerned only with the making of knives. Forks as eating-irons came later: they first appear in the 14th century, a gesture to improved table manners. Table manners in the middle ages, it must be said, lacked finesse. Jean Suplice, writing in 1480, councils that it is unseemly to grab your food with both hands at once, and that one should not scratch oneself at meals and then put ones fingers into the communal bowl. Erasmus, in Britain a little later (1530), remarks that it is not good manners to wipe your hands on your jacket after eating. But almost anything else went. Sophistication in eating, as in so many other things, seems to be an Italian import. Thomas Coryat, returning to Britain from a visit to Rome in 1611 reported that it had become customary for the Italian 'to use both a knife and a little fork, because he could by no means endure to have his dish touched with fingers, seeing that all men's fingers are not alike clean'. The British saw the point.

The forks of the 15th century had two long, straight prongs (Figure 15.5 top); it looks like a dagger, and was probably used like one. It evolved slowly towards the decorous, elegant and yet functional object it is today (Figure 15.5, centre). Or perhaps one should say: was, yesterday. Not all contemporary forks function well, nor are they all elegant — but we are getting ahead of ourselves.

The function of a fork is to transfix bite-sized morsels and transport them to the mouth. In use it is loaded in bending, and must be designed to stand this without flexing too much or collapsing completely — everyone knows the cheap cafe fork which succumbs, bending if metal, breaking if plastic, when used. And there are other design requirements. Food should not slip off the prongs and down the shirt-front on the way to the mouth; long slender prongs are better here than short wedge-shaped ones. The business-end of the instrument should enter and leave the mouth without causing injury; gentle curvature helps here. The tail should be shaped in such a way that it does not hurt the palm when the fork is used. The balance should be right; a fork which tips backwards when picked up is poorly designed. And its form, finish, and decoration should be such as to give pleasure.

With these criteria in mind, re-examine the forks of Figure 15.5. The one in the middle is a classic design known as Old English. The four prongs are long, slender, rounded on the shaft and well finished at the root. The tip of the handle is smoothly rounded with a gentle upward curve which fits well in the palm of the hand. It balances when picked up at the natural point — the high point of the neck. The form is exceptionally pleasing; it flows, and looks every inch what it is: a

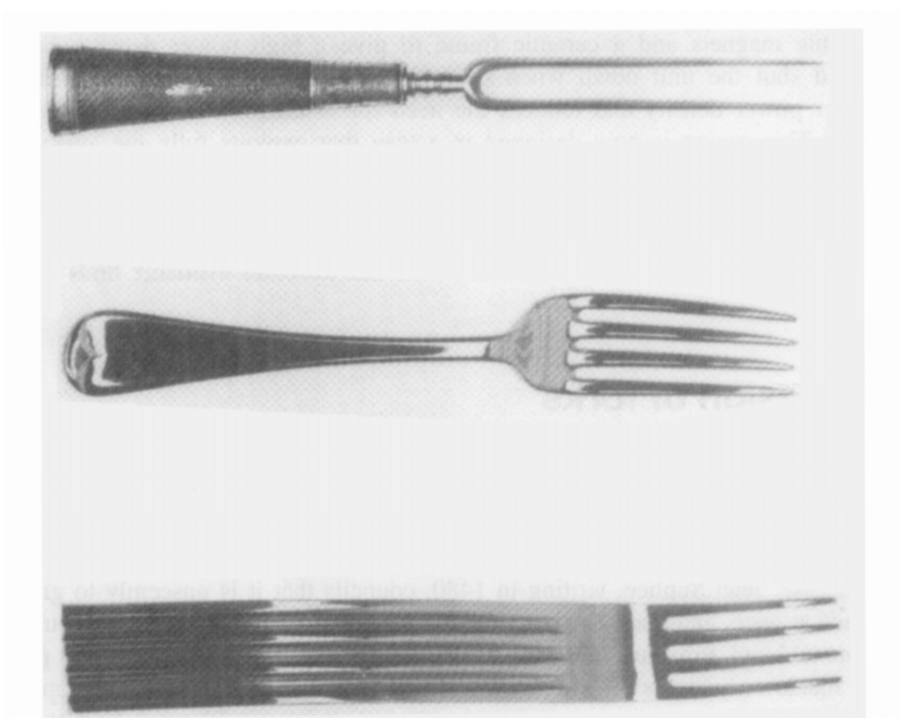

Fig. 15.5 Top: 15th century fork, more a weapon than a domestic object, but the progenitor of the elegant forks of later centuries. Middle: Old English, a classic design. Bottom: a fork of post-modernist design.

shape which has evolved to meet a human need effectively, gracefully and without pretence. Such a shape has little need of decoration, and there is little here: only the discreet double crescent, or 'rattail' as it is called, at the end of the handle.

Contrast this with the fork at the bottom, a product of the post-modernist movement. The shape is certainly striking: it has the shear linearity loved by modernists (think of modern office blocks). The longitudinal channels suggest a machine element, and by implication, mechanical efficiency. But where modernist design emphasized function, post-modernism takes modernist (and other) forms and uses them in ways which, sometimes, do not function well. This is an example. The prongs are adequate enough, but the handle is too long and too wide and because of this, it balances at completely the wrong point. The end of the handle has sharp corners which dig into the palm. The harsh form and linear decoration are better suited to the office than the dinner table, though poor balance and awkward corners are a drawback there too. Here is an example of function sacrificed to style.

15.7 Summary and conclusions

Competitive design requires the innovative use of new materials and the intelligent exploitation of their special properties. The case studies illustrate how one generation of materials replaces another, with the most successful designs exploiting the special properties of new materials. We live in an age in which polymers are replacing metals in many applications. The case studies illustrate how this can allow an enormous saving in the number of components, the use of elastic design in place of kinematic design for hinges and pivots and the use of moulded snap-fasteners to replace older screws and rivets, simplifying assembly. The successful designer has escaped from the mentality associated with the previous generation of materials, and has exploited the special properties and design freedom of the new ones. It will not end there. Novel composites now drive change in the way that polymers did in the 1980s. Ceramics, functionally graded materials, and novel manufacturing routes which allow greater freedom of shape and assembly are all just round the corner.

But today this is not nearly enough. Consumers look for more than functionality in the products they purchase. In the sophisticated market places of developed nations, the 'consumer durable' is a thing of the past. The challenge for the designer no longer lies in meeting the functional requirements alone, but in doing so in a way that also satisfies the aesthetic and emotional needs. The product must carry the image and convey the meaning that the consumer seeks: timeless elegance, perhaps; or racy newness. One Japanese manufacturer goes so far as to say: '*Desire* replaces *need* as the engine of design'.

Not everyone, perhaps, would wish to accept that. So we end with simpler words — the same ones with which we started. Good design works. Excellent design also gives pleasure.

15.8 Further reading

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On forks

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