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DESIGN, PRODUCT IDENTITY AND TECHNOLOGICAL INNOVATION

MARCH 1983

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STUDIES UNDERTAKEN IN CONNECTION WITH THE PROGRAMME OF RESEARCH

18 October 1977	Bruce Archer - Lecture, "Design Research as a Distinctive Mode of Enquiry", Royal College of Art, London (RCA).
19 October 1977	Bruce Archer - Lecture, "A Language for Design", RCA.
4 November 1977	Bruce Archer - Faculty Lecture and Seminar, Sheffield City Polytechnic.
10 November 1977	Tony Dawson - Lecture, "The Design and Marketing of a Motorcycle", Sheffield City Polytechnic.
13 November 1977	Natasha Spender - Lecture, "Experimental Case Histories", RCA.
22 November 1977	Natasha Spender - Lecture, "Introduction to Psychology", RCA.
29 November 1977	Natasha Spender - Lecture, "Statistical Methodology in Psychology", RCA.
23 January 1978	Colin Gilligan - Seminar, "Company Product Policy", Sheffield City Polytechnic.
26 January 1978	Colin Gilligan - Seminar, "The Research of Markets - Evaluation of Consumers", Sheffield City Polytechnic.
30 January 1978	Talk by the Marketing Director, Sterling Health on New Product Policy, Sheffield City Polytechnic.
14 February 1978	Colin Gilligan - Seminar, "Ideas for New Product Development", Sheffield City Polytechnic.
20-24 February 1978	Mario Bellini - "Habitat Workshop", RCA.
1 March 1978	Visit to the Ergonomics Unit, Loughborough University.
2 March 1978	Colin Gilligan - Seminar, "The Evaluation of Success", Sheffield City Polytechnic.
2 March 1978	Dr C Sutton, Head of Economics/ Business Studies - Seminar, Sheffield City Polytechnic.

9 March 1978	John Mitchell - Lecture, "Wheelchair Design", Sheffield City Polytechnic.
13 March 1978	Colin Gilligan - Seminar, "Organisational Implications of New Product Development", Sheffield City Polytechnic.
16 March 1978	Visit to Computer-Aided Design Department, British Leyland, Cowley.
17 March 1978	Colin Gilligan - Seminar, "Social Responsibilities of Marketing", Sheffield City Polytechnic.
3 May 1978	Brian Smith - Faculty Lecture, "Design Management", Sheffield City Polytechnic.
17 May 1978	Visit to the Computer Graphics Department, Bradford University.
13 October 1978	Peter Chisnall - Lecture, "Consumer Behaviour", Sheffield City Polytechnic.
27-29 September 1979	Conference, "Frontiers of Design", RIBA/SIAD, London.
21-22 January 1983	Conference, "Young Blood", Department of Design Research, RCA. (Paper given by the author.)

Note: A list of research visits is housed in the project records.

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ABSTRACT - "DESIGN, PRODUCT IDENTITY AND TECHNOLOGICAL INNOVATION"

PhD Thesis - Author: Martin Woolley MDesRCA

This research evaluates the role of industrial design in the development of technologically innovatory products (t i p's) designed for untrained users.

Technologically innovatory products are studied because of their unpredictable patterns of use, visual identity and market potential.

Untrained users are studied since it is likely that they are less well equipped to adjust to new design characteristics than trained users and thus present a greater requirement for a self-explanatory product identity.

The thesis examines recent technological developments and their potential effects on product design. A working definition of the t i p is developed and particular problems posed for manufacturers, designers and users identified. Contemporary secondary source material is employed, together with primary source material culled from interviews with design practitioners and theorists in Europe and the United States.

The concept of product identity is explored with reference to the differences apparent in professional, domestic and leisure contexts.

Four research hypotheses are established, the principal of which states "that a series of differentials exists between product design intentions and medium to long term user needs and preferences". A research method for making direct comparisons between design intentions and user responses utilising a two-part questionnaire is described. The pilot and application of the method to a single t i p - a microwave oven - is documented.

Responses are divided into four groups: operational, stylistic, manufacturing and technological, which facilitate the direct comparison of user and design responses.

The research demonstrates that there are perceptual mismatches between designer and user responses and between members of the design team itself.

The thesis concludes with an examination of the results with respect to their detrimental effects on product use, and a discussion of the potential reapplication of the method as both a research and design tool.

March 1983

PREFACE

In the summer of 1977 the author embarked on a research programme outlined by members of the industrial design staff at Sheffield City Polytechnic. A prime motive for the programme was a suspicion that developments in technology, in particular the emergence of the microprocessor, were exerting a profound influence on the design of products. It was felt that an investigation into predicted technological developments, the expectations and methods of designers in the field and the observation of product users would yield valuable insights into the changing role of the industrial designer.

The research programme commenced in November 1977 with a search of existing secondary source material in industrial design and related fields. It became apparent that there was little pre-existent knowledge on the subject under investigation. A list of Doctoral Dissertations on Design edited by Woudhuysen,(1) for example, revealed a number of studies of individual product design methods, plus studies of innovation in areas of technology unrelated to products. It was also evident that the bulk of the dissertations were written in the United States and would therefore have limited relevance to the problems of designers in the UK. A basic ground-clearing process was therefore instigated.

This process included the scrutiny of the associated fields of market research, design history, engineering, design research, technological assessment, plus initial interviews with design practitioners, theorists, manufacturers and some product users, the purpose being to acquire suitable research techniques and to construct an information-base subsequently used to construct the introductory section of this thesis. This section formed the link between the core area of investigation and related fields. (It is for this reason, and the fact that little industrial design research work exists in this field, that the introduction is extensive and forms more than one-third of the written text.)

As the research progressed, it became clear that, although developments in micro-electronic technology were significant, it would be short-sighted to limit the research method to this one aspect. A method was therefore devised which could be applied to any technologically innovatory product (t i p QV) in the consumer durable field, and which was designed to monitor design decisions and compare them with user responses to the effects of those decisions. There were two major reasons for the choice of this type of method. Firstly a generally applicable methodology would allow for further extension of the research beyond the limited scope of a single research study. Secondly, as well as providing useful academic data, the cross-comparison method could, in theory, be used in a modified form as a design tool.

Although the method has been designed to adapt to a wide range of technological innovation, it is inevitable that the subject of its application will be constantly changing. Over the five-year period that this study has been carried out, a number of social, technological and economic changes have occurred which, whilst they do not affect the methodology, tend to colour the examples and illustrations used in the text to explain the purpose and basis of the methodology. In particular, a deepening global recession and decline in UK manufacturing output would appear to place increasing limits on the rate of diffusion of technology into society and its products. Thus a number of the predicted problem areas related to user alienation have yet to emerge. Also the risks that are connected with product innovation tend to reduce the rate at which new products are designed and marketed, reducing the relevance of the method in the short term.

It is nevertheless felt that a successful procedure has been devised whereby the visual language of products can be decoded in a form which allows the direct comparison of design intentions with user responses. It is envisaged that this research will contribute, through the improved handling of the visual identity of t i p's, to the matching of the aspirations, needs and preferences of users to the production constraints of the designer.

NOTES

1 Woudhuysen, J: "Doctoral Dissertations on Design", University Microfilms International (EH), London, 1979.

M S WOOLLEY
Spring 1983

CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 RECENT DEVELOPMENTS IN TECHNOLOGY AND THEIR IMPLICATIONS FOR THE DESIGN OF PRODUCTS

Throughout the period from the beginning of the Industrial Revolution to the present time there have been obvious and unprecedented technological developments linked to equally dramatic social change and upheaval. Recently a great deal of interest has been centred on studies of the relationship between technology and society. Some of this work has been concerned with attempts to discern patterns and to assess the rates of change of technological development. Much of this investigation, although valuable, has been speculative and conflicting, with the exception of a consensus opinion that the current rate of change is extremely high.

There have been many people willing to comment on the future. Writers such as Toffler(1) have observed a threatening mass-chaos, whose possible origin may be the rapid advances in technology:

> "The high velocity of change can be traced to many factors. Population growth, urbanisation, the shifting proportions of young and old - all play their part. Yet technological advance is clearly a critical node in the network of causes; indeed, it may be the node that activates the entire net."

Others, such as Clarke(2) and Pedlar,(3) view society as moving rapidly towards an over-dependency on a technology which is unnecessarily complex and whose unpredictable side-effects are having a devastating effect on our environment and hence quality of life. Yet another, perhaps less pessimistic, group predicts that Western industrial society is transforming itself into a radically new form which may offer new possibilities for social, political, economic and technological improvement - the so-called post-industrial society. Influential authors in this group - Bell,[4] Gershuny[5] and Trist[6] - whilst disagreeing on the form that such a society might take (eg the service versus the self-service economy), nevertheless are in no doubt that a radical transformation is developing and that technological change is a major stimulus.

To identify the individual effects that technological development has on society is beyond the scope of this study. However, it is important to understand the implications for design of the changing relationship between technology and society. The first stage in gaining such an understanding is to catalogue the key issues involved.

As Cross, Elliot and Roy[7] have pointed out, there is a "chicken and egg relationship between technology and society", that is, technology can stimulate social change and vice versa, the two being virtually inseparable. In cataloguing the specific technological issues for the design of products it is necessary to include broader technologically related issues.

The most recent technological development to affect profoundly life and product design has been innovation in micro-electronics. The impact of microprocessor-based automation concerns much of the writing about the post-industrial society. Many observers, such as Dickson and Marsh,[8] believe that chip technology is at the heart of a shift from the traditional patterns of employment from agriculture/manufacture to service or self-service occupations. This fundamental change must cause a revision of the material requirements for society, which must in turn affect the products of industrial design. The direct implications for the professional activity of design are referred to by the Open University Course Team for Microprocessors and Product Development:[9]

> "The whole process of choosing a product, development, design, manufacture, marketing and after sales servicing is influenced by the introduction of the microprocessor . . . The microprocessor places few constraints on those specifying a product and those designing the product, so they can choose the behaviour, the presentation and the layout that they want. This freedom must be paid for in the meticulous attention that must be paid to the thorough specification of the product."

Thus the introduction of micro-electronics has implications for a number of production disciplines, including industrial design. However important the impact of microprocessors may be, it represents only a part of the spectrum of technological innovation and it would limit the scope and value of this research if only those products which incorporate micro-electronics were studied. However, because this research project is concerned with products that represent innovation to their users, in 'real time', only those products that are currently available on the market have been studied. Many, if not the majority, of the products, if they can be described as technologically innovatory, incorporate micro-electronic components. In order for the study to be as representative of the current design field as possible, such products are bound to dominate. However, every effort has been made to assess other forms of technological innovation. For example, early pilot testing of the questionnaire focused on the touch-control ceramic cooking hob which incorporated both micro-electronic and materials innovation.

This investigation is concerned with a wide range of technological innovation, although current developments in micro-electronic technology are particularly significant.

A consideration of the breadth of scope of the term 'technological innovation' gives some indication of the area that the research project covers. Parsons[10] provides a definition of technical innovation which is compatible with the research definition of 'technological innovation':

> "When existing knowledge is applied to satisfy human wants which result in new and improved products, materials, services and manufacturing processes, it is known as technical innovation."

although the word 'technology' should perhaps be more precisely substituted for the word 'knowledge'.

The industrial designer is directly concerned with 'new and improved products', although materials, services and manufacturing processes are all vital aspects of this concern. Products may be new and improved in a variety of ways and it is important to note that in the course of this research very few technologically innovatory products(11) incorporate just a single, isolated technological innovation. Even a purely electronics-based product, such as the pocket calculator, exists as something more than an integrated circuit in a box (if not, the component-like identity would put it outside the core activity of industrial design); separate technological innovations have been developed to facilitate the read-out/print-out functions and, in some cases, to facilitate keyboard input functions, for example with the aid of a touch control panel.

Woudhuysen(12) suggests that microprocessor technology shows "a tendency to accelerate the development of 'adjacent'(13) technologies", as the developments in calculator technology illustrate. It may also be possible that other technologies may be just as influential. This is the case in a number of the product areas that have been studied. The emergence of the microwave oven, for example, hastened the development and application of the plastic 'Polysufone' for cookware.(14)

In the creation of "improved products", alterations to an existing product to facilitate ease of manufacture have often led to the incorporation of recent electronic innovations. This trend has been encouraged by the following three factors:

(a) The rapid increase in the cost of energy, dating from the quadrupling of the price of oil by OPEC at the end of 1973.

(b) A steady increase in the cost of raw materials.

(c) The rising cost of labour, as related to other economic factors by the SPRU[15] team:

> "A continuous rise in the capital per man employed but a decline in the rate of increase in the capital productivity over the same period (from the mid or late 1960's) and in some cases a negative trend in the productivity of capital."

These three factors, although associated with negative effects, such as a decline in industrial output, have, to a degree, stimulated both the development of more economical manufacturing techniques and products which are in themselves more economical to produce. The motor car industry is a prime example of both developments. The advent of robotic production lines at Fiat and in the BL Metro, and the increasing use of integrated circuitry to improve petrol consumption, illustrate the respective changes.

The costs of energy and labour can also be viewed as major stimuli for the domination of product innovation by micro-electronics, because they facilitate the fine control conditions necessary for the reduction of energy consumption in both manufacturing process and product utilisation. Also, reductions in manufacturing manpower may be achieved by process automation, as well as reductions in post-sales servicing man-hours brought about by increased product reliability. This latter property can be seen in many solid state and electro-mechanical products such as television sets and automatic washing machines.

Again it should not be assumed that micro-electronics innovation is the only area of technological innovation which is currently responsive to the problems of energy, materials and labour. From the design point of view, the expense of raw materials is a particular area which is not open to solution by electronics applications (although the reduction of mechanical components does have a limited effect). Instead, two extreme options are open: the development of new, cheaper materials and/or the design of products which require less raw material, or which incorporate a cheaper material. In design terms, this represents à possible source of conflict, since the saturation of many of the markets for consumer durables may result in the need to alter products to suit a more affluent section of the market.[16] The designer is thus faced with the problem of increasing the apparent value of products, whilst decreasing the cost of the raw material used to achieve this 'up-market' identity.

There is a closely related problem which compounds this conflict in certain consumer durables, such as cookers and washing machines. It is caused by the use of integrated circuits to automate product control functions and hence reduce and simplify the visual dominance of the controls. A corresponding reduction of scale related to the small size of integrated circuits only adds to this (ref Illustration I1). However, as Barron and Curnow[i7] show:

> "The high front-end cost of micro-electronic systems demands relatively high short term manufacturing costs and confines application to high cost (consumer) products, which can

Internal Technology

The functional technology of the oven is imperceivable, but more complex than the non-t i p and includes: pyrolitic self-cleaning, residual burner and cross current ventilator.

Synthesised Technological Interface

The functional technology of the glass/ceramic hob has become a synthesised layer which internalises the previous explicit forms of the gas and electric plate hobs.

EXAMPLE OF THE RELATIVE LEVELS OF EXPLANATION OFFERED BY DIFFERENT TECHNOLOGICAL ZONES OF AN INNOVATORY OVEN/HOB COMBINATION

Synthesised Technological Interface

The control panel has increased functional flexibility, both in terms of programmed automation and the fact that it is now a physically remote terminal. Also the analog control knobs now take the form of digital switches. All these external characteristics emphasise the discontinuous quality of the innovation.

absorb the differential over current electro-mechanical or mechanical alternatives."

Thus, in many cases, the application of microprocessor control devices is, at present, restricted to products at the top end of the market. The paradox that this represents in visual terms is that frequently the more expensive and sophisticated the product, the less visually complex is its control function. Traditionally some consumer durables have been designed so that the visual appearance is commensurate with the monetary value of the product; at Sears Roebuck[18] in the USA, for example, the company has developed a line structure[19] to ascribe different design features to its range of washing machines:

GOOD	BETTER	BEST
low cost	medium cost	high cost
no refinement	some refinement	many refinements
one cycle	more cycles	"sud saver"
no frills	temperature control	agitator
	lint filter	plus better product features
	plus good product features	

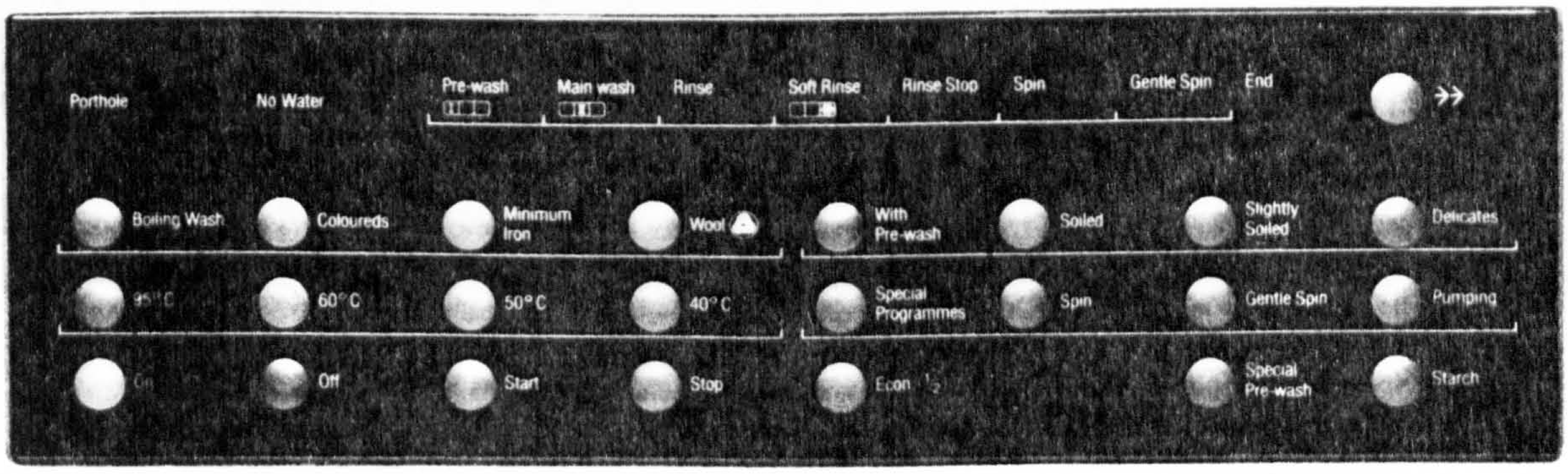
The designer, working within such a structure and faced with the need to incorporate increasingly automated controls, could easily produce an expensive design with the control simplicity traditionally associated with low cost equivalent (ref Illustration I2).

Through such examples, a picture of possible problem areas begins to emerge in terms of the 'newness' of innovatory technology, the inference being that innovatory technology creates new identities and associations which become encoded in products and which may be interpreted by their users correctly or incorrectly, perhaps with

ILLUSTRATION I2

TECHNICAL INNOVATION IN THE PRODUCT LEARNING PROCESS

The functional complexity of the washing machine is simplified by the interactive control interface through which the user participates in a learning game with the machine.



- Individual programme selection by dialogue electronics.
- Operating panel with enclosed, robust, press button controls for optimum operation.
- LED light signs during programme runs and for programme finish, as well as fault warning lights. Additional sound signals.
- Electronically controlled detergent dispenser with three compartments, and in addition a fourth direct water channel.
- Door locking device dependent on revs., water level and voltage.
- Economy key for half loads of washing.
- Integrated "economy" programme — hot wash at 60°C.
- Two electronically controlled drum speeds during washing, with eight individual drum rhythms.
- Electronically controlled motor.
- Multi-interval system with variable spin speeds for all types of washing.
- Capacity 4.5 kg.
  Drum content 45 litres.
- Programme continuation up to thirty minutes after power failure.
- A new electronically controlled water level sensor. Controls six different water levels for economical use of water.
- An electronic temperature sensor saves power consumption by determining the exact amount of energy received.
- Electronic time setting for up to six hours for use at night.
- For the first time, electronically controlled hot and cold water connection with thermatic control.
- Fluff-free water pump.
- Changeable machine door with interchangeable hinging and decor frames in merian brown.
- Two variable height front feet.
- Height adaptable plinth.
- Can be built-under.
- H × W × D 85 × 60 × 60 cm.

reference to existing traditional products (ref Illustration I3).

The investigation is particularly concerned with the new identities of products which may result from technological innovation.

Examples of this can be seen in the way many modern materials are deliberately used to simulate some of the qualities of more established ones. As Rune Mono[20] states:

> "Identities are disguised. What purports to be gold, silver, copper, aluminium, iron, leather, rubber, wood, concrete, brick or stone is something else, probably some kind of plastic."

The reasons for the apparent mass-market preference for certain traditional or quasi-traditional visual qualities, irrespective of whether the effect is genuine or simulated, have been little researched, although Lloyd Jones[21] may be innacurate when he points out that little work has been carried out in the whole field of 'the sociology of consumption':

> "Curiously enough, in view of the immense economic importance of the issue, there has been relatively little research in this area. What little work on the 'sociology of consumption' has been done has been crudely quantitative - so many people in this or that group have central heating, etc. A tiny exception are studies on the role of dress in personal and group identity . . . Given the stakes, it would surely be wise to accompany any further efforts to 'educate the consumer' with some efforts to understand 'why?' and 'how?' as well as 'what?' he consumes."

Lloyd Jones goes on to speculate about the dominance of

THE VARIABLE IDENTITY OF CONTINUOUS INNOVATIONS

The three electric kettles illustrate the fact that, although technological innovation is evolutionary, its representation in the market place is frequently lateral, innovation and non-innovation sharing the same market sectors at the same point in time. In the above case, the innovation is predominantly materials-based, new plastics being substituted for the more traditional use of steel. Yet no single kettle could be assumed to be replacing any other; they exist at the same point in time to exploit different consumer preferences. This tendency may well contribute to the difficulties in user product selection - where several rather than a single new technical innovation require evaluation prior to purchase.

The differing identities of the products may add to the selection problem - new materials may demand or make possible new forms. In the above examples, kettle 3 has departed radically from the traditional form represented by 1. Kettle 2 on the other hand, with a few minor alterations, remains within the traditional visual code. The dilemma for the designer is clear: should traditional codes be replaced by innovation and risk being unrecognizable, or should the code be retained even when functionally inappropriate?

the symbolic character of objects and the way in which incongruities in visual style can elevate this symbolic power:

> "Hence the need to draw attention to the symbol and away from the background. One way to do this is to use recognizable things as symbols, say a coach lamp by the door or a Baroque wrought iron grille - in polystyrene - over the window. Although designers may be aghast to notice that the iron is plastic, this fact is of no importance to the consumers. (When in non-symbolic mood, they are quite capable of perceiving the difference.) But, from a symbolic point of view, the lack of integration of the imagery with its background is a perceptual advantage to them."(21)

This lack of concern with the design ethics of 'honesty and truth to materials' and the 'natural self-expression of materials' is frequently fed back to the designer via sales research and marketing channels. Often during the research interviews the designers talked in terms of defending the 'purity' and 'integrity' of their work from the pressures of poor quality simulation or artificiality. Evidence that often they lose this particular battle can be seen in many of the mass-produced objects on the market. In order to make considered judgements on the user acceptability of such objects, it is vital that the implications of symbolism, for the designer, are assessed.

The identity or meaning of a product is used, and manipulated, to create sales appeal in order to make it commercially viable. Technology is most potent in a symbolic sense when it is new to the mass market, ie when it is innovatory. For this reason technological innovation can be deployed as a feature to re-style or re-think the presentation of an object in order to sell it.

Technological innovation may be utilised as a purely stylistic device. (Ref Illustration I4.)

The positive and negative effects of manipulating the identity of materials innovation can be illustrated with reference to a recently designed acrylic bathroom suite developed by 'Altulor', part of the CdF Chimie Group of Paris. In France, acrylic and glass-fibre reinforced polyester together account for only about 2.5% of an estimated annual market of 850,000 to one million units (compared with about 50% of the UK market). The company's market research indicated considerable consumer resistance to the conventional acrylic bath, because of the hollow sound and the lack of stability under pressure, which conveyed a low-quality identity. To overcome this, Altulor designed a bath with a thermoformed double skin, which is filled with a specially developed mortar until the desired 'solidity' is achieved.[22]

This illustrates a design dilemma: that the satisfaction of the consumer's demands for the simulation of traditional materials (in this case, the conventional enamel bath) may confuse the user's perception of what constitutes correct care and maintenance, for example, the abuse of acrylic bathroom fittings by the use of conventional abrasive cleaning agents.

Of course, many other innovations in materials application are nothing to do with simulation, but rather

ILLUSTRATION I4

DESIGN USING OFF-THE-SHELF DESIGN SERVICES AND COMPONENTS

"In order to achieve maximum efficiency, it is necessary to standardise production as far as possible. But to remain competitive, you must create an individual image for your various marketing outlets.

These two pre-requisites can now be linked together. The articles produced by P I allow you to vary your products during the last phase of manufacture, just before the decorative panels are to be applied. Appliances which are manufactured to identical technical specifications can therefore be given a slightly different appearance by this final touch of a different decorative panel.

This enables you to meet the special requirements of your customer, without losing the advantage of large series production."

Accompanying advertising statement for the illustration shown overleaf, by 'Plaquettes Industrielles' of France.

provide a new product with new functional characteristics (such as the ceramic hob), or exist as a partial innovation in a traditional product. The latter case is illustrated by the recent emergence of the plastic domestic 'iron' on the US market.[23]

> "The almost metal-free steam iron represents the latest commercial acceptance of phenyl oxide-based resin for high-heat electrical housewares. And it is almost a classic example of a trade-up from metal, resulting in the achievement of new performance levels . . . and operating economies. Called Seamstress II, the iron is injection-moulded for Osrow Products . . . it competes with conventional metal irons and weighs about the same - 9 lbs. The plastic version is reported totally shock-free, safe for use on all fabrics and guaranteed never to scorch. Also, thanks to moulded-in features, it can concentrate the steam as needed or permit full steam action for normal ironing."

Again the materials innovation has, in certain directions, altered the identity of an existing product. As was shown with the acrylic bath, the more accurate the simulation is in visual terms, the more likely it is that functional confusions will arise. Unlike the example of the acrylic bath, however, the confusion of the new iron with its traditional counterpart may result in a lack of awareness by the user of the new capabilities offered. For example, unnecessary care may continue to be taken to prevent scorching. By definition an innovation does not retain its status indefinitely and new materials become absorbed into the traditional environment: few people nowadays would waste furniture polish on the melamine formaldehyde surface of a table, even if the finish did, in some ways, simulate the visual characteristics of wood. The unnatural flatness and smoothness of the material is the vital clue to the user in this instance. Technological innovation has recently advanced the state of the art of wood simulation. A German manufacturer has developed a method of photographically reproducing a wood grain pattern which, accurately aligned with a three-dimensional relief pattern, creates a convincing illusion of natural wood.

Simulated materials may confuse product identity and lead to incorrect care and maintenance.

Product Identity is explored in greater depth in the final section of the thesis introduction. However, it is necessary at this stage to examine other problems connected with the design of the technologically innovatory product (t i p), beginning with a definition of the term.

NOTES

1 Toffler, A: Future Shock, UK, Bodley Head, 1970, p 379.

2 Clarke, R: The Pressing Need for Alternative Technology, Impact of Science on Society, 23, 4 (1973).

3 Pedlar, K: The Quest for Gaia, UK, Souvenir Press, 1979, p 109.

4 Bell, D: Notes on the Post-industrial Society, The Public Interest, Part 6 (Winter 1967).

5 Gershuny, J: After Industrial Society, UK, Macmillan, 1978.

6 Trist, E L: Towards a Social Ecology: Contextual Appreciation of the Future in the Present, Plenum Press, 1972.

7 Cross, N, Elliot, D and Roy, R: Man-Made Futures, UK, Hutchinson, 1974, p 13.

8 Dickson, K and Marsh, J: The Microelectronics Revolution: A Brief Assessment of the Industrial Impact, UK, Technology Policy Unit, December 1978.

9 Course Team in consultation with Lowe, J, Robertson, A and Taylor, R: Microprocessors and Product Development, Unit 3, Open University, 1979, p 40.

10 Parsons, S A J: The Framework of Technical Innovation, UK, Macmillan, 1968, p 1.

11 See 1.2 for the research definition of Technologically Innovatory Products.

12 Woudhuysen, J: How Micros Can Rub Away the Bumps on Top and Leave New Lumps Below, London, Design Magazine 366, June 1979, p 18.

13 Refer to the Glossary of Terms in the Appendices for a definition of Adjacent Technology.

14 Modern Plastics International: Meeting Design Demands, September 1977, p 37.

15 SPRU: The Current International Economic Climate and Policies for Technical Innovation, November 1977.

16 Research Interview D1, Design Manager, Creda Cookers.

17 Barron, I and Curnow, R: The Future with Microelectronics, UK, F Pinter, 1979, p 134.

18 Research Interview - Clough, Chief Industrial Designer, Sears Roebuck, Chicago 1978.

19 Ref Glossary of Terms for a definition of Line Structure.

20 Mono, R: It's Simple, It Works Well, but What is it?, Design Magazine 352, April 1978, p 49.

21 Lloyd Jones, P: A Taste of Class, UK, Architectural Review, February 1979, p 75.

22 Modern Plastics International: A Solid Feel for Bath Fixtures, April 1977, p 12.

23 Modern Plastics International: Plastics in Electrical Housewares, May 1977.

1.2 DEFINITION OF TECHNOLOGICALLY INNOVATORY PRODUCTS

Any industrially produced article which incorporates a new technology (either new to the user, manufacturer, or both) may be termed technologically innovatory. However, for the purposes of this study the definition and application have been modified as follows.

Firstly, the field is being examined within the context of industrial design and, as such, is concerned with industrially designed products, ie those mass-produced products which have a user interface.

Secondly, the innovatory technology must have some direct effect on the product/user interface. For example, it cannot be a component designed into a product purely to reduce the manufacturing cost or to simplify the production process. A more tangible example could be a cigarette lighter whose metal internal parts are replaced by a new plastic moulding, where a common external casing presents the same interface to the user. This product would not be included in the study, whereas an analog alarm clock in which the existing clockwork parts have been replaced by the electronic/quartz equivalent would be an appropriate product to study, on the grounds that the nature of the interface has altered, ie the time is more accurate, it does not have to be wound up and that it is quieter. The products selected for detailed analysis must, therefore, exhibit genuinely new characteristics and new facilities for their users which stem directly from their integral technology.

To summarise, the definition of a technologically innovatory product is as follows:

> A mass-produced useful object that requires new control techniques and which exhibits new functional capabilities as a direct result of developments in its integral technology.

1.3 THE SPECIAL PROBLEMS OF MANUFACTURE, DESIGN AND USE OF T I P'S

Many writers (including Charpie[1] and Schon[2]) have stressed the uncertainty and risk that is inevitably connected with any innovatory activity and Schon states that:

> "The notion of innovation as an orderly, goal-directed, risk-reducing process must appear as a myth."[2]

He comments further:

> "The innovative work of a corporation consists in converting uncertainty to risk."[3]

Whilst it is not assumed that uncertainty is the sole problem factor in t i p design, evidence does suggest that it is a major problem and one which impinges on all the other problem areas that have been identified.

In general terms, Charpie, Schon, Langrish[4] and other writers concerned with innovation tend to describe and analyse it within the confines of the manufacturing/research and development/design/marketing context (defined as the producer group for the purposes of this study). This study, however, concerned as it is with the differences between design intention and user needs, requires that the term 'innovatory activity' is used when discussing the behaviour of both the producer and user groups, the reason being a suspicion that there are areas of similarity between the innovative process which produces t i p's and the innovative activity involved in the purchase and use of t i p's by users.

Similarities exist between the process of designing t i p's and the process of selection and purchase of t i p's by consumers.

The above supposition[3] by Schon is an example of this type of overlap, which can be effectively rephrased thus: "The innovative work of a t i p purchaser consists in converting uncertainty to risk", which is the case during the stage when consumers are making pre-purchase decisions. ("The decision to purchase by non-owners is preceded by a period of weighing the positive and negative qualities of the product . . .".[5]) Throughout the thesis further comparisons of the behaviour of both the producer and the user are made. However, their relevance at this stage is to indicate the dual nature of many of the problem areas.

During preliminary investigations amongst manufacturers, designers and users, a small number of fundamental problem areas related to t i p's was identified, as follows:

(i) Uncertainty about the outcome of innovatory activity.

(ii) The resolution of t i p identity and style.

(iii) The relationship between technological development and market demand.

(iv) The complex and remote quality of many aspects of innovatory technology.

(v) The rapid rate of change of many technology-based industries.

There are five major problem areas which are of particular significance for this research:

(i) Uncertainty about the outcome of innovatory activity.

(ii) The resolution of t i p identity and style.

(iii) The relationship between technological development and market demand.

(iv) The complex and remote quality of many aspects of innovatory technology.

(v) The rapid rate of change of many technology-based industries.

This last problem (v) is one which does not correspond directly with an equivalent form of innovatory activity in the user group, although this does not mean that it does not affect the user group.

The following section explores each of the five problem areas identified above on an individual basis.

1.3.1 Uncertainty about the Outcome of Innovatory Activity

The unpredictable effects of technological development have been described by a number of writers and researchers. Much of this work stresses that technological innovation cannot be isolated from other, more general changes. Brooks[(6)] is worthy of attention on this point:

> "The forecasting aspect of technology assessment is complex in itself. The difficulties lie not only in forecasting technological development in the narrow sense, but also in assessing the ways in which social changes will influence the evolution of technology;

> assumptions about the state of society ten or twenty years hence are usually highly questionable. The problem is that neither social change nor technological change are independent variables. They react on each other in surprisingly devious and indirect ways and one of the consequences of this is that assessment is an art rather than a science - an art to which science has much to contribute, but for which it cannot substitute."(6)

Whilst many of these studies are on a macro-scale (eg "Methodological Guidelines for Social Assessment of Technology", OECD, 1975), the breadth of their approach encompasses many factors which may be influential at a micro-level, ie in this study, individual products. Coates'[(7)] definition of technological assessment is useful in this context:

> "Technological assessment may be defined as the systematic study of the effects on society that may occur when a technology is introduced, extended or modified, with special emphasis on the impacts that are unintended, indirect and delayed."

In this definition there is essentially no difference between the concept of a 'pure' technology and a technology embodied in a product in terms of the possible impacts so far described. Uncertainty concerning such impacts may be heightened in technological innovation by the remaining four problem areas.

1.3.2 The Resolution of T I P Identity and Style

The resolution of product identities and styles is a core activity in the field of industrial design.[(8)] It is therefore appropriate that a considerable part of this research is devoted to this area. Current debate within the design profession questions the changes in product form that innovatory technology demands or causes. This debate is reflected in a series of articles in 'Design' magazine, published between April 1978 and February 1980, where the arguments range from the highly critical stance of Swedish industrial designer Rune Mono:[9]

> "With the rise of solid-state technology, functional design values threaten to reduce all products to featureless and meaningless boxes."

to the acceptance by G Hollington[10] that:

> "It is not surprising that we seek to suggest their (electronic products) power and complexity by constructing a succession of enigmatic shells."

Developments in micro-electronic technology may diminish the perceived identity of traditional products.

What is common to all these viewpoints is the idea that current developments in technology radically affect the criteria by which product identity and style are determined by the designer. It is the conflicting views within the community that have led to the supposition that special problems exist in determining appropriate t i p identities. The lack of evidence that particular product identities and styles are more or less successful in use suggests the need for investigation of the possible problems connected with the interpretation of these visual characteristics.

It is useful at this point to differentiate between product identity and product style. A suitable definition is encapsulated within the statement by Rune Mono[9] that:

"Products are losing their identity. Our ability to recognise what things are, what they do and what their purpose might be is slipping out of our grasp."

In other words, product identity is the expression of what a product is, what it does and what its purpose might be. One might also add that it is derived only from those characteristics embodied in the product itself, and does not include information from any other source, such as advertising. From this definition, a definition of style follows, as being the mode in which this expression is presented.(11)

There are therefore parallels between visual identity and verbal language, as both comprise information content and manner of expression. A questionnaire technique has been used to explore this relationship by documenting the informational content of products as intended by the producer and perceived by the user. Similarly, the attitudes of the producer group towards style, and its acceptability to the users, have also been explored.

The fact that there is a general lack of information and research about user product perception is summed up by Archer:(12)

"Almost the whole of the development of design theory and practice has concentrated on modelling the relations between design decisions and building properties. Apart from a rather limited concern with the geometry of good form, in either the classical or Gestalt sense, there has been little effective work on the relations between the properties and value attributes. There has been even less on the relations between attributes to which people attach value, and the objectives which they are trying to pursue . . ."

It is this knowledge gap that the research topic seeks to examine, analyse and partially fill.

The investigation seeks to examine, analyse and partially fill the knowledge gap that exists about the way products are designed, and their intended purpose.

1.3.3 The Relationship between Technological Development and Market Demand

There are indications that this could be a major problem, judged from the existing controversy within the design profession and elsewhere. They are most commonly argued under the "technology push/market pull" heading, where the dominance of technological development is seen as running counter to user needs, or alternatively the dominance of immediate user needs is believed to inhibit technological progress. For a balanced view of this dilemma it is necessary to quote Langrish, Gibbons, Evans and Jevons:(13)

> "The motor car, television and photography are all examples of technology push innovations. No market for horseless carriages, the transmission or the recording of pictures could be said to have existed prior to invention and innovation. The innovation created a 'need' when people perceived the difference between what they had and what they might have.
>
> A thousand megawatt generating sets and by-pass jet engines are examples of market pull innovations. The generating boards' requirement for cheap electricity in the first case and the airlines' and public demand for quieter aircraft in the second, appear to have led to the innovations. The 'need' existed prior to invention and innovation. Many 'affluence' consumer goods (central heating, home freezers, etc) appear to involve

both technology push and market pull.

> In general it is difficult to find clear-cut examples of innovation determined either by technology push or market pull factors. Market pull, however, appears to be more common. In a study of 84 innovations that won the Queen's Award for Industry, nearly half were categorised as having been influenced by market pull, only five by technology push and the remainder by a mixture of the two."

The products studied in this research incorporate some form of technology, which could be there either as a result of technology push or market pull. Langrish et al,[13] in their study of Queen's Award to Industry winners, defined the phenomena of 'push' and 'pull' as follows:

> "If a sales manager realises that a product needs a particular new property and then persuades the firm to develop a product with this new property, then the innovation is of the 'need pull' type. If, on the other hand, a research department discovers a material with new properties and the firm attempts to find out if the new properties have any commercial value, then it is an example of the 'discovery push' type."

Evans[14] takes the view that whichever of the forces causes the technology to be present is relatively unimportant, as each is capable of contributing to the success of the final product. Important, however, is the way in which the product as a whole meets the requirements that the user places on it. As Walker says:[15]

> "Technically centred product innovations can often result in commercial failure if their designers do not reflect the correct needs, level of understanding and familiarity of the consumer with the application areas."

The technological input for products originates from a variety of sources, such as research and development programmes within companies or public research establishments, eg advanced programmes in aerospace. Three examples are cited below to show that those responsible for technological development can exert pressure to utilise the technology more rapidly and widely, irrespective of demonstrable existing needs. In the first example the broad field of electrical technology is the subject of a conscious attempt to encourage the transfer of technology from research to products:

> "The Electricity Council's Research Centre at Capenhurst, Cheshire, is anxious to speed up the rate at which new technology comes to the marketplace. Consequently it is setting up a special commercial division which will liaise with companies at a much earlier stage in the investigation of new fields."(16)

In the second example a similar attempt is made in the field of micro-electronic technology, with the emphasis on the speed rather than the effectiveness of transfer:

> "Having established itself as one of Europe's leading centres of research on microprocessors, UMIST has now branched out to channel its ideas and know-how through to industry.
>
> The Micro-electronics Applications Unit's main aim is to bridge the notorious gap between British research and British development in this field.
>
> In offering its research, development and consultancy services to industry, the overriding objective will be the quickest possible transfer between the laboratory and the production line."(17)

(Note the emphasis on speed rather than effectiveness of transfer.)

Finally, the deliberate speeding up of the 'spin-off' process from the aerospace programme is described by the director of the Technological Utilisation Office, specifically established for the purpose:

> "There have been many examples of serendipity in the course of the United States' space exploration programme. But rather than rely on accidental discovery, the National Aeronautics and Space Administration began as early as 1962 to identify and widely disseminate information about these useful scientific and technological advances and thus accelerate their application to benefit mankind.
>
> From this effort, which has been deliberate, structured and planned, has come a steady stream of new products and processes."[18]

Equally, there are examples of market 'pull' in which an identified demand induces an appropriate technology to be developed:

> "The first microprocessor was developed by INTEL Corporation in 1971 in response to an order placed by a Japanese calculator manufacturer who required a custom-built processing chip which could perform arithmetic and other functions and yet be cheap enough to allow the selling price of the calculator to be sufficiently low to create a mass market."[19]

In an article in Design Magazine in 1977,[20] Woudhuysen argued that a method of manipulating 'invention push and demand pull' for optimum success requires specialised design information systems. He went on to quote Pitts,[21] who "regards the general lack of 'demand pull' data sources for designers as especially crippling, citing consumer goods as an example."

There is a potential problem for the consumer. It is possible that the selection and purchase of t i p's is especially difficult and confusing and that an over-dominant technological emphasis may heighten this problem.

Parsons[22] elaborates upon this argument:

> "Technical change has obviously affected consumers through the introduction of new and improved goods, some of which are complex engineering products. New materials have been introduced with special characteristics. The major problem which confronts the consumer is choice. To make an effective choice it is necessary for him to be able to discriminate and to select from a number of alternatives. Modern advertising methods also have created difficulties. Advertisements may make exaggerated claims for the products with which they deal and consumers often find it difficult to assess their true worth."

It must be added that inappropriate product identity may contribute as much to the confusion of consumer choice as the advertising slogan or the complexity of product technology.

Inappropriate product identity may contribute to the confusion of consumer choice at the pre-purchase stage.

Parsons' point, that for the consumer to make an effective choice it is necessary for him to be able to discriminate and select from a number of alternatives, must be closely examined with respect to t i p's. It should also be borne in mind that current innovations in sales, and marketing methods play an important role in the discrimination process.

Rogers[23] has outlined and defined five stages in the consumer innovation adoption process: (a) awareness, (b) interest, (c) evaluation, (d) trial, (e) adoption. These are discussed in the appendices 6.6, under "The Five Stages of Adoption of Innovation by Consumers".

1.3.4 The Complex and Remote Quality of Many Aspects of Innovatory Technology

The reference here is to 'new' technology that is currently diffusing into products. This does not include the 'innovatory' qualification which refers to the period when technology is new to the mass market. The basic premise is that, because much new technology is complicated beyond the understanding of the average layman, it can contribute to the general alienation of the user from the product environment. The current importance of electronic technology may be slightly misleading, in the sense that many other forms of technology may contribute to this 'alienating' effect, such as: sealed mechanical units within products which prevent self-maintenance; the use of new materials camouflaged as traditional ones, causing confusion over maintenance and care; the increased disposability of many products, which may reduce the care and attention required for successful operation; the high rate of change of technologies, making 'keeping abreast' of product developments difficult.

The complexity of technological innovation may contribute to user alienation.

In this section, current attitudes to the notion of alienation will be examined, both from the point of view of design and other related disciplines. It will be demonstrated that these attitudes are often conflicting and very few are based on research-based evidence.

An extreme view is expressed by Pedlar[24] who, in a recently published book, presumed that a commercial conspiracy misleads consumers by deliberately designing a false value system into products:

> "The luxury cooker does not cook food quicker or more elegantly, and it does not have a longer life-time, given the same degree of care, as the cheaper one. The second cooker certainly lacks a spit-roast and electronic controls, so the owner cannot turn meat while it is cooking, nor can he or she go horse racing or play bingo while the cooker is lit, since it requires human attention. The difference between the two is nothing to do with quality.
>
> The real difference (apart from £866 in cash) is one of shape and massiveness. In the expensive cooker every surface, door and handle has been exaggerated by a stylist, and uses more metal than the other. It has more stove enamel, more plating, more chrome-plated edging strips. It is also more difficult to use successfully - a training in computing logic would be an advantage."

Here advanced technology is equated with superficial and wasteful styling techniques which, in later statements in the book, compound the vulnerability of the user to the effects of breakdown in the surrounding technology-based society. In a similarly critical appraisal of contemporary US product design, Papanek[25] links the mis-application of technology to a reduction in the quality of products:

> "This attitude has spawned scores of 'new' concepts; hot-doggers, fry-daddies, little macs, do-nut fryers, rotating toaster-ovens with inboard music systems and menu calculators, carving knives with headlights, electric carrot-peelers (that must be worked more slowly than the manual kind, but are harder to clean), electronic shoe horns and battery-driven rolls of toilet paper dispensing horoscopes; the list is endless.
>
> Without doubt some unknown 'scientist' is

hard at work to develop the ultimate electronic grapefruit knife, a vibrator to massage the backs of people whilst driving to the supermarket, an electric page turner for comic books or a 48-inch TV set that looks like a Mongolian officer's desk at the time of Tamburlane.

Each product is shoddily made, rarely performs its ridiculously limited job and usually breaks down before its short warranty period is over."

In this case the consumer is viewed as an easily seduced recipient of comparatively useless products, whose technology promises far more than is provided in practice and whose lack of utilitarian value makes any joy in use impossible.

In a recent address to the Industrial Designers Society of America, Nader(26) recognises that products are increasing in complexity and relates this to a failure on the part of the manufacturer to respond to user needs:

"So as the products become more complex or more penetrating technologically of human values like health and safety, it seems that your interest extends to that level of penetration . . .

It is absolutely astounding the extent to which modern design and merchandising can make consumers accept the parameters of what is appropriate and what is desirable.

The human beings are expected to adjust to the products and the technical environment rather than the products and the technical environment required to adjust to human frailties, anticipating human misuse as well as not putting excessive burden on the motor and the sensory capabilities of the human being."

Human beings are often expected to adjust to the products and the technical environment rather than the products and the technical environment required to adjust to human frailties. (R Nader)

Although in many ways Nader is subscribing to the 'commercial conspiracy' views of both Pedlar and Papanek, his attitude towards technology would appear to be more ambivalent. He sees the role of technology as being essentially a neutral force which is just as capable of improving product performance as reducing it. Indeed, his final comment in the quotation suggests that technology might well reduce direct human control over products in a beneficial way, particularly with regard to safety, human fatigue and error.

Technology may reduce direct human control over products in a beneficial way.

Thus Rune Mono[27] links disposability and complexity to some broader social issues:

> "More and more products are made for use only once; and an increasing number of complicated products, though not explicitly disposable, are made impossible to repair. Thus we are denied the possibility - and, I would say, the pleasure - of getting to understand things through studying the way they work . . .
>
> And paradoxically, these anonymous products are often made unnecessarily complex to use. Just for marketing reasons.
>
> These factors are dangerous because they interact with other, well known forces in our community, seemingly trying to make us passive, alienated and unaware of what is really going on."

In discussing the collective effects of new products, Mono draws general conclusions about user responses. Individual product characteristics may be relatively insignificant or even apparently beneficial. On the other hand, the cumulative effect of related characteristics across a number of new products when operated by a single user may be less easy to predict, evaluate and control. For example, a high degree of automation, when applied to one kitchen product, may reduce the overall workload to a more tolerable level, but the automation of a number of kitchen tasks may reduce the job or role satisfaction. There is an analogy here between domestic chores and factory production line work.

A more extreme view of technology is held by Stanley(28) who postulates a growing disenchantment throughout society:

> "Yet the fear of technology not only persists but has found new and widely ranging expression within this century. Such expression ranges from serious philosophical and sociological literature and anti-utopian fiction, to counter-culture youth movements. At the heart of this pessimistic reaction is a general conviction that there is something about technological norms and values that is capable of eroding or destroying non-technological norms and values.
>
> Can it seriously be maintained that there is something about modern technology that comes to dominate persons and transform them into functions of technology?"

Thus, alienation is seen as the substitution of technologically related values for more traditional social values. This view is frequently voiced in terms of the industrial worker's alienation from mass-production manufacturing techniques, boredom, lack of involvement on a skill or craft level, and the limitation of personal decision-making being frequently cited side effects. It is less frequently voiced in terms of the non-professional, untrained participant in industrial society. However, as Gershuny[(29)] shows, there are increasing changes in industrial and domestic, economic and behavioural patterns:

> "This growth in consumption of goods represents a fundamental change in the nature of economic activity. Instead of capital investment taking place in industry, and industry providing services for individuals and households, increasingly capital investment takes place in households leaving industry engaged in what is essentially intermediate production, making the capital goods - the cookers, freezers, televisions, motor cars - used in home production of the final product."

The domestic environment may, therefore, be currently viewed as a microcosm of the industrial production unit of the past and it could well have inherited, or be in the process of inheriting, many of the supposed alienating aspects of the industrial milieu. Stanley's substitution of technologically related values for more traditional social values may conceivably occur within the domestic environment, with the ensuing aforementioned problems of boredom and lack of involvement in personal decision-making. One must, however, tread carefully, as many of the strategies devised by industry to counter such problems may already occur naturally within the domestic, self-service environment. An example would be job-rotation, which automatically exists in the domestic environment because of the wide variety of final 'products'. Similarly the domestic 'worker' also has greater autonomy over the use and application of work time than his or her industrial counterpart, so that unrewarding domestic tasks, speeded up by automation, will increase the time which can be devoted to other activities.

Technological and social changes in the domestic environment may cause alienating effects, which have been more commonly associated with the industrial environment in the past.

Gershuny's self-service domestic environment has important implications for design generally and t i p design in particular, in that it raises considerations for critical assessment of job satisfaction, professional development and career fulfilment within a domestic context. The products of new technology cannot be viewed in isolation, but rather as elements in the consumer environment. The concept of user alienation can only be fully evaluated in terms of a complete role and, if that role involves the use of several products, it is the combined effect of all those products that must be assessed. Job satisfaction for a housewife may depend upon both a sense of skill and efficiency. In many domestic products these qualities are not mutually compatible. A highly automated cooker (such as the AEG Cookbit) which saves time and effort may reduce the sense of skilful involvement with food production. This may not be true in the case of an automatic dishwasher, where a sense of 'professional' competence may be engendered by the sheer speed and efficiency with which the task is accomplished. To throw a blanket of automation over all products used for domestic tasks may well reduce role fulfilment, so that it could be equated with the drudgery associated with labour-intensive housework of the past.

It may be argued that, although such factors are important, the designer has little control over the way different products relate to each other. He is bound by the current rules of commercial production (as well as sales competition) to concentrate exclusively on the individual product. However, this is to ignore the changes that have already occurred and which continue to bring about a more direct relationship between many products. The kitchen is a good example - with the increasing use of modular unit sizes and the linking of different machines (such as washer/dryers, microwave/ infra-red/convection ovens), the modularisation of functional components (the food processor) and the extension of product ranges within large manufacturing companies all serving to encourage a more unified[30] working environment, similar to the modularised work stations to be found in offices and factories.

The complex and remote quality of many t i p's itself contributes to a reduction in required user skills, in parallel with many industrial production methods. There are conflicting attitudes on the necessity for product users to understand the internal working of products. On the one hand, the Consumers' Association[31] has made the general complaint that product instruction literature is frequently inadequate, in that it fails to explain why an action should be carried out whilst explaining how; the Association believes that it is, therefore, less easy for the user to operate the product logically. On the other hand, a number of companies, when interviewed, firmly believed that it was unnecessary and frequently impossible to convey such information to the consumer. For this reason a key aspect of this questionnaire method examines the level of understanding of the product required by the user and correlates this information with the views of the t i p designer and the information considered necessary to explain the function of the product.

1.3.5 The Rapid Rate of Change of Many Technology-Based Industries

There is little doubt that we are moving through a period of rapid technological transition. This view has been voiced by numerous writers, economic, technological and social pundits, from Tofler(32) to Schon(33) (to take two extremes). The link between the technological innovation that has been responsible for this transition and commercial competition is stated clearly by Jewkes, Sawers and Stillerman:(34)

> "The supposed antithesis between price competition and innovation competition is false: they are different forms of the same competitive process. Innovation is competition."

The competitive edge that an innovation offers a company over its rivals is a fundamental consideration, when assessing the value of its development and manufacture. As was made clear previously, user needs with respect to innovation are difficult to determine or prove, but competitive advantage may be relatively easy to demonstrate and so will provide the motivation for a project. As Jewkes et al[34] point out:

> "Competition is in itself a stimulus. The knowledge on the part of one firm that other firms are on the same track forces them all to move more rapidly, the prize lies in what can be gained from priority and, transient as the lead may be, it still remains a powerful motive."

It is possible therefore that conflicts may arise between competitiveness and long-term user needs, in certain areas of innovation. A hypothetical example which illustrates this point is a company pressed to market an innovation which is incompletely developed and which may be detrimental to long-term use, in that the first generation of users may be hindered by products which become obsolete in a short time.

A further example of competitive pressure running counter to user requirements may be found in the lack of compatibility among certain tape, disc and film products. This is particularly evident in the variety of conflicting video tape and disc standards that are currently available; not only are there differing standards between companies but, in some cases, the design evolution within a company is so rapid that different system standards may exist within the company's own product range. This is made clear in the following passage:[35]

> ". . . Currently, the conflict and confusion over systems must deter the first time purchaser. And anyone who has already bought one system - for instance the Philips 1502

> machine - and seen it apparently made obsolete overnight by the introduction of another from the same stable - the Philips N1700 - will naturally be nervous of any further spending of such large sums of money."

There is some evidence in the domestic video field that standardisation is occurring by way of agreements between the manufacturers of similar systems, such as Philips/Sony and RCA/JVC.[36] These negotiations do not always appear to centre around the relative merits of the systems for their eventual users. For example, in April 1979 Philips and Sony manufactured similar systems. The Sony video disc unit played 30 minutes per side with a stop-frame facility and the equivalent Philips unit played 60 minutes per side, without a stop-frame facility. The resolution was achieved by the willingness to compromise of one of the companies on manufacturing grounds rather than according to user requirements.[36]

This problem is particularly acute for manufacturers of hardware, who rely upon firmware produced by other, possibly competing, companies. Examples may be found in the fields of computing and photography. In the latter case GAF, in proposing a film standard for its movie camera, relied upon film cassette specifications obtained from other film manufacturers, such as Kodak and Agfa, leaving the product vulnerable to any technical changes made by the film manufacturers.[37]

In the highly competitive field of consumer products, product planning for these companies often consists of "introducing a feature, incorporated as part of the product, that competitive products do not have, or to improve the function of that product".[38] On this point Schon's view,[39] in the context of the technological climate of the mid to late sixties, is as follows:

> "In the consumer products field, most technical effort is devoted to minor product change or to quick imitation of live items developed by competitors. The profitability of those firms seems to vary more with the effectiveness of their marketing and market research than with their technology."

Within the context of this period, the 'minor product changes' are probably references to superficial stylistic changes and hence a moderately evolutionary approach to design was possible. However, the current rapid development in many areas of technology, combined with the search for original product features (mentioned by Clough),[40] has possibly created a problem for the manufacturer. Modifications are not always a 'minor' or 'quick imitation' of competitors' products, for today it is not perhaps as easy as it once was.

One argument put forward by Schon[41] does have perhaps even more relevance to the current situation than it did in 1967:

> "The concept of satisfaction of human need has been eroded in similar fashion. With the important exception of the abiding poor, we have become so well satisfied, to the extent that products satisfy, that it is progressively harder for industry to discover new needs for products to fill. But the requirement of expanding industrial production is essential to industrial growth, which, as we have seen, is one of the

> cardinal principles of corporate life. It forces companies to ever more frenetic proliferations of products, to finer and finer product differences, so that distinguishing one product from its competitor becomes more and more difficult, and to the exercise of increasing pressures on consumers to consume.
>
> There has been an ironic reversal in the relationship between producers and consumers so that it is no longer possible to say whether producing industries exist in order to satisfy consumer needs or whether consumers, goaded by ever more persuasive advertising, exist as appendages to the system of industrial production."

An extreme example of such a relationship is reflected in the life-cycle of the pocket calculator which, in less than a decade, has evolved from satisfying a well-defined need to a myriad of minimal product variations, such as a wristwatch/calculator and a cigarette lighter/calculator, which have rather questionable functional capabilities. The danger is that the benefits of technological change become misdirected into blocking or filling a market gap, without in any way perceiving or fulfilling a 'need gap'.

The five problem areas that have been outlined in this section form the basis of the second hypothesis of this investigation (ref 2.2.2).

In investigating and documenting the relationship between the designer's intentions for the t i p and long-term user perception of t i p characteristics, this research project seeks to explore the parallel relationship between perceived market gap of the producer and perceived 'need gap' of the user.

This research is concerned with an investigation of the relationship between the marketing intentions of the producer and the requirements of the consumer.

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1.4 ALIENATION AND THE TECHNOLOGICALLY INNOVATORY PRODUCT

The following section examines existing theoretical work concerned with the alienation of the industrial worker and extends it to include users operating in non-industrial settings employing technologically innovatory products. There is an assumption, which is based upon Ollman's[1] interpretation of Marx's theory, that products can affect their users beyond the satisfaction of a particular user need:

> "Besides manipulating people's needs, the form given to articles of consumption helps determine the prevailing mode of consumption. Every product carries with it a whole set of accepted usages. Taken together they constitute the greater part of what is meant by the way of life of the people."

Hypothesis (a) (see Chapter 2), "that a series of differentials exists between industrial design intentions for products and medium to long-term user needs and requirements", is essentially concerned with the difference between the 'effects' of an individual product on its users and the preferred 'way of life' of the user.

The concept of personal alienation has a long political and sociological history, stemming from the early works of Karl Marx,[2] which describe the alienation of the industrial worker. This estrangement is seen as a consequence of two basic phenomena:

(i) The capitalist economic institution;
(ii) Modern factory technology.

(i) In the first category, Marx views the property ethic as being responsible for a system in which the factory belongs to the entrepreneur - who has the legal and social power to hire labour, to market and sell the products of the enterprise, and to personally appropriate the profits. The worker has no legal or social claim to the product of his labour, the profits do not benefit the worker personally, there is no motivation to work with energy and intelligence because the employee is isolated from the system of organised production and its goals, and so he is therefore unlikely to identify with the enterprise. Secondly, because such employment does not allow control, it reduces the sense of purpose and so work becomes simply a means of economic survival. Productive work, which Marx believes is the means of attaining self-identity, is relegated to the elementary animal level of satisfying material needs.

(ii) The second category, modern factory technology, is seen to be responsible for the powerlessness of the employee - automation has reduced the control of the individual, by which craftsmen and peasants had previously regulated the pace and nature of their tasks. Factory technology thus dominated the worker, rather than the reverse.

More recently Seeman(3) has utilised Marx's concepts in describing the industrial climate of the late 1950's. In his analysis the four types of contributory factor which Marx believed caused alienation are shown to have a current relevance. They are (a) powerlessness, (b) meaninglessness, (c) isolation and (d) self-estrangement. Blauner[4] provides the following brief description of each:

> "<u>a. Powerlessness</u>
>
> The split in man's existence and consciousness into subject and object underlies the idea of powerlessness. A person is powerless when he is an object controlled and manipulated by other persons or by an impersonal system (such as technology) and when he cannot assert himself as a subject to change or modify this domination. The non-alienated pole of the powerless dimension is the state of freedom and control.
>
> <u>b. Meaninglessness</u>
>
> Alienation reflects a split between the part and the whole; a person experiences alienation of this type when his individual acts seem to have no relation to a broader life-programme. Meaninglessness also occurs when individual roles are not seen as fitting into the total system of goals of the organisation but have become severed from any organic connection with the whole. The non-alienated state is understanding of a life-plan or of an organisation's total functioning and activity which is purposeful rather than meaningless.
>
> <u>c. Isolation</u>
>
> Results from the fragmentation of the individual and social components of human behaviour and motivation. Isolation suggests the idea of general societal alienation, the feeling of being in, but not of, society, a sense of remoteness from the larger social order, an absence of loyalties to intermediate collectivities. The non-alienated opposite of isolation is a sense of belonging and membership in society or in specific communities which are integrated through the sharing of a normative system.
>
> <u>d. Self-estrangement</u>
>
> Is based on a rupture in the temporal continuity

> of experience. When activity becomes a means to an end, rather than an end in itself, a heightened awareness of time results from a split between present engagements and future considerations. Activity which is not self-estranged, but self-expressive or self-actualising, is characterised by involvement in the present-time context. Self-estrangement also entails a separation between work life and other concerns. When work is self-estranging, occupation does not contribute in an affirmative manner to personal identity and selfhood, but instead is damaging to self-esteem."

There are a number of reasons for the inclusion of this theoretical work on alienation in the thesis, even though it describes professional employment rather than the untrained user/domestic context of this research. The reason for inclusion is the blurring of the differences between professional and untrained/domestic activity, already referred to in Section 1.1, so that some elements of the alienation theory can be more widely applied to include unpaid 'work'.

Social attitudes to what constitutes work have altered considerably since Marx's time. In particular, the emancipation of women has provoked a re-evaluation of the significance of housework, to the extent where serious debate has been devoted to the adequacy of remuneration for such work.

The nature of certain types of domestic activity has also altered in a way that mirrors many of the methods employed to improve the efficiency of industry. This is not confined to automation (such as the washing machine) but extends to less obvious areas, such as high volume purchasing for freezers, the use of more efficient chemical cleaners and the decreasing maintenance requirements of many products.

An economic study of the changing domestic environment was recently carried out by Gershuny,[5] in which he produces evidence which contradicts Bell's[6] assumption that, as primary and secondary goods require a decreasing labour input, then growth in production and employment will be concentrated in the tertiary 'services' area.

There is an indication from Gershuny's study that the economic and social role of many domestic t i p's has altered to such an extent that they increasingly resemble scaled-down industrial plant. Thus there is the possibility that Blauner's alienation thesis, associated with industrial plant, may well be applicable to some t i p's in both a domestic and industrial context.

One must proceed cautiously, however, as changes on both the industrial and domestic front have not been one way. Just as technology has de-skilled and increased the tedium of certain occupations, so it has removed the drudgery in others or promoted the demand for a new set of skills. Similarly, certain domestic chores which were repetitive and monotonous, as well as others which were highly skilful, have been displaced by technology. The complexity of such transitions is demonstrated by a simple comparison between the domestic cleaning process for dishes and for laundry. The former has been associated with a low level of skill and a high level of monotony; the advent of automation in the form of the dishwasher has simply reduced the amount of time devoted to this fairly undesirable task. On the other hand, traditional hand laundering, whilst possessing unskilful, monotonous elements, also included quite demanding components in the form of cleaning certain types of natural fabric. Technological developments, in the form of new man-made textiles, dry cleaning services and automatic washing machines have de-skilled the washing process. It could be argued, however, that a new set of more cerebral skills are required to cope with fabric identification and decisions about the appropriate machine function.

Technological developments may have de-skilled some activities but it can not be assumed that new skills are not created or demanded in the process.

In other areas reductions in apparent skills have been counteracted by broadening the scope of product capabilities. In the cooking process the technological leap from the solid fuel range to electric or gas stoves increased direct control over the process and consequently reduced the traditional ingenuity required. At the same time there was a rapid expansion in the range and variety of diet, which called for, or was made possible by, new cooking skills.

A number of advertising campaigns for t i p's with increased automation put an equal emphasis on the widening of product capabilities and on the time-saving and convenience factors.[7]

The picture is further complicated when the environment in which the product is situated is examined and seen as an interactive system, possibly comprising a large number of similar or dissimilar products. The exact combination may determine whether the user is generally alienated or not. With this range of possibilities it would be misguided to attempt an all-embracing theoretical approach to t i p alienation.

1.4.1 Alienation Theory and T I P Design

The previous section examined four types of alienation which were identified by Blauner as being frequently experienced by manual workers in industry. These have been related, where possible, to the wider context of t i p operation on the basis of Gershuny's thesis that a positive movement of capital equipment into the home has, and will continue, to occur, thus broadening the areas of activity where technologically related alienation can take place. Blauner's view is that the Marxist origins of alienation are rooted in the formative period of the industrial revolution and therefore take no account of any corrections made as the industrial society matured. From the point of view of this research, the assumptions that Blauner makes concerning 'maturation', in the sense of a radically improved industrial society, may or may not be true. What is undeniable is the changed nature of industrial production, particularly in the area of automation, which perhaps throws open to question certain of Marx's theories concerning the relationship between exploited labour and production. Nevertheless, it is acknowledged that the possibility of alienation through product operation may still occur and inappropriate design parameters may be a major contribution.

It is also recognised that another, as yet undiscussed, form of alienation was defined by Marx as the "fetishism of commodities", which in some respects can be viewed as an extension of the alienation of industrial production methods, to include the final product itself. As Marx, quoted by Ollman,(8) says:

> "The product is . . . but the summary of the activity, of production . . . In the estrangement of the object of labour is merely summarised the estrangement, the alienation, in the activity of labour itself."

Hence the final product is seen to symbolise to the worker all the previously mentioned, detrimental aspects of the production process itself. The almost mystical connotations which Marx ascribes to the product's symbolic value are described by Ollman:(9)

> "The interaction which occurs in all productive activity between man's special powers and their object results, in capitalism, in a one-sided enrichment of the object. The product gains in power the more the worker spends his own and, Marx maintains, even acquires qualities (now suitably altered) that the worker loses. As the embodiment of powers the workers no longer have, products may be spoken of, Marx believes, in ways otherwise reserved for the people who produce them."

When the products of labour are exchanged or sold, Marx suggests that people begin to misconceive what the objects really represent in terms of labour and resources and begin to graft human characteristics onto the inanimate objects, as a substitute value system. This is referred to as the "fetishism of commodities". The extremity of this vision of the product can be judged from a statement by Marx in "Capital"(10) describing the fetishism of commodities:

> "This false appearance and illusion, this mutual independence and ossification of the various social elements of wealth, the personification of things and conversion of production relations into entities, this religion of everyday life."

Such is the potency of the 'deception' that Marx believed the symbolic power of the product existed for other people besides the worker directly involved with its manufacture and hence its false value had a distorting effect on the value system of society as a whole.

It is not central to the scope of this research that this view of products is tested. The inclusion of the term 'product identity' in the title implies a detached observation of the phenomenon, rather than either a critical or approving stance. However, it is recognised that mass-production methods, whilst providing many advantages, notably low cost/volume ratios, do create a restrictive climate of knowledge of, and involvement with, the production and design method.

Mass-production methods create a restrictive climate of knowledge of, and involvement with, the production and design method.

The complexity of the technology within products may increase this lack of direct involvement, which is of little consequence in terms of the individual product but highly significant in terms of the total product environment and way of life of the user. Lukacs[(11)] concluded this, in the book "History and Class Consciousness", in 1922:

> "The commodity can only be understood it its undistorted essence when it becomes the universal category of society as a whole. Only in this context does the reification produced by commodity relations assume decisive importance both for the objective evolution of society and for the stance adopted by men towards it."

On the assumption that a true understanding of the commodity is as vital to the designer as Lukacs indicates it is to the social scholar, the implication for the t i p design process is clear. It must include not only an understanding of the relationship between product and user, but an understanding of the relationship between all the products within the user environment. Similarly, design decisions which are related to user satisfaction or alienation can only be made successfully if the product is seen to be a part of a way of life and not viewed in isolation.

It is at this point that the fundamental difference between the manufacturing worker's role and the product consumer's role assumes particular significance. The difference lies in the ability to control the form of the process(es), and it is with reference to this that a counter to consumer alienation can be examined.

1.4.2 The Management of the Consumer Environment

The general improvement in the domestic living standards which occurred during the late nineteenth century and continued,with the exception of periods of recession and war, up to the present, was characterised by an increase in the complexity and variety of purchasable commodities. Accompanying this change was a similar growth in information concerned with the problems of running the domestic environment. Newspaper articles, magazines for women, books on home-making, sales literature and, latterly, consumer advice and television/radio programming have all shown a consistent growth pattern. A characteristic of many of these sources is the similarity of their ideals to the way that industry organises itself. This is perhaps epitomised by the use of the terms domestic science, home economics and home management to describe the organisation of the domestic environment. (It must not, however, be inferred that the term has been borrowed from the industrial context - the OED provides a reference to the term 'household management' dated 1857 and attributed to Ruskin.)

The flavour of this ideal can be illustrated by referring to some of these sources. "The Home of Today",(12 published in 1934, for example, states the following in relation to the problem of the home without a maid:

> "There is, however, a large proportion of homes in which no maid is kept and the best way of managing the work and handling the domestic situation is, therefore, an important matter to the mistress who is also the maid.

Housework can become a really interesting study once it is regarded in the right way. The running of a house should be considered as a business proposition - requiring just as much careful organisation and planning as any other type of industry."

The theme that interest is created by effective management is a recurring one and surfaces in a more recent view expressed in a domestic guide of 1970:(13)

"We can describe 'comfort' as the satisfying of our bodily and other needs. Being comfortable, then, may only mean that we are not suffering discomfort or pain, weariness, hunger, and so on. But we can also have a conscious feeling of satisfied ease and well-being which we enjoy - and a belief that we are controlling our environment helps to give us this feeling. In fact, we are only fully at ease, in mind and in body, when we feel confident that our environment serves the purpose we want it to."

Both these examples suggest that a sense of fulfilment can be achieved not simply by exercising a range of domestic skills, but by the effective administration of the home. A book entitled "The Management of the Home", published in 1960,(14) adopts a similar tone but sounds a note of caution:

"In industry, the expert study of work processes has resulted in higher efficiency, and less absenteeism on the part of the workers. While similar consideration of the work processes in the home is undoubtedly desirable, there is a danger that too much rigidity may result; where the well-being and complete happiness of people are at stake, adaptability is always necessary, even if it entails more time and effort than would appear essential; the very character of a home must not be lost sight of.

. . . Some knowledge of domestic science is of great advantage to the housewife, for while the numerous scientific developments have resulted in products intended to simplify her work, they may instead, if they are not used intelligently, complicate her life."

Here slightly more involved consideration is given to the concept of household management, which is described in terms of a balance between rigid efficiency and ordinary humanitarian needs, perhaps echoing the diplomatic aspect of contemporary management technique.

Forty[15] has shown that the serious study of household efficiency began in the USA with the work of Catherine Beecher in 1869 and he goes on to state that there was renewed interest in it when, around 1910, the principles of Taylorism (time and motions studies) were applied to housework by Christine Frederick. This clearly demonstrated a connection between industrial and domestic management.

These examples all illustrate the point that, just as in the industrial sector, there are several layers of activity which have the potential to provide job satisfaction, from the application of physical skills to the more cerebral skills of organisation and direction. So, in the 'self-service economy', there exists the potential for job satisfaction in the form of both physical and organisational skills. As the trend in many t i p's is ostensibly to increase automation and hence operational efficiency, a reduction in physical skills on a par with the industrial equivalent is a distinct possibility. The nature of domestic work may thus change, in a similar way to industrial work, ie the skills become the skills of managing and controlling complex processes, rather than direct physical involvement with those processes.

The new skills associated with new technological developments may become the skills of managing and controlling complex processes, rather than direct physical involvement with those processes.

It is argued that job satisfaction, like its opposite, alienation, can be equally present in occupations which require physical skills and those which demand management skills. Thus a t i p user could derive occupational satisfaction from the deployment of a range of equipment, the constituent products of which might well require minimal operational skills (eg the so-called 'smart' products). Yet even this phase of controlling simplified t i p's might be thought by some to be transitional. For example, much has been made of the fact that many products now incorporate electronic time control devices which, in spite of a high degree of accuracy, operate independently from one another and hence have to be controlled independently. A degree of organisational ability must therefore be devoted to co-ordinating the functions of products which, in theory, could be linked to a single time control unit. A reduction in control 'satisfaction' in a simplified, inter-connected product group (eg a home entertainment complex or the equipment in a kitchen) may therefore be a significant design factor.

In industrial design terms, a major problem in overcoming alienation in domestic product groups results from the fact that few related products are co-ordinated at the design stage. The situation is rather different in the case of non-domestic equipment, IBM providing a good example, where products are designed to co-ordinate with existing equipment and even competing companies are encouraged to adopt the IBM standard. However, domestic products industries are more fragmented and fewer companies are in a position to dictate a unifying standard which would rationalise product group design. This applies also to the organisation of activities within individual companies. For example, Tube Investments' "Creda" company is split into a number of sub-divisions: cookers, washing machines, etc. The Sears organisation in the USA has departments to handle white goods (excluding cookers) separately from other domestic products.

A major problem for the designer may result from the fact that few related products are co-ordinated in design terms.

Also, where there is greater emphasis on a fashion cycle in domestic equipment styling, a non-functional dislocation of product characteristics is more common, in terms of both individual product evolution and the differences between competing manufacturers' products.

It is thus probable that consumer satisfaction derived from the effective control of combinations of technologically innovatory products may be lessened because of the weak design relationships the products have with each other. The microwave oven is a useful illustration of this, in that it is usually recommended as an additional product to the conventional cooker, and not a replacement for it:(16)

> "A microwave oven can do most of what a conventional oven and hob can do. It can also defrost food and is very fast at heating up food. But we think most people would want a conventional cooker too - a microwave oven is not a perfect replacement. So a microwave oven is likely to be an extra expense."

This extract from the Consumers' Association magazine "Which" questions how the t i p interfaces with 'conventional' equipment. In pure design terms it is probable that 'conventional' peripheral equipment is unsuitable. Changes of scale of the oven, possible reduction in the number of hot plates, changes in the heating-up characteristics, different demands on control/timing devices, alterations in ergonomic characteristics, can all be justified if the ideal combination of microwave oven and conventional oven is to be produced. This is particularly significant, given the usual premium that is placed on the appropriate use of kitchen space. An unused conventional oven volume may contribute to a sense of alienation of the kitchen user. The fact that the free-standing microwave oven may be a transitional product, preceding conventional ovens with inbuilt microwave facilities, in no way reduces the argument, as the design of transitional products is still central to the industrial design activity.

Although the microwave oven is an isolated example, many t i p's are required to interface directly or

TECHNOLOGICALLY INNOVATORY PRODUCTS WHICH INTERFACE WITH TRADITIONAL PRODUCTS

The above illustration demonstrates how perceivable characteristics may suggest incorrect functional capabilities.

The 'Monitel' telephone call charge indicator incorporates perceivable characteristics - colour, size, shape, corner radii, etc - which are derived from those of the British Telecom telephone receiver. These factors, together with the close proximity of the unit to the receiver, may combine to create the false illusion that the timer is linked directly to the telephone. Such a case of mistaken product identity may create misconceptions about the operational requirements of the product. In this case that the product would automatically time calls, rather than require a stop and start procedure from the user. In design terms, such an illusion may have been created for sound aesthetic motives, such as an uncluttered, simple appearance, or for ease of operation.

Paradoxically many examples exist of telephone receiver peripheral products, eg answering equipment, which, althoug linked technologically, remain unconnected in terms of visual identity. (For example, the GMTC telephone answer equipment.)

indirectly with traditional products (ref Illustration I5) or, in some cases, other t i p's - video recorders with television receivers, programmable washing machines with tumble dryers, cassette recorders with radios, telephones with computer keyboards, microwave ovens with freezers, digital disc players with amplification equipment, and so on. As the demand for direct physical skill from the user is diminished by technological development, the emphasis for occupational satisfaction is placed on the organisation of equipment use and the design of appropriate interfaces for such equipment becomes vital, not merely in terms of the individual product/user interface, which is the current industrial design focus, but the interface between one product and another and between complete product groups and the user.

NOTES

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1.5 THE MANIPULATION OF PRODUCT IDENTITY BY TECHNOLOGICAL MEANS

This section examines the theory that technology and the symbols of technology are frequently utilised by designers for motives which owe more to visual style than to the products' functional capabilities. This is a complex issue because it is a question of design emphasis rather than polarised differences between style and function. As Lloyd-Jones[1] says:

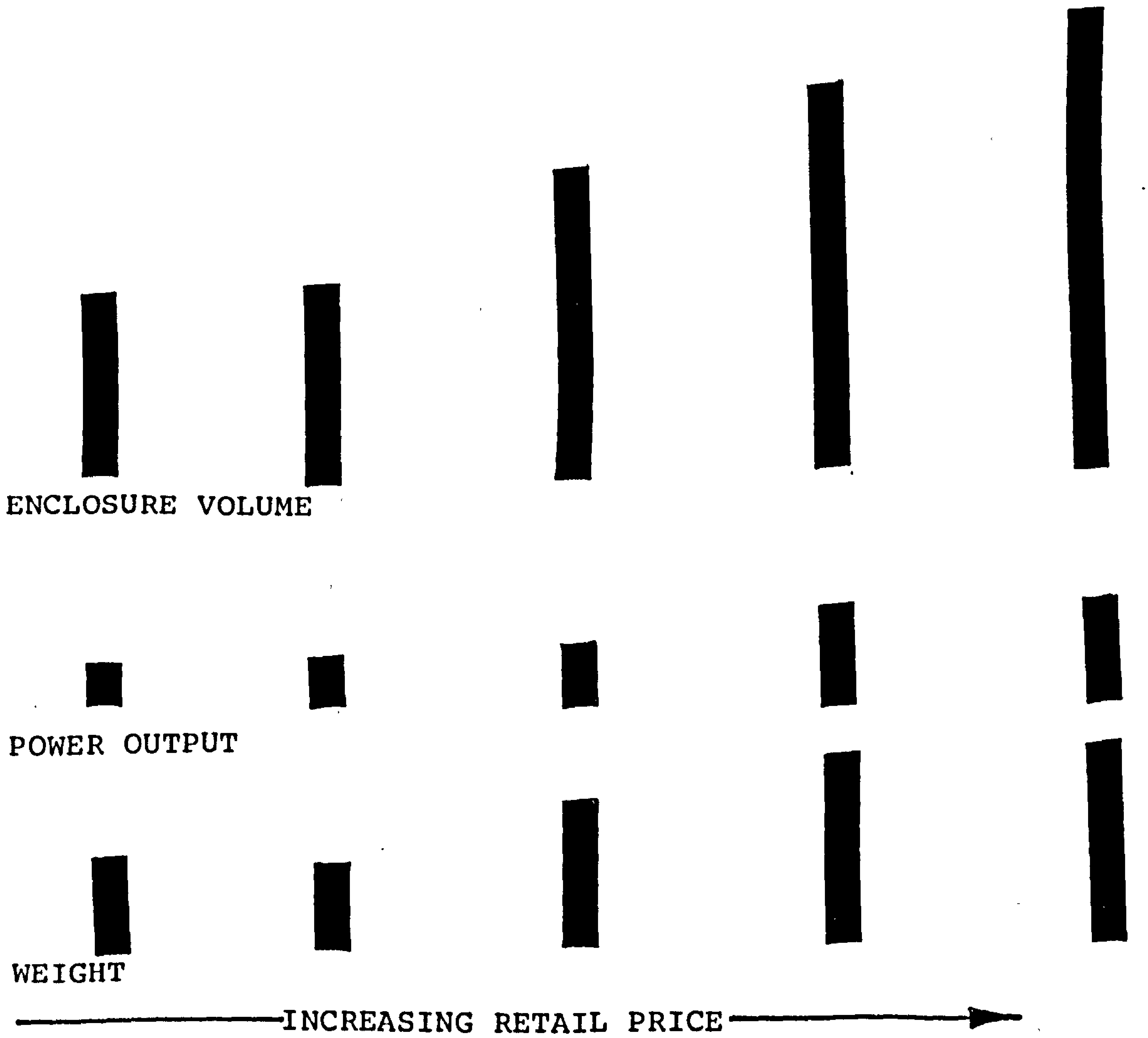
> "We seek a sense of apparent rationality and purposefulness even in the most conspicuously symbolic gadgetry."

This may well be true of both designers and users -for instance during the period of this research few products with purely symbolic attributes have been documented. Similarly, very few product users have defined their preference for an attribute in purely symbolic terms. One of the few examples of an apparently symbolic attribute that has been encountered was identified by Dossett,[2] who provided the example of a hi-fi turntable which was improved by incorporating a microprocessor-controlled servo system. This device automatically regulated the running speed of the turntable, without recourse to the stroboscopic unit that was still retained in the product. Even so, it is argued by the designers of this product that the stroboscope does possess a non-stylistic function, in that it reassures the consumer that the servo system is doing what it is designed to do. It could be argued that the device was retained because it possessed a symbolic identity which indicated the advanced technical status of the product, relative to other similar products, in which case it becomes as much a stylistic element as the glass and light trim with which Creda embellish their more 'up-market' cookers.(3)

Examples which are less extreme but which are more truly representative of the use of technology for stylistic reasons can be observed in products which incorporate elements which are both technologically stylistic and functional. Obvious examples can be found in the domestic sound equipment field (ref Illustration I6). The majority of manufacturers have managed to achieve a tight correlation between the technological capabilities of products, the pricing structure and the visible indications of technological capability. The illustration (ref Illustration I7) shows how closely these factors can be correlated: size, weight, power, frequency response and applied trim all increase 'conveniently' with selling price. Each unit has therefore been built to a well defined price bracket, not perhaps following the adage 'the best product at the price' but rather 'the most appropriate product at the price'. In this case, although each perceivable characteristic has a function, the apparent sizes and numbers indicate a symbolic statement which describes the capabilities (and limitations) of each model. The symbolic statements number, therefore, at least two - an indication of the degree of expense/luxury of the product, together with a statement about the functional

THE STYLISATION OF INTERNAL COMPONENTS

The speakers intended for use in the car increase in price and technical specification as they descend the page. The elaborately styled internal cones match this progression.



THE RELATIONSHIP BETWEEN PERCEIVABLE CHARACTERISTICS, TECHNOLOGICAL SPECIFICATION AND PRICE, FOR A PRODUCT LINE

The external technical components, usually unexposed in earlier examples, also provide a strong perceivable indication of product capabilities. The products are all supplied with front covers - thus the specification can be 'read' from the perceivable characteristics then effectively removed.

capability. This is consistent with Barthes'[4] view that symbol systems frequently signify more than one concept. In "Système de la Mode" the example given is fashion clothing which, Barthes states, indicates both that the wearer is part of 'high society' and that the clothing is itself fashionable.

In discussing this type of symbolism it is evident that an almost infinite variety of semiotic interpretations is possible for a single design, depending on the viewpoint of the analyst and the particular social context in which the product is placed. However, as Dorfles[5] states:

> "And yet is is true that this kind of 'popular art' (industrial aesthetics- author's note) which is nearly the only aesthetic 'food' available to the masses of our time, almost always possesses an exclusive unipolar direction: its channel of information runs only from the producer to the consumer, just like the other mass media - TV, radio, etc. It is here indeed that we find the most dangerous aspect of modern mass-communication (among which we must include design in its various forms) - their unipolarity and their compulsive character."

In other words, mass-produced artifacts possess a uniformity in terms of information content and hence symbolic characteristics. It follows therefore that there exists a consensus interpretation of the sign systems of individual products amongst both their designers and their users.
A part of this research has been devoted to uncovering the consensus perceptions of product identity. For the purpose of this consideration of technical styling, there follows a description of some of the possible contenders, based on

the preliminary research interviews with designers.

One of the most frequently encountered descriptions of the styling of t i p's is in terms of the technological content being allowed to dominate the product and, in so doing, to present the technology as a mysterious and inaccessible phenomenon (ref Illustration I8). The technical styling thus becomes concerned with emphasising and, in some cases, exaggerating the technological characteristics of the product. Two examples which are very similar were documented during the interviews with Pemberton[6] and Brickwood[7] when designing the Sinclair 'Microvision' miniature television receiver and the 'Micro 2000' digital micrometer respectively. Both intended the products to have a positive identity of precision ('camera-like' in Brickwood's case). The significant aspect in both cases was that the 'precision' was linked by both designers to a belief that the technology itself was synonymous with precision.

The visual characteristics of t i p's may often be manipulated by designers to emphasise and exaggerate the technological characteristics of products. (Ref I9.)

Little academic work has been carried out to investigate this particular rendering of the technical image, although a small number of design historians have paid it some attention. Forty,[8] in discussing "Symbolic Design and the English Radio Cabinet, 1928 - 1933", has unearthed a particularly relevant comment by Captain Gregory,[9] the

THE MUTUAL REINFORCEMENT OF PRODUCT IDENTITY AND PUBLICITY BY TECHNICAL INNOVATION

The example of the Belling Formula 90 CHU ceramic hob shows the way in which a single product characteristic, the colour black, is used to emphasise the mysterious potential of the technological innovation. The accompanying sales description reads as follows:

"The Incredible 'Black Magic' Hob

It's not just beautiful, it's sheer black magic! It introduces a completely new elegance in the fitted kitchen.

Black is beautiful, black matches all the Formula units (and every other make, British and Continental), black does not show the marks so easily, black is different and modern.

But there is another great advantage with the Formula black ceramic. On most conventional white ceramic hobs, little more than a yellowish glow -an be seen when the elements are on, but with the Formula black ceramic the radiant elements can clearly be seen glowing red through the black surface: it's just like black magic!"

THE VISUAL IDENTITY OF A TECHNOLOGICALLY INNOVATORY, ELECTRO-MECHANICAL PRODUCT

The toaster incorporates a microprocessor which facilitates "more reliable and accurate toasting with a wider browning range". It will only engage when connected to the mains supply and is ready immediately after use for the next batch of toast.

Both the new technology and its related functional advantages are not directly perceivable from the product alone. Hence the attempt to reveal these new characteristics through an applied graphic identity - the printed statement 'Electronic' and the general 'black-box' style more commonly associated with photographic equipment and non-mechanical electronic products.

editor of 'The Cabinet Maker', in the following report on a speech of his:

> "He regarded wireless as an elaboration of life coming out of the blue, a miracle, some manifestation of a person he knew nothing about. When the ancients became aware of a mystery they built a temple. Why could not the wireless trade make wireless temples instead of wireless cabinets, and why not call them so? He suggested that the cabinet manufacturing trade should steadily avoid making their productions useful. The temple would have no use whatsoever. It should be an ornament, a symbolic ornament at that. But it must convey the idea of a mystery, and that meant it must avoid the general forms of furniture."

Forty goes on to link this attitude to the architectural Greek, Egyptian and Mayan styles of radio cabinets of the early thirties and points out that:

> "It is significant that this style had vanished by 1935, when radio had ceased to be so unfamiliar."

Although this is a somewhat dated example, a point is clearly made that may well have relevance for other technologically innovatory products, particularly those which are aimed at untrained or domestic users. This is that a t i p may be treated in design (or publicity) terms in such a way that its newness is emphasised by a deliberately contrived attempt to make it more mysterious and remote. Forty's specific point is that this may only last until familiarity with the object is achieved by the public. This is endorsed by the industrial designer Goldsmith,(10) who agrees that the design identity of the anonymous, rectilinear box (as employed in many pocket calculators and digital clocks) may become redundant once the products are in common use, to be replaced by forms which are "able to communicate what the spirit of the product is",(10) (Illustration I10).

An alternative possibility was voiced by Woudhuysen(11) in a review of the 1979 Hanover Technology Fair. He observed that the visual style associated with electronics-based products was being applied to other non-electronic durables:

The visual style associated with electronics-based products is applied to other, non-electronic durables.

> "Gruppe Interform's beautiful hand-held/wall-mounted hairdryer, designed for Rotel, comes in orange and black. Without its flex you can easily mistake it for a rather bulky floppy disc drive: jam it in the right interface and out pop a hundred programmes. Does it have a chip in it? No. Even the most fashionable dryer doesn't require that - yet. Busse Design's radiator was selected for the Gute Form exhibition. Intended for domestic use, it is in that silver and black office gear yet again: and it looks like the in-tray for a flash photocopier. No chips, no electronics, just for the functionalism of a high powered typing pool.
>
> Or take Frank's mobile water sprayer. Silver and black again, it more resembles a photocopier on wheels than a piece of hydraulics intended for street use. Nor is it exceptional: a lot of fork lift trucks at the fair would not seem out of place in an office - after all, they're painted in the standard orange and blue of his mini-computer. Yet there are no chips in any of these."

As this research is directed towards technologically innovatory products, the manipulation of technological characteristics for stylistic purposes is clearly of great

AN EXAMPLE OF DEPARTURE FROM THE 'BLACK BOX' PRODUCT IDENTITY

Although the camera is not a 'black box' product in the sense of the purely electronics-based object, it has frequently displayed similar traits in recent years, particularly in the non-professional sector. The above illustrations demonstrate how the product identity of the object can be developed specifically for non-professional use. In this case the object has been provided with visual characteristics which have distinct associations with the leisure/holiday market.

importance. The following sections describe aspects of product identity which are also important.

NOTES

1 Lloyd-Jones, P: A Taste of Class, Architectural Review, February 1979, p 75.

2 Dossett, R, Director Marplan - London, 5 June 1979, interview. (Ref RM8)

3 Speedman, B, Cooker Division Manager, Creda - 25 January 1980, interview. (Ref RM26)

4 Barthes, R: Système de la Mode, 1967.

5 Dorfles, G: Design History; Past, Process, Product, Design Council, 1979.

6 Pemberton, J, Industrial Designer, Sinclair Radionics - September 1978, interview. (Ref RM21)

7 Brickwood, D, Industrial Designer, PA Design Unit - August 1978, interview. (Ref RM5)

8 Forty, A: Wireless Style, Architectural Association Quarterly, Spring 1972.

9 Gregory: Cabinet Maker, 21 October 1933, p 86.

10 Goldsmith - Interview housed in the research interview records. (Ref RM7)

11 Woudhuysen, J: Things to Come, Design Magazine 367, July 1979, p 41.

1.6 FUNCTIONAL INFORMATION IN PRODUCTS

This section discusses the methods that product manufacturers employ to explain how to operate their products, in terms of both separate, explicit instructions and informative characteristics within the product itself. The advantages and disadvantages of both types are then compared and the resulting conclusions used to validate the research method.

It is evident that the products which are intended for trained, professional use differ from those intended for untrained use in terms of the requirements for operational instruction. The latter rely either on the product itself or instructions supplied with the product to inform the user, whilst the former may, in addition, depend on the flexible and skilled aural communication of potentially complex and lengthy information. It is conceivable that the presently increased functional complexity of many of the technologically innovatory products that are intended for the untrained user pose greater problems than hitherto for the instruction-writer. The problems may result from the limited scope of the information channels available, and also from the innovatory nature of the products, since, in many cases, the products will have no predecessors to serve as information references for the user.

This research is concerned with products which are intended for untrained users, one reason being the special requirements for operational instruction.

The field of instruction-writing is a wide and somewhat specialised one, which it is beyond the scope and intention of this research to encompass. Therefore only those aspects of the subject which are considered crucial to successful t i p design are referred to, together with those which are significant for the research method.

The term 'instructions' itself requires some clarification and, to accomplish this, a new term 'functional information' is employed and is defined as follows:

> Functional information is information which explains or helps to explain what the product does, how it does it, and how to use it.

The term 'instruction' relative to this definition is seen as a vehicle for functional information, but one in which the information is formalised with a narrative or teaching quality, and includes wordless diagrams and illustrations of use.

Thus it is possible to describe 'instructions' in terms of a structured and explicit learning plan, by means of which functional information about the product is communicated to the user. It would be a mistake, given the recent developments in self-teaching machines, to assume that instructions are invariably remote from the product, when in fact they can be applied in many forms, from audible tape systems to graphics. Nor must it be assumed that such instructions are necessarily centralised when applied to the product. For example, a structured and explicit learning plan may be located near to a number of separate controls in a single product.

The above definition of 'instruction' leaves room for other forms of functional information to be presented in a less contrived manner, if they are presented, in the formal sense, at all. Thus a user might gain insight into the function of a product by decoding inexplicit, perceivable characteristics as readily as he does by studying explicit instructions. A simple example of complementary instructions and other perceivable characteristics can be seen in the illustration (ref I11) of a washing machine control switch, where the explicit instruction "Push for Off" is reinforced by the implications of the tactile quality of the knob when under pressure and the relatively large gap between the head of the control and the control facia (similar to the depth of the rather obsolete push-and-turn gas oven control switches). Both the instruction itself and the other perceivable characteristics can be assumed to convey a degree of functional information about the synthesised user/technology interface only (ref Illustration I13).

At this point it is worth considering the relative merits of separate product instructions, as opposed to functional information which is product-based, in order to isolate the purpose of the latter in the design activity.

VERBAL INSTRUCTIONS COMPLMENTED BY NON-VERBAL PERCEIVABLE CHARACTERISTICS

The explicit instruction "Push for Off" is reinforced by the feel of the knob when under pressure and the relatively large gap between the head of the control and the control facia. Both the verbal instruction and the other characteristics convey information which is only indirectly linked to the internal technology of the product.

TABLE T1

Comparison of Separate Instructions with Product-based Information

Separate Instructions	Product-based Information
1. Can be ignored, forgotten or lost by the user.	Cannot be lost; less easily ignored by the user.
2. Remoteness from the product can necessitate a sometimes difficult comparison of the instructions with the characteristics of the product, by the user.	The integration of information and product reduces the necessity for difficult translation.
3. Can be highly explicit in a variety of forms which can be matched closely to the language, skills, knowledge and preferences of the user groups.	Usually simplified in form and matched to a narrow range of user abilities and preferences. Although recent technological developments in control and information hardware are providing greater flexibility in this area.
4. Unlikely to play a major role at the purchase and pre-purchase stages of the adoption cycle.	Can be influential at the purchase and pre-purchase stages of the adoption cycle. The simplified form and ready accessibility can be suited to the needs of the inexperienced buyer.
5. Usually conveniently disposable if and when their role is complete.	Usually non-disposable when their role is complete; may render the product unnecessarily cluttered over the long term. Again, technical developments are increasing the scope for disposable, product-based information.
6. Usually low cost to produce.	Can be costly to produce, although technological developments can reduce this.

Comparison of Separate Instructions with Product-based Information (Continued)

Separate Instructions	Product-based Information
7. May contain an almost infinite quantity of information.	Usually only capable of communicating a limited quantity of information. Again, technological developments have increased this capability to the point where it can exceed the capabilities of separate instructions.
8. No effect on the visual identity of the product.	May change the visual identity of the product.
9. Relatively simple to design.	May require involved design work to be successful.
10. Less suitable for products which have a constantly changing, untrained user group.	Suitable for products which have a constantly changing, untrained user group.

The above table shows how current technological developments are making new forms of product-based information possible, through innovations in the physical flexibility of the product/user interface, (eg LCD display and touch-sensitive switches), and innovation in the information processing capacity of the product/user interface. It is apparent that a reassessment of the relationship between functional information and product design has already begun and will continue.

In order to evaluate the implications for industrial design, it is necessary to understand something of the type of functional information that might become product-, as opposed to instruction-, based. Such information explains broadly what a product does, how it does it and how to use it. Of these three categories, the first and the last are essential, although their relevance varies according to the position in the adoption cycle. The information on 'how the product does it' is not vital and would appear to become even less important as the synthesised product/user interface increasingly displaces any forms of externalised technology. However, products in which the product/user interface is totally synthesised and has totally displaced any externalised technology are still rare in the consumer market. A hypothetical example of such a product would be a voice-controlled machine buried in the wall, in which any required input or output of materials takes place through an anonymous hole. Clearly even the modularised and camouflaged products manufactured for the kitchen (ref Illustration I12) have some way to go before reaching such a stage. In the more low-cost market sectors, the expensive technological developments are even further off, the bulk of consumer durables still taking the form of isolated, unlinked units, which remain uncamouflaged and separated from the surrounding environment and other products.

In the case of these more typical products, a totally synthesised technology/user interface is rare in all but purely electronics-based objects. This interface is not

THE CAMOUFLAGED PRODUCT

The above illustrations show the effect that camouflaging and modularising products has on diminishing the externalised technology in favour of a totally synthesised user/product interface. The washing machine's input/output interface (the door and rotating drum) is not an anonymous opening to an invisible interior.

The principal effect of the camouflage has been to restrict perception of the product's identity to the occasions when it is operated - the identity (control panel excepted) does not exist until it is required: in many ways a functional aesthetic attribute.

(Ref. Fagor 1980 I2, Publicity Material) merely a description of the control interface, but covers all the parts of the product that the user is likely to come into direct contact with. Thus the interface is more usually composed of an amalgam of synthesised characteristics and externalised technology, in many ways indistinguishable from each other to the untrained user.

The fact that a product may exist in the form of technology surrounded by an enclosure is deceptive, since it is easy to assume that the act of enclosing technology prevents its external presence at the user/product interface. Whilst this is sometimes the case, in many products the enclosure possesses characteristics which are a direct consequence of the integral technology. Refrigerators and freezers are a good example. Viewed most frequently from the front, they appear to be the epitome of the anonymous enclosure, divorced from any apparent technology. However, looked at more closely, many perceivable characteristics have a technological basis, from the wall thickness, door seals and pump housing to the distance of the enclosure from a wall at the rear.

The illustration of the oven and hob unit (ref I13) demonstrates how a product may possess a variety of zones, each offering different levels of technological explanation. In this example, which is not within this research's definition of a technologically innovatory product, a great deal of the perceivable information relies on existing user knowledge for its interpretation. Experience of

Partially
External
Technology

The functional technology of the electric hob is partially perceivable by the user. However the lack of direct visual characteristics connected with electric power renders it less technologically explicit than the gas hob.

Synthesised Technological Interface

The control panel is an abstracted, indirect manifestation of the internalised and externalised technology.

External Technology

The gas hob is an explicit form of technology in which the functional process is directly perceivable.

Internal Technology

The functional technology of the oven is predominantly imperceivable.

EXAMPLE OF THE RELATIVE LEVELS OF EXPLANATION OFFERED BY DIFFERENT TECHNOLOGICAL ZONES OF AN OVEN/HOB COMBINATION WHICH IS NOT TECHNOLOGICALLY INNOVATORY previous products has familiarised most users with what the various external components are, what they do and, to a degree, how they work. If this is compared with a related but technologically innovatory product (ref I1), this knowledge has strong limitations, as it would with any innovation. However, user perception is further limited by the adopted visual forms of the innovation. A comparison of the two diagrams reveals that there has been a change in one zone from an externalised technology to a synthesised interface, and two other zones have become less explicit within existing categories.

Like its non-innovatory predecessor, the t i p becomes better understood the longer it is in existence. However, that it may possess little in the way of externalised forms of technology implies that the acquired knowledge may be almost exclusively concerned with the synthesised interface. Thus the product designer may inherit a new responsibility in terms of deciding what functional information is presented to the product user and what is not. Previously, this decision was much less arbitrary and shared between the designer and engineer.

Developments in control technology may require increased design involvement in determining the nature and scope of functional information in the product.

Decisions about the role of functional information are thus likely to be critically important in the design of t i p's. Therefore a proportion of the methodology of this research is concerned with monitoring its sources and effects. In the Creda microwave oven, in particular, the balance between separate instruction and product-based information would appear to be poorly rationalised (with graphic, product-based symbols being ignored in the instructions, etc). The research conclusions therefore include an analysis of the role of functional information in the product and some general conclusions on its role in future t i p design.

Technological innovation in products may radically affect patterns of use which may, in turn, affect the identity of the product.

1.7 THE RELATIONSHIP BETWEEN PATTERNS OF WORK/ LEISURE AND PRODUCTS

1.7.1 Introduction

It has been stated that product identity is a complex combination of many associations: historical, social, technical and perceptual. Previously such associations have been consciously manipulated by publicity and advertising myth and, less directly, in the design of products themselves. As Berger points out in "Ways of Seeing",(1) it is physically impossible for advertising methods to convey the reality of product attributes to consumers. The methods depend on the deployment of mythical values with which to describe and surround the product. In the case of a mass-market product, such myths must, by necessity, be commonly understood by the majority of consumers, independently of the advertising strategy itself.

In terms of the use of such methods in product design, circumstances are rather different, since the functional reality of the product can be self-demonstrating. Thus the deployment of purely mythical qualities is interwoven with more tangible attributes. In order to analyse product identity effectively, it is necessary to have some means of distinguishing between applied myth and inherent, functional capabilities in products - a difficult task since, in some cases, myth and function are mutually dependent. However, the functional capabilities of products are determined by different forms of user activity, ranging from paid, professional work to passive leisure activities. Since the mythical and functional components of product identity are linked, it is likely that the character of the latter has some significant effect on the former.

The effects of technological innovation, in radically changing the patterns of use of products, invariably cause fundamental changes in the relationship of the product to the spectrum of activities between paid work and passive leisure. In simple terms, product identity is based on both functional capabilities and mythical values, the former being closely related to patterns of use. Technological innovation radically affects such patterns of use and thus has a profound effect on the identity of the product.

In order to observe firstly the existing relationship between products and their patterns of use, secondly the effects of technical innovation in changing this pattern, and thirdly the resulting shifts in product identity, it is necessary to examine the links between products and patterns of use. This section is devoted to such an examination, by grouping different products and product types in terms of their positions in the work/leisure spectrum and then looking for common attributes within those groupings. Finally the effects of technical innovation on each group are assessed and projected.

It is emphasised that the theoretical relationships between patterns of use and product attributes, described in this section, are not based on formal research findings.

It is suggested that a thorough investigation of the relationships, which is beyond the scope of this investigation, would be a valuable resource for the resolution of product identities by designers.

1.7.2 The Work/Leisure Spectrum

Characteristically, products which are designed purely for leisure purposes and products which are designed for professional work only are relatively easily distinguished from one another and usually fit into well defined patterns of use. Between these two groups exists a grey area in which leisure and work merge to produce a group of products which are not characterised by a cohesive, unified system of visual symbols and whose patterns of use are less clearly established. In occupying a position between leisure and professional work, such products will, in terms of functional attributes, incorporate elements of the other two. In terms of mythical values, this may not be the case, since such values are as much a product of emotional needs as they are of functional capabilities.

Superficially it may seem a simple matter to arrange products according to these three patterns of use: leisure; untrained, unpaid work; and paid, professional work - which it is, in the case of those objects which are intended to fit only one of these categories. It is common, however, for many products to fulfil multiple roles. Musical instruments, for example, may be used by a trained professional or used by an amateur for leisure purposes, or even as a form of unpaid work. Also the distinction between unpaid work and the more active forms of leisure is particularly blurred. Nevertheless, some general patterns of use are related to product attributes in Table T2.

A further distinction occurs in patterns of leisure, between those activities which are characterised by participation and those which require passive behaviour on the part of the consumer.

The following definitions relate to all the constituents of the work/leisure spectrum.

<u>Passive Leisure</u>

Any activity in which the consumer absorbs stimuli and does not produce any externalised physical or mental output and which is performed in the consumer's own free time, primarily for pleasure.

<u>Active Leisure</u>

Any activity in which the consumer is physically involved or in which there is an externalised mental output, which is performed in the consumer's own free time, primarily for pleasure.

<u>Unpaid Work</u>

Any activity in which the consumer performs a task whose purpose is not primarily pleasure and for which there is no financial remuneration.

<u>Professional Work</u>

Any activity in which the consumer performs a task whose purpose is not primarily pleasure and for which there is financial remuneration.

Clearly, products can be grouped on the basis of a number of qualities: size, user group, capabilities, environment, cost, status, etc. However, once classified, the groups begin to look less rigidly defined in the light of the complex activities of their users, which all too easily transcend such artificial classification. For this reason the Work/Leisure Patterns of Use has been used in this research as an analytical and not a classification method, since it links the product directly to the mode of use and not to its own inherent characteristics. However, it must be viewed as a continuous spectrum, ie as a progressive, continuous band of product characteristics and not a rigid series of abrupt classifications. Although products may appear in one or more classifications, there is the possibility of use in another area.

This form of classification is in a constant state of flux, with patterns of use influencing product attributes and vice versa. Illustrations (ref I14 and I15) show the way in which products can straddle two or more classifications with appropriate changes in product identity. Illustration I16 demonstrates the way that this change of identity can be deployed to present a new package of attributes in an area of relative saturation - the vacuum cleaner market.

The 'rules' which govern the relationship between product attributes and patterns of use are as ill-defined

THE REVERSAL OF CONTROL CHARACTERISTICS OF PRODUCTS FOR UNPAID AND PROFESSIONAL WORK

A comparison of the above Philips 810S catering microwave oven with the Philips 'Cooktronic' 7915 designed for domestic use (overleaf) reveals differences which highlight the deskilling of some professional activities compared with their domestic counterparts.

Clearly the oven is simpler to operate, can time only up to 5 minutes and is smaller in capacity. As the sales literature states: "It can be plugged straight into an earthed socket and it is simple enough to be used by inexperienced or temporary staff........".

Philips sales literature, CAT 008/Sept 78, Model 810S

THE REVERSAL OF CONTROL CHARACTERISTICS OF PRODUCTS FOR UNPAID AND PROFESSIONAL WORK

The Philips 'Cooktronic' shows a higher degree of control complexity, including defrost, variable power, longer time setting, extra indicator lights. The domestic user thus has a more complex and difficult learning process to master than the contract user.

The stylistic identity of each oven remains within the traditional general distinction - functional in the contract oven, highly stylised in the domestic - in spite of the reversal of traditional operational attributes, ie that control simplicity is more commonly associated with domestic and/or unpaid activity and control complexity with professional/paid activity.

THE MIGRATION OF PRODUCTS FROM THE PROFESSIONAL WORK SECTOR TO UNPAID WORK

The heavy duty vacuum cleaner, originally used exclusively for contract cleaning in workshops, offices, factories etc., has in recent years been marketed and in some cases re-designed for domestic use. This has spawned a range of different models from the original contract standard to low-cost, reduced quality or power models which still maintain the contract product identity. (Ref. Toshiba sales literature TUK/SH/501079. Additional ref. Sunday Times, 8.3.81., p91, "Cleaning Up With The Heavy Mob".)

and malleable as the behaviour and attitudes of consumers, so that the factors listed in Table T2 are not as rigid as they might appear. Nevertheless, even in this form, they may be developed into useful design guidelines once further applications of this research method have been used to verify them.

It is envisaged that the t i p designer, in attempting to develop product attributes, might use a more well-defined version of the table as an aid to decision-making. With this in mind, the research results are examined to check their consistency with the theoretical patterns of use/product attribute analysis. The limitations of examining only a single t i p prevent the detailed testing of the necessary theory, but it is envisaged that if subsequent applications of this research method are made, an increasingly verified table will result, with consequently more reliable design capabilities.

It is believed that certain general principles govern the way that product attributes are presented in traditional products and that these, although subject to modification with time, ought to be understood. The principles may then be embodied in t i p design to reduce the alienation of the user. In broad terms, it can be seen as a method of predicting the way that the product identity of t i p's, which are evolving from high technology sectors into wider use, can be appropriately generated. Such a progression is illustrated in Table T3, which shows the territory that a product planner might well inhabit, particularly if he is involved with an organisation which deals with all three levels: advanced technology users, small private users and ordinary consumers (eg IBM).

NOTES

1 Berger, J: Ways of Seeing, Penguin, UK, 1972.

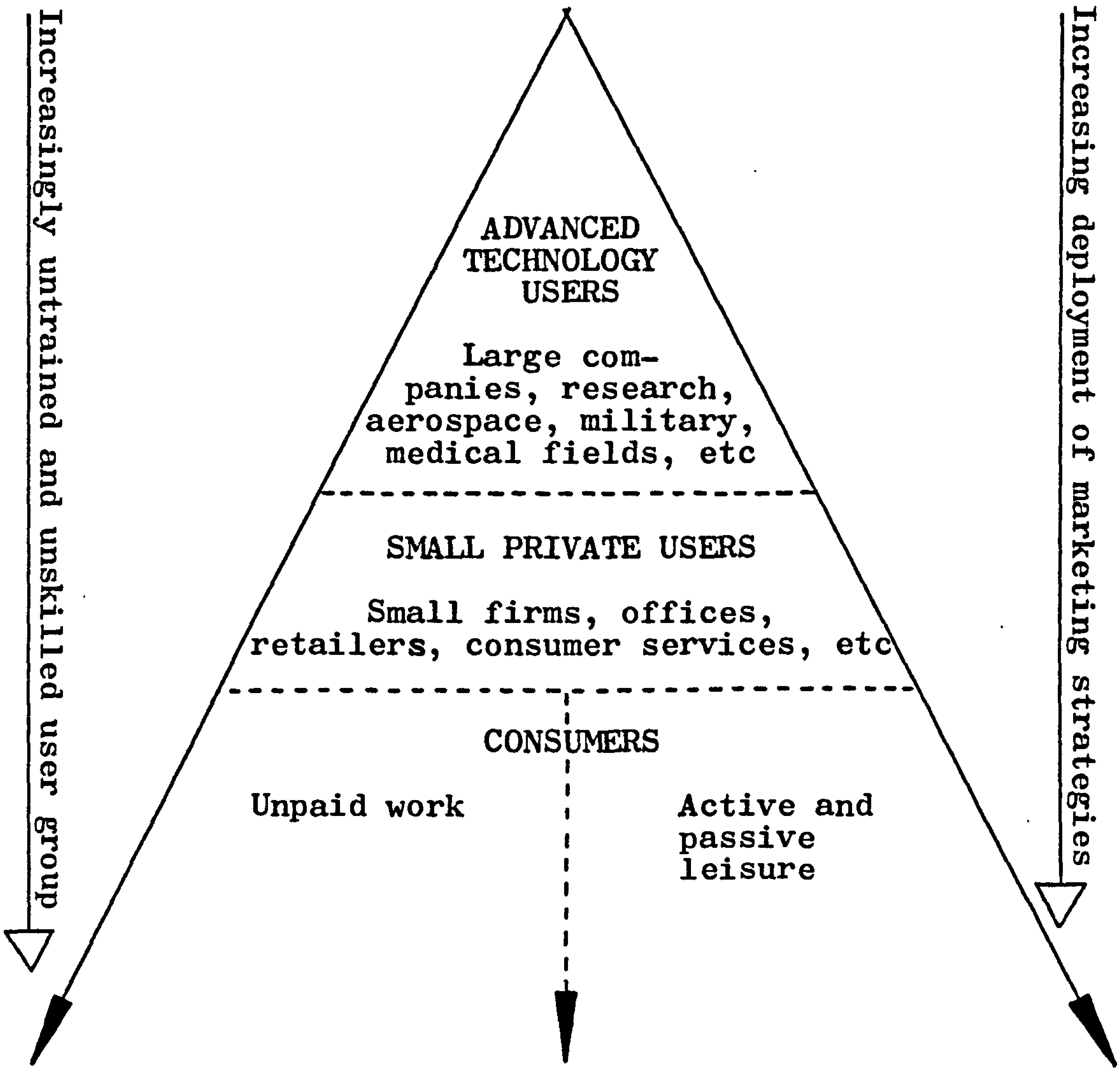
TABLE T2 PRODUCT ATTRIBUTES AND CHARACTERISTICS RELATED TO PATTERNS OF USE

Attribute	Passive Leisure	Active Leisure	Unpaid Work	Professional Work
Visual Style	Often highly stylised, drawing on unrelated fields for stylistic influences.	Product style frequently related to professional equivalents, or evolutionary characteristics.	Style often related to attempts to disguise the frequent similarity with professional equivalents.	Low-profile stylistic content which is closely related to functional characteristics, ie efficiency, economy, technical sophistication, power, range and flexibility.
Durability	Passive nature of use frequently does not require a high level of durability.	Wide range of durability.	Less durable than professional equivalents, although patterns of use can be similar. Tendency to present the illusion rather than the reality of durability.	Often highly durable.
Control Interface	Range from extreme simplicity to a complex, often contrived, mimicry of professional, scientific equipment.	Range from simple to highly complex interfaces - aimed at untrained or trained users, facility to expand the required skills.	Less complex than professional equivalents, frequently self-explanatory and aimed at untrained users.	Frequently complex and requiring special training and skills.

TABLE T2 (Continued)

Attribute	Passive Leisure	Active Leisure	Unpaid Work	Professional Work
Functional Range		Often highly specialised functional range, although the lack of automation in some products increases functional range.	Frequent wide functional range, occasional sacrifices in quality to achieve this.	Often highly specialised, narrow functional range.
Cost	Highly variable.	Highly variable.	Highly variable.	Variable, although usually greater than the other three.
Reasons for Disposal	Boredom, technical innovation related to functional range and quality improvements, fashion changes.	Wear and tear, increasing skill and interest matching new product needs.	Wear and tear, new products with real or mythical advantages, especially efficiency.	Technical innovation in new products, wear, new uses requiring new equipment.
Marketing Strategy	Both mass and specialist.	Both mass and specialist depending on degree of user involvement.	Usually mass, high volume.	Usually specialist.
User Profile	Wide cross section, often increasing with age and general increase as products become more generally available.	Wide cross section, often decreasing with age in physical activities.	Wide cross section, although particular emphasis on unemployed women and those socio-economic groups in the middle to low income range.	Users confined to employable age groups. Operation of products tends to diminish with increased professional status.

TABLE T3



AS TECHNOLOGY DEVELOPS, RELATED PRODUCTS BECOME ACCESSIBLE TO MORE PEOPLE AT LESS COST

Diagram based on Doblin's Pyramid (Industrial Design, January/February 1981, p 37)

1.8 THE COMPREHENSIBILITY OF PERCEIVABLE CHARACTERISTICS

A discussion of the degree to which the visual attributes of products should be rendered explicit and non-ambiguous to their users.

> "Likewise, industrial design has need of that fine art quality which Massimo Vignelli calls 'ambiguity'. To achieve a subtle mixture of likeness and difference, industrial designers must work with a mass of symbolic values and connotations, some of them (like the facets of human personality) actually contradictory. Ambiguity of meaning (like complexity of meaning) is a feature of identity."[1]
>
> Ambiguity - n. Double meaning; expression capable of more than one meaning. Concise OED.

The above statement by Brutton[1] highlights the difficulty of making rules for the design of products that would be totally explicit in their presentation form (ie any externalised characteristic). This difficulty would not be avoided by design limitations; rather it would fail to produce objects that are acceptable to the consumer, as it is clear from the above that ambiguity may have some basic attractions for users.

This may take several forms: it may alter the functional meaning to a more acceptable mythical form, it may remove a clear functional or mythical meaning to provide an interesting paradox, it may provide multiple meanings for a variety of patterns of use, or it may simply relate an object to its proposed surroundings at the expense of its functional meaning.

There is a wide variation in the degree to which products are subject to ambiguity of meaning and there are potential pitfalls in attempting to define where, in design terms, ambiguity is either existent or desirable. Nevertheless, the successful design of t i p's for non-professional consumption will depend on a knowledge, both intuitive and reasoned, of how to control and where to establish ambiguities. This is because such products are frequently placed in a domestic context, where the volume and persistence of design factors which possess multiple meanings indicates the necessity for their presence, even in new, technical and function-orientated products.

If the patterns of use associated with product groups are studied, it becomes apparent that both ambiguity and explicitness vary according to the role of work/leisure in which the product performs. A surgical instrument, for example, is commonly employed by a highly trained user. Hence it is unnecessary that the product is self-explanatory in terms of what it does and how it is used. It is important that it is clearly and unambiguously recognised for what it is, relative to other objects - for instance, it might be labelled with a letter of the alphabet, colour-coded or distinguished by shape or size. The function of the surgical tool, involving, as it does, extreme safety constraints, must negate ambiguity, whilst reducing self-explanation to a minimal label by which it is identified.

At the other extreme, a novel domestic appliance may be operated by an untrained user, in which case the product must help to define what it does and how it is used - even if this is only strictly necessary at the pre-purchase stage or during the initial period of use (ref Illustration I17). The meaning of the product may be ambiguous, since extreme safety and professional constraints are not applicable.

It would appear from these examples that a relationship exists between the need for ambiguity or explicitness and the place of products in the work/leisure spectrum.

The two qualities
vary according to a product's position(s) in the spectrum and, as many products actually migrate within the spectrum, so their predisposition to ambiguity and explicitness may change. This factor is especially important in considering the appropriate identity of the microwave oven. In the UK market the product has extended its field of use from initial use in the area of professional work (catering establishments) to consumption in the domestic area. Significantly, it was first marketed as a device primarily for defrosting and reheating foods, and only secondarily for initial cooking. Thus its impact in the area of active leisure was limited; it was merely a device for increasing the efficiency of domestic food production and therefore represented a product whose primary function was unpaid work. (This was borne out by the questionnaire findings, in which an overwhelming

VERBAL DESCRIPTIONS OF PRODUCT CAPABILITIES WHICH DOUBLE AS INSTRUCTIONS

The explicit nature of the descriptions stresses the new functional potential of the product, which would otherwise tend to remain anonymous and ignored during the pre-purchase period. In design terms, the rather cluttered appearance of the graphics may be unnecessary once the user is familiar with the controls.

response of efficiency and speed was obtained from the question about the attractions of microwave cooking. Similarly, a significant number of users discussed the relevance of the product to other aspects of work (housework, paid work, shift work, etc) as a time-saving device to facilitate these other activities.)

A product which fulfils this role is unlikely to be perceived as primarily related to the pursuit of active leisure. Nevertheless, all food preparation has the potential to involve the participant in a fulfilling and enjoyable experience, and so cannot be entirely divorced from active leisure. Recently, increased competition in the microwave oven industry from the Japanese has motivated Creda to alter advertising methods, to emphasise the supposed improved quality of certain foods cooked in the oven (ref Creda advertising salmon cooking, 1980). In employing this strategy, the company is in effect creating an extended identity for the product, which begins to move further across the spectrum in the direction of active leisure, since it allows new skills and involvement to develop in the consumer if increased food quality is desired.

The disadvantage of this kind of use is the non-traditional appearance of the food when cooked.[2]

> "It is more usually used to reheat food, for unless an oven that makes use of microwave energy and heated recirculating air together is employed, the appearance of food cooked from the raw state by microwaves is not the same as that cooked by conventional methods."[2]

Thus the sensitivity of users to the appearance of food has a restraining effect on the diffusion of the product into areas of food preparation which are related to the pursuit of perceived quality.

The example of the microwave oven is not unusual in the way that it migrates within the product spectrum. New marketing segments, changing leisure/work patterns and technological innovation all act to produce such changes. One of the principal problems is therefore to resolve the level of ambiguity and explicitness which is tolerable or necessary for new products or products which operate in new patterns of use.

The resolution of the level of ambiguity and explicitness in t i p's is closely linked to their pattern of use.

The research methodology is designed to provide an assessment of how consumers perceive and comprehend visual product characteristics and to indicate the importance, or otherwise, of their correct identification. The methodology concentrates on those products which are intended for untrained use, where no clear guidelines for the resolution of the levels of desired ambiguity and explicitness exist. Ambiguous meanings, whilst common in professional work products, are usually restricted to functional myths - power efficiency, precision, etc, unlike their counterparts in other sectors where they are infinitely more diverse, unpredictable and ephemeral.

The effects of technological innovation on meaning increase the potential for unintended and therefore undesirable forms of ambiguity. Conversely, certain forms of explicit design may be more necessary than ever, but less easy to make decisions about because the existing knowledge and ability of the user is an unknown quantity. For example, an observed form of indecision[3] surrounds the introduction of keyboard, as opposed to control knob, operation, since many producers of domestic products are unsure about the keyboard literacy and preferences of potential consumers.

The effects of technological innovation on meaning increase the potential for unintended and therefore undesirable forms of ambiguity.

A cautionary and pertinent example of this dilemma is described by an Open University Course Team:[4]

> "A microwave oven was designed using a microprocessor-based timer and controller to replace the old electro-mechanical design. On the old design the temperature and cooking time were set on two separate knobs by rotating them to the required settings. The oven with the microprocessor had a keyboard and the user first typed the cooking temperature and then the time. When the oven was operated correctly the system worked well. However, setting a knob not only gave a control setting but, from its position, the user could tell what the setting was. A problem arose with the new arrangement because, once keys

> were pressed one after the other, there was no reminder of what had been keyed. The user could key in a temperature, get it wrong or forget it, and then could not check it. The keyed time could not be checked either. Occasionally the user made a mistake in keying in a temperature and a time and was unaware of the mistake until the food was eaten! Either the controls should have remained knobs or indicators should have been added to show the temperature and the time settings."

Thus, once the ambiguity in operational information has been identified, the design options become clear. The research findings show that many perceivable characteristics possess ambiguous and unintended meanings for the product user and that, in the case of the microwave oven, the fact that it is technologically innovatory has been the cause of a number of misinterpretations. It is difficult to draw a general conclusion about which types of mismatches are desirable and which are undesirable. This has been done on an individual basis within the conclusion sections following each question analysis.

It is sufficient to state after this single product examination that the designers of t i p's should, where possible, determine the perceived meanings of the t i p characteristics prior to marketing. This could be accomplished by adopting a similar method employed in the first part of the questionnaire, where users are asked why certain characteristics are designed in that way. As the concern is with perceivable characteristics, a prototype model, series of photographs, drawings, etc, could be employed for this purpose. The resulting pool of information could then be examined to determine which meanings are desirable, given the envisaged pattern of use of the product.

NOTES

1 Brutton, M: After Modernism - Towards a New Industrial Aesthetic, Design Magazine 368, August 1979, p 84.

2 De Bono, E: Eureka, UK, Thames and Hudson, 1979, p 150.

3 Ref Design Interviews, Creda. (RM26)

4 Open University Course Team, Microprocessors and Product Development course - Unit 3, Designing Products Incorporating a Microprocessor, 1979, p 26.

CHAPTER 2 THE RESEARCH HYPOTHESES

2.1 HYPOTHESES

The initial section of the thesis has, so far, described in general and speculative terms the nature of products and the role of the industrial designer, with special reference to the effects of technological innovation on that role. Following this ground-clearing phase of the research, a number of linked hypotheses have been established, as follows:

(1) That a series of differentials exists between product design intentions and medium to long term user needs and requirements.

(2) That some of these differentials are wide in products which are technologically innovatory (t i p's).

(3) That a methodology may be devised which can be used to evaluate the series of differentials for a wide range of t i p attributes and characteristics.

(4) That this methodology, if applied to a sufficient number and variety of t i p's, will yield knowledge which will enable the t i p designer to reduce the differentials and hence produce more successful product design solutions.

The four hypotheses have varying levels of significance for this research. Hypothesis (1) is almost self-evident, in that there are some inconsistencies between product purpose and actual use. It could be argued that a high proportion of the contents of the consumer magazine 'Which' is devoted to an examination of the differences between claims for products and their true capabilities (albeit in purely functional terms). This hypothesis is included to form a foundation for the other three.

Hypotheses (2) and (3) are the primary hypotheses on which the study is based and, of these two, (3) is the more important, in that it requires the acquisition of new knowledge and techniques to be validated, unlike (2), which requires the collection and collation of new data.

Hypothesis (4) cannot in itself be proved within this single study, as it requires the repeated application of the research method to produce statistical evidence. It therefore represents the eventual long-term aim of the research, beyond the scope of this document.

2.2 DESCRIPTION OF HYPOTHESES

2.2.1 That a Series of Differentials Exists Between Product Design Intentions and Medium to Long Term User Needs and Requirements

This first hypothesis is an elaboration of the frequently quoted adage that "the designer is often out of touch with the market".[1] Theoretical work exists which takes this premise as a starting point for the development of design/user feedback techniques (eg Page, J: Planning and Protest, in 'Design Participation', Academy Editions, 1972), but no work has been carried out on the measurement of the success rate of individual design decisions and which might have formed a more tangible basis for such strategies.

A study which is close to this ideal is Project Sappho[2] (SPRU), which, in attempting to "create a complete pattern or profile of a successful innovation" concluded that "successful innovators understand the needs of their potential customers better than their less successful competitors".[3] However, the definition of success in purely commercial terms[4] does limit the findings in terms of design assessment.

"A 'failure' is an attempted innovation which fails to obtain a worthwhile market share and/or make a profit, even if it 'works' in a technical sense."[4] Presumably the converse is also true, that a success is an attempted innovation which manages to obtain a worthwhile market share and/or make a profit, even if it 'fails to work' in a technical sense.

The concept of 'design intentions' in the hypothesis is used in a broad sense to include both conscious design decisions, as well as expectations after the design stage on the part of the design group, ie it is conceivable that a product characteristic may exist which may not have been consciously conceived at the design stage, but about which some marketing expectation may emerge during the research questionnaire application.

2.2.2 That Some of These Differentials are Wide in Products which are Technologically Innovatory

The basis of the above hypothesis is the assumption that any innovative activity demands a degree of experiment and risk-taking[5] and that there is an inverse correlation between the level of innovation and the ability to anticipate the effects of the innovation. There is a further assumption that a technological innovation represents a high level innovation and therefore a high degree of unpredictability of the end result. Related to this are the causal factors that were discussed in section 1.3:

(i) Uncertainty about the outcome of innovatory activity.

(ii) The resolution of t i p identity and style.

(iii) The relationship between technological development and market demand.

(iv) The complex and remote quality of many aspects of innovatory technology.

(v) The rapid rate of change of many technology-based industries.

2.2.3 That a Methodology May be Devised which Can be Used to Evaluate the Series of Differentials for a Wide Range of T I P Attributes and Characteristics

The underlying assumption of the above hypothesis is that products generally consist of broad groups of characteristics, attributes and functions which can be cross-compared from one product to another. No attempt is made to ascribe relative levels of importance to the different characteristics, as these may vary considerably from one product to another and make comparison difficult. Also the designers frequently allocate priorities to product characteristics which differ from those allocated by users.

However, some work has been carried out which does ascribe a value system to an analytical list of product characteristics(6) and this work is described in the later descriptive passages on the questionnaire method. The 'Function Analysis in Product Planning' system is designed for use in the development of products rather than the analysis of existing products. As the Consumers' Association point out,(7) a growing number of worldwide consumerist bodies are using the technique in a modified form for existing product analysis. Thus a methodology does exist already, although it is limited in scope by being a 'Function' analysis, where function as a term does not include concepts of product identity. The hypothesis therefore stresses the point that a methodology can be developed which covers a 'wide range of t i p attributes', a wider range of attributes than is identified in the 'Function Analysis in Product Planning' system.

2.2.4 That This Methodology, if Applied to a Sufficient Number and Variety of T I P's, will Yield a Knowledge which will Enable the T I P Designer to Reduce the Differentials and Hence Produce More Successful Product Design Solutions

It is probable that the greater the number of products that are studied, the greater will be the general knowledge revealed concerning the t i p design process. However, it is inevitable that there will be a diminishing return above a certain number.

The question of what would be the minimum number of applications of this research method to produce reliable evidence may be answered in the SAPPHO[8] project, in which approximately 60 innovations were analysed. As in the Sappho study, it is probable that at lease double that number would have to be investigated in order to choose suitable products which obey the t i p selection criteria.

NOTES

1 Ref Research Interviews - TI Creda, Marketing Manager. (RM1)

2 Success and Failure in Industrial Innovation, SPRU, 1972, p 7.

3 Ibid, p 21.

4 Ibid, p 8.

5 Schon, D: Technology and Change, Pergamon, 1967.

6 'Function Analysis in Product Planning', AW-Design Group of the Establishment for Product Design and Product Planning and IPI Institute for Product Research and Information, Germany, 1978.

7 Research Interviews - Consumers' Association. (Ref RM20)

8 Science Policy Research Unit: Success and Failure in Industrial Innovation, University of Sussex, SPRU, 1972, p 4.

CHAPTER 3 THE RESEARCH METHOD

3.1 AIMS, OBJECTIVES AND RATIONALE

The research method which is described in this chapter is designed to systematically investigate the meaning or identity of the t i p as intended by the design team. Similarly, it is used in a modified form to investigate the meaning or identity of the t i p as perceived by a sample of its user group. The two sets of results are then classified according to their general functional roles so that they can be cross-compared. Characteristics of the product which exhibit a degree of mismatch in the comparison are deemed to be unsuccessfully designed (apart from certain special cases, as outlined, ref 3.1.5.7) and, in some cases, information gleaned from the collected data may be used to suggest modifications to the product.

The basic information-gathering tool of the research is a questionnaire (ref page 86 in the appendices) which is put to the design team and, after minimal modifications, to the user group. The questionnaire is in two parts: a non-support and a support section. The former consists of a list of simple questions which ask the designer and user why a particular product characteristic has been designed in a particular way. The characteristics are determined by the reduction of the t i p into discreet domains (input, output interface, control interface, etc)[1] and the selection of representative characteristics within those domains. Clearly, it would be difficult with highly complex products to question the role of all perceivable characteristics, so that single questions are devoted to multiple characteristics where these are similar.

The second or support section of the questionnaire is designed to elicit more general information, which may contribute less directly to the product's identity through association, patterns of use and performance, background of the user group, etc. This secondary data may be drawn on to illuminate a particularly significant mismatch, identified in the non-support section of the questionnaire, but should not be viewed as being of unqualified relevance to that section.

A structured and closed-ended questionnaire technique is employed, so that re-application of the method to a range of t i p's will be possible with a consistent approach to each (ref 2.2.3). It is also intended that the flexibility of the technique, where a pre-existing structure can be adapted for general application, will enable it to be used in two ways. Firstly, as in the case of this investigation, for academic purposes to provide a variety of practitioners, educationalists, students and researchers with information about the design activity. Secondly, to provide a method which can be modified for use to improve the process of designing a particular t i p.

The research method aims to establish a means whereby the identity of the t i p can be more clearly understood by its designers, so that it may be more precisely matched to the needs, preferences and aspirations of its users.

The questionnaire method has had a single pilot application, followed by a single, debugged application to a single product: a microwave oven. The method of application is now described in detail, commencing with the parameters for the selection of t i p subjects.

NOTES

1 Reference Appendix 6.8 for explanation of Interfaces.

3.2 TECHNOLOGICALLY INNOVATORY PRODUCT SELECTION CRITERIA

The method by which t i p's are defined and selected as being suitable for investigation by this research method is relatively simple, being a matter of choosing those products which comply with the under-mentioned parameters. It is recognised that the number of products that would actually comply with the entire range of parameters would be small. They have therefore been divided into primary and secondary conditions, the former being those conditions which must be stringently satisfied, the latter being those which it is preferable to satisfy but not essential.

3.2.1 Primary Conditions

The product must:

1. be manufactured by industrial methods;
2. incorporate innovatory technology which is responsible for new functional characteristics, which are observable to the casual user (ie the technology should not merely be an improvement in an internal component).

3.2.2 Secondary Conditions

The product must:

3. be high volume as opposed to small batch production;
4. be reasonably complex in design terms;
5. be aimed at untrained users;
6. have achieved an apparent level of success, both in

design and financial terms;

7. have been designed by a team or individual which is capable of describing the product design process accurately and honestly.

3.2.3 Explanation of Product Selection Criteria

3.2.3.1 The product must be manufactured by industrial methods

This condition precludes those products which may be hand-assembled in small numbers, products manufactured by amateurs in domestic premises or small workshops and products in pre-industrialised cultures. It is included as a primary condition because of this research project's concentration on the field of industrial design and consequent involvement with the problems of mass-production and automated manufacture.

3.2.3.2 The product must incorporate innovatory technology which is responsible for new functional characteristics, which are observable to the casual user

This criterion ensures that the product innovation is not simply an internal improvement to the product, which is largely undetectable in use. It thus places the innovation in the sphere of activities which the role of the industrial designer is associated with, ie the design of the product/user interface.

3.2.3.3 Be high volume as opposed to small batch production

Although there is no reason why this research methodology should not be applied to goods produced in small batches, it is believed that there are more severe and complex problems which demand exploration with high volume products aimed at untrained users. Also the work done by Moody (Technology Policy Unit, Aston University)[1] covers the small batch area adequately, whilst being relatively uninvolved with high volume products.

3.2.3.4 Be reasonably complex in design terms

There is a risk that to concentrate this research on a simple product with few perceivable characteristics and attributes would cause the resulting information to be scanty and fairly trivial, thus falling below academic requirements at this level.

3.2.3.5 Be aimed at untrained users

It is assumed that the problems related to the design of the product/user interface of t i p's are greater for those intended for untrained use, since more self-explanation is required in terms of the product's identity. Although the interfaces themselves are frequently more complex in products intended for trained or professional use, their rationale is often more straightforward.

3.2.3.6 Have achieved an apparent level of success, both in design and financial terms

This criterion excludes those products which have very obvious failings, where the detailed analysis of this research methodology is not required for their identification. It is also felt that a product which has been successful in terms of meeting intended sales volumes will yield a more balanced and typical user group than a product which has failed and consequently been used by only a small number.

It has been decided not to select products which have been defined as successful by their inclusion in the Design Council Awards Scheme or Index (as in the case of Moody's research).(1) This is because the Design Council selection procedure may well prevent the selection of t i p's from being representative of the market as a whole and may introduce factors which, though important from the Council's point of view, are not particularly relevant to this research. For example, the insistence on the Award Scheme winners being predominantly designed in Britain, whilst obviously necessary to promote British design, may prevent t i p's which are characteristic of the British market from being selected.

3.2.3.7 Have been designed by a team or individual which is capable of describing the product design process accurately and honestly

This is a difficult criterion to apply rigid rules to, since in the first place it may be impossible to assess and secondly the fact that this research is retrospective means that there will be inevitable difficulties in obtaining accurately recalled information from the design team. Nevertheless a product where the design team has disbanded, where company loyalty prevents a critical appraisal of the product, or where a designer is unable or unwilling to describe perceivable attributes in verbal terms cannot be considered for the application of this research method.

The Creda microwave oven was selected for the application of this research method after detailed preliminary interviews with company staff (ref research interview records) established that it fulfilled the two primary conditions and satisfactorily adhered to the secondary conditions.[2] There was some disagreement between the members of the design team on why certain design decisions were made. However, on balance, this was thought to result from the shared development of the product between two companies (Litton in the USA and TI Creda in the UK), and the comparative lack of involvement of the industrial designer in fundamental decision-making. It was therefore assumed that this was not an untypical trait in t i p design.

The following section explains the purpose of the questions that were subsequently put to Creda microwave oven users and the product design team.

NOTES

1 Moody, S - research interviews. (Ref RM9)

2 Ref RM1, RM25, RM26 and RM29.

3.3 DESCRIPTION AND EXPLANATION OF THE USER QUESTIONNAIRE

The following section is intended to describe the purpose of each individual question and the mode in which it is asked, including details of any probe or auxiliary questions. A similar descriptive breakdown of the design-orientated questionnaire follows in the next section. The relationship of the two is then explained.

3.3.1 Introduction

The user questionnaire, dated 1 October 1980, results from the development and correction of pre-pilot and pilot testing, details of which are included in the thesis appendices (ref 6.3). The questionnaire evolution is not described in this section; rather, the individual questions are examined as they stand in the fully evolved questionnaire.

3.3.2 Presentation of the Questionnaire

The questionnaire interviewees were selected from a computer print-out of Creda microwave oven users, based only on those users who had supplied a completed guarantee card by post to the manufacturer. The print-out covered an area specified for the research and dictated largely by the anticipated limitations of this research programme's travel budget. This area encompassed the whole of the counties of South and West Yorkshire and included the major cities of Leeds and Sheffield, as well as smaller towns such as Barnsley, Huddersfield, Halifax and Doncaster.

The total number of user records supplied was 126 and initially the towns of Sheffield, Rotherham and Doncaster were selected as target areas. At first, door-to-door calls were made, which proved to be wasteful of the research resources as the comparatively wide scatter of Creda users meant that there were few opportunities to arrange a sequential tour of user addresses. The possibility of sending the questionnaire through the post was rejected because of its length and complexity and the low probability of returns. The possibility of the approaches being made by post, to be followed by a personal interview, was also rejected, again because of the probable low rate of returns. Instead it was decided that the initial approach should be made by telephone. A sampling of the Sheffield area users showed that only two out of twenty-one users were non-subscribers, so that the bias of results was likely to be of a fairly low order.

The print-out contained a twenty-two digit code for each user entry and a portion of this code indicated the date of purchase of the oven, eg:

4770342458E<u>130679</u>8106 date: 13.06.79

All the purchase dates fell within the period between January and December 1979, interviewing commencing with the final revision of the questionnaire during October 1980. This effectively covered users with a minimum of 9 months and a maximum of 21 months' experience of the product. This was felt to be a suitable period, in that interviewees would still be able to recall some aspects of the pre-purchase and purchase phase, as well as remembering details of the learning phase. The length of use was also sufficiently well established to enable short-term, 'novel' behaviour patterns to be minimised and thus produce information about the way the oven is used over the major portion of its anticipated life-cycle.

Initially users within the Sheffield, Rotherham and Doncaster areas were selected, as this grouping was thought to contain a wide socio-economic mix of users. The area included a wide variety of housing types: council flats and houses, National Coal Board property, remote rural establishments, owner-occupied housing developments, as well as up-market suburban and urban dwellings. Similarly, it included a wide potential selection of employment, since the area was noted for heavy industry, including steel production, coal mining, glass making; for education, including a university, polytechnic and numerous colleges of education and technology; for some agricultural activities (and the manufacture of agricultural machinery); as well as for white-collar administrative and clerical jobs. The unemployment rate appeared to be about the national average, although politically the area had a predominantly left-wing bias.

Every user/telephone subscriber in the area was thus contacted and meetings arranged, with only a one in twenty refusal rate. The approach over the telephone was made in a fairly straightforward way, indicating that information on 'problems' encountered by the user was needed in order to produce successful microwave ovens in the future. It had become apparent during the pilot interviews that many users wanted more information on their ovens and so some emphasis was placed on a two-way exchange of information. Also, the fact that many of the users did not know other users appeared to encourage them to want to compare notes with someone. Thus the formality of the questionnaire was deliberately understated, in order to create the impression that a relaxed exchange would occur.

A flexible approach to interview timing was deemed essential from the early pilot, since many of the interviewees worked either during the day or, in some cases, on shift work.

An 'Interview Kit' was constructed, which consisted of the following items:

The five-page questionnaire (ref Appendices 6.4).

Two illustrations of other microwave ovens, clearly labelled A and B (ref Illustration I18).

One illustration of the Creda oven (in case the oven was not easily accessible, as with a pilot interviewee with the oven at the end of a tiny larder).

One Creda instruction manual (ref Research Records).

One Creda advertising brochure with enlarged illustrations (ref Research Records).

A letter of introduction from Creda, plus a photocopy for each user to keep (ref Research Records).

The appropriate answer selection cards(1) for the

COMPANION PRODUCTS USED IN THE QUESTIONNAIRE product identity questions.

Assorted maps, pencils, etc.

3.3.3 The Form of the Interview

Although the interview consisted almost entirely of the questions detailed in the questionnaire, there were some differences in the order in which they were asked.

To begin the interview, the user was given a repeat explanation of the nature of the enquiry, but this time informed that there were "quite a number of questions". The 'Support Questions' (page 3 of the questionnaire) were asked first, because it was thought that their fairly orthodox forms would ease the interviewee into the more complex questions and would gradually prepare him or her for the more difficult topics in Section One. After the completion of the 'support questions' (page 5), the interviewee was introduced to the questions in Section One (pages 1 to 3 of the questionnaire).

> "We are trying to find out how much consumers understand about what they can see of the product. I am going to ask you a number of questions about individual features and I would like you to tell me what is their purpose. I would like you to read this card and, if you cannot think of a particular answer, refer to it and choose the most likely reason or reasons. If you feel that there is more than one reason, please state them.
>
> You will find that some of the questions are very easy and some extremely difficult . . . even I have difficulty answering them, but I would like you to attempt them all."

It was important that the interviewee should not feel intimidated by the possibility of the kind of failure usually associated with difficult examinations. This is why the 'impossibility' of some of the questions was stressed, and the fact that I (an expert?) would find difficulty with them. However, a slight hint that the questions were a test remained and appeared to promote a greater interest in participation in the majority of interviewees.

If the interviewee did appear to become dispirited, a number of encouraging comments were made:

"I only scored three out of ten for that one"

or

"You were the only person to get that one right today"

etc.

Frequently consumers would want to know the answers to some of the questions during the interview. It was then explained that providing answers would condition their replies to the questions to come, but that they could ask me what they liked at the end of the interview.

Towards the end of this section some of the interviewees would become concerned about the length of time remaining, and again encouraging comments ("just two or three questions remaining") were made.

Following the 47 Section One questions, the personal details on page 5 were recorded, followed by 3 final and more generalised questions: a self-image question, an assessment of the percentage of microwave oven use and a question about the degree to which early expectations had been fulfilled.

At the end of the formal questionnaire, if the interviewee was still willing to spend more time, a general discussion took place. Frequently, curiosity about microwave oven use would encourage a two-way exchange of information to take place. The discussion often provided an opportunity to discuss any interesting answers that had come to light during the formal interview. As a final remark, the interviewee was usually asked if there was anything that he or she felt had been left out, or that they would like to comment on.

3.3.4 The Questions

In the section entitled The Individual Function of the Questions (Appendix 6.5), the purpose and presentation method of each individual question is described in detail, in the order that it appears on the document and not in the order that it is put to the interviewee. All the questionnaires were put to users in the presence of the product, so that their attention could be clearly directed at some of the less obvious product characteristics. It also tended to stimulate the user's recall of many of the details asked during the 'support questions' section.

The prompt card (or cards, if two users were interviewed) contained the following phrases:

THE FEATURE:

ENABLES OR HELPS YOU TO OPERATE THE OVEN (OPERATIONAL).

MAKES THE OVEN EASIER OR CHEAPER TO MANUFACTURE (MANUFACTURING).

ENABLES THE OVEN TO WORK, OR IMPROVES THE WAY THE OVEN WORKS (TECHNOLOGICAL).

IS THERE TO ENHANCE THE LOOKS OF THE OVEN (STYLISTIC).

The order in which these statements appear on the cards was rotated for each interview, in order to reduce any bias resulting from concentration on the early statements.

As the product was present, a feature was indicated, where it was relevant, by pointing it out rather than by describing it. This had been provoked by an extreme response in one of the pilot interviews, when the red light was described verbally and the user expressed surprise that it was a light (unusual background lighting and poor eyesight partially explained this). A policy of asking "What is this for?" or "What is this red strip for?", where the minimum of information about the characteristic was proffered, was therefore adopted.

3.3.5 Support Questions

This section, in contrast to the previous one, contains questions of a more general and open-ended nature. They are grouped under a series of headings to cover periods such as the pre-purchase/purchase phase and the period of learning to operate the product. Also a section on the user's wider interpretation of the product identity is included. In some questions the user is asked to ascribe a particular value to a feature or characteristic. Because of the length and complexity of the rest of the questionnaire, these value judgements have been tabulated using simple methods where possible. Again, the function of each individual support question is described in the appendix, The Individual Function of the Questions (Appendix 6.5).

NOTES

1 Ref Section 3.3.4.

3.4 DESCRIPTION AND EXPLANATION OF THE DESIGN QUESTIONNAIRE

3.4.1 Introduction

The purpose of the parallel questionnaire technique is analogous to the diagnostic technique employed in medicine. Unusual and unwanted symptoms are observed in terms of the way that products perform in use, which are then traced back to their causes within the design process itself. Such an analogy helps to explain the reason why the design questionnaire is a development of the user questionnaire, and not vice versa. Any attempt to reverse this and base the user investigation on the design interviews would involve speculative assumptions about the nature of product use and hence a critical analysis of the design process would have to be based on a separate model.

In devoting this section to a description and explanation of the design questionnaire, much of the motivation for the individual questions can be found in the previous section. It is not proposed therefore to repeat the explanation but simply to describe where necessary any important differences between the two sets of questionnaires.

3.4.2 Selection of Product and Interviewees

No attempt has been made to apply the research methodology to a representative group of t i p's at this stage. The choice of the first subject, the Creda microwave oven, is not therefore of great significance beyond the satisfaction of the criteria that are defined in section 3.2. This was the result of a series of preliminary general interviews with the chief project engineer, the cooker division manager and the cooker division marketing manager.(1) At this stage a general approach was adopted to try and establish a picture of new design and technical developments within the industry, and also to learn as much as possible about the company structure, policies and market, together with some indication of the roles of designers and technologists. Initially a touch-control cooking hob was also considered, although this was subsequently dropped in favour of the microwave oven because it was very new to the consumer market and consequently would not provide the medium-term user experience necessary. The subsequent adoption of the microwave oven and the ensuing user interviews had a profound influence on the type of questions contained in the design questionnaire. This, in turn, exerted an important influence on the question of whom, within the company, it was necessary to interview using the technique.

The fact that the questionnaire possesses a closed-ended question component has meant that this selection process is simplified. The objective of the questionnaire is to check specific design intentions rather than to establish a comprehensive case study of the product's development. In practice, this has meant that the selection of necessary interviewees has depended mainly on obtaining a consistent series of responses within a relatively narrow area of manufacturing activity. For example, major policy decisions about the motivation within the company for the adoption of microwave ovens have little relevance within the user questionnaire context. Thus there is no corresponding requirement to interview those personnel involved with such decisions.

The concentration on central design issues within the user questionnaire has thus determined to a degree the nature of the interviewees. It can be assumed that if the designer is interviewed and fails to answer certain questions, then there is a strong probability that he can refer the interviewer to someone who does. This is because, in the relatively narrow design territory covered by the questionnaire, there is likely to be a close, lateral relationship between the various design disciplines involved, unbroken by the largely hierarchical structures which determine advanced company product policies.

Other factors related to the specific characteristics of the individual company play an important part in determining the interview group. In the case of Creda, the separate, relatively autonomous nature of the different T I manufacturing divisions meant that, as cooking appliances were concentrated within one division, the product design process normally took place to a great extent within that division. Hence personal communication links existed between many of the design personnel. However, this was not the case with the microwave oven, since it was developed in collaboration with Litton, an American company with previous experience in the field, unlike Creda. The design process was therefore dislocated, both geographically and chronologically. The implications of this are discussed in section 5.4.3.

In the case of the Creda company, the research strategy adopted was firstly to make general enquiries about who was involved in the design process, and then to begin the questionnaire process within the defined group in a fairly random way. The questionnaire itself served as a vehicle for determining future interviewees, since knowledge gaps usually indicated areas of uninvolvement with the design process. Hence the interviewee was asked for a reference to the relevant participant, who could then be interviewed. Once the series of interviews started to produce referals back to those already interviewed and ceased to generate new inputs, it was assumed that all the avenues within the scope of the questionnaire had been covered. Only if a significant part of the questionnaire remained unanswered would it be necessary to open up new channels elsewhere within the company.

In practice, the final design group selected for the application of the questionnaire methodology was narrowed down to the following three:

D1 The Design Manager, T I Creda, Cooker Division.

Role - Administrative, also responsible for the technical development and approval of the product and components.

D2 The Chief Industrial Designer, T I Creda Cooker Division. Role - Supervision of design work on the microwave oven.

D3 European General Manager, Litton Europe. Role - Co-ordination of cooker design and development between Litton and Creda. Involved in all the aspects of marketing, technical development, sales and design decision-making.

3.4.3 Presentation of the Questionnaire

The familiarity of the design interviewees with the product meant, in practice, that, unlike the user group, it was not considered essential to confront them with the product. (However, it is possible that this would be necessary with more complex t i p's). Photographs of the product were employed to ensure that the interviewee understood clearly which parts of the product were being referred to. Also, the two photographs of the competing products were employed in a similar way as in the user questionnaires.

Before the questionnaire was used, the interviewee was briefed on the details of this research project and was queried on the time available. If this was less than the requisite one-and-a-half hours the interview was postponed. Care was taken not to mention any of the previous findings from the user interviews, as this would obviously prejudice the designer's responses.

NOTES

1 Reference - Research interviews. (RM1, RM25 and RM26)

3.5 THE RELATIONSHIP BETWEEN QUESTION AIMS AND FORMS

The purpose of this section is to provide a general explanation of the structure and form of the questionnaire and to link this to the overall aims and intentions of the research methodology. It is not intended to describe individual questions in detail. Further information can be found in the appendices, section 6.4, The Function of the Questions. It is anticipated that the material in this section will provide the underlying conceptual model on which the exploratory methodology for a given t i p is constructed. Specific references to the microwave oven investigation have been minimised, so that any future application of the methodology can draw directly on the following material without the need for re-interpreting this research's experimental application. However, some reference is made to the microwave oven questionnaire to illustrate and provide examples for the explanatory material.

The questionnaire is in three parts. Firstly, the questions devoted to an examination of the functions that users and designers attribute to the perceivable characteristics of the product. Secondly, a series of support questions which examine the general attitude of the user to the product, and the corresponding expectations of the designers concerning such user attitudes. Lastly, a brief section concerned with personal background information about both the user and designer groups.

These three subdivisions are generally suitable and necessary for any anticipated application of the methodology. It is therefore important that the general relationship of these three question groups is clearly defined and, to this end, their relative importance is outlined as follows.

The first section concerned with the functional roles which are attributed to perceivable characteristics is the core of the questionnaire and provides the basic material by which the two experimental hypotheses 2.2.1 and 2.2.2 can be proved or disproved. The subsequent support questions are intended to provide an indication of the relative levels of importance of this material for different products and user groups. The final background section is designed to put the particular application of the methodology itself into context, by including information on potential error or general limitations related to particular socio-economic, geographic or organisational constraints of an individual interviewee.

It follows that the questionnaire logic is rooted in the first section and must be explained before the relevance of the other two can be understood.

3.5.1 Explanation of the Questionnaire Section Devoted to the Meaning of Perceivable Characteristics

3.5.1.1 All the perceivable characteristics of products are present for a reason or reasons determined by the production group

This statement emphasises the non-accidental nature of product design: that unlike the fine art activity, there is no place for uncontrolled, random elements feeding directly into the final product. However, this is not to deny the possibility of such elements existing elsewhere in the design process and being fed indirectly and in a controlled way into the product. For example, the design of fabric patterns often incorporates a random component, but one which is effectively matched to the constraints of the production medium.

3.5.1.2 Because perceivable characteristics are determined by reason, they therefore have meanings or functional roles

In other words, the non-accidental nature of the characteristics means that they fulfil purposes in the product.

3.5.1.3 The functional roles of a characteristic will fall into one or more of the following categories:

(i) A Manufacturing Role -
The characteristic facilitates production and/or minimises production costs by minimising the use and cost of energy, materials, labour, machinery, research.

(ii) A Technological Role -
The characteristic enables the product to function and/or increases its functional efficiency or potential.

(iii) A Stylistic Role -

The characteristic exists to enhance the visual appeal of the product to the consumer.

(iv) An Operational Role -

The characteristic exists to facilitate, enhance or ease the safe and effective control of the product.

These four roles are sufficiently generalised to accommodate any conceivable purpose that an individual characteristic might possess.

3.5.1.4 <u>In practice, an individual characteristic is likely to fulfil more than one of the above roles</u>

One of the fundamental aims of industrial design is to maximise the number of these roles that a single perceivable characteristic can serve, since this can mean that the product is easier to manufacture or simpler to operate.

3.5.1.5 <u>The designers of the product are likely to possess a great deal of factual knowledge about the purpose of its perceivable characteristics</u>

This is a result of the designer's involvement with the product/user interface in the first place. He is likely not only to know what purpose or purposes various characteristics serve, but also something about the relative degree of importance of these roles.

3.5.1.6 <u>The consumer, by comparison, is likely to have a relatively shallow and sometimes confused understanding of the meanings of the product's</u>

perceivable characteristics

It is likely that this manifests itself in several different ways. Firstly, the user is likely to be aware of fewer roles for the individual characteristic. Secondly, the roles might be confused, one for another. Thirdly, misunderstanding of roles within the same functional category might occur; for example, a characteristic might be ascribed a particular technological meaning which differs from the actual technological meaning, as defined by the design group. Fourthly, the user is less likely to be aware of the relative degrees of importance of several identified roles for a particular characteristic.

3.5.1.7 In general, the greater the degree of misinterpretation of perceivable characteristics by the user, the less successful the product's design and hence performance in use is considered to be

At one extreme this confusion of perceivable characteristics might be so exaggerated that the user is unable to operate the product, is suspicious of and dislikes its visual appearance, has an incorrect view of how it works and has no clear idea what it is designed to do. Alternatively, there are certain types of misinterpretation which can actually enhance the perceived performance of the product in use. For example, a characteristic which is essentially a manufacturing detail, such as a strengthening indentation in the body panel of a car, may be interpreted as being a purely stylistic detail by the majority of the car's owners and may diminish the user awareness of the cost reduction involved in thinning down the body panel.

3.5.1.8 There are differences in the degree of significance that the variety of potential misinterpretations represents

In practice, the variety and complexity of perceivable characteristic functions renders any orthodox and comprehensive analysis virtually impossible. However, two important simplifications occur in this research questionnaire method. Firstly, the design responses define the most significant functions of perceivable characteristics and not the entire spectrum. Similarly, the user responses define only a limited number of possible functions. Thus the overall comparative process is simplified to a more manageable level by the limits set by the interviewees themselves.

3.5.1.9 It is possible to directly compare the user's interpretation of perceivable characteristics with their major functions, as defined by the production group

The significance of the results can only be determined by careful reference to the general attitude of the user (as documented in the 'support' question results) and to the Analysis of the Significance of Multiple Functions in Single Perceivable Characteristics, housed in the appendices, 6.5.

CHAPTER 4 RESULTS AND INDIVIDUAL CONCLUSIONS

4 THE PRESENTATION OF RESULTS

In this chapter the results and individual conclusions are described in two sections, directly related to the non-support and support sections of the questionnaire. In order to simplify presentation, only classified responses are documented in the former, and kept to a minimum in the latter. The reader is referred to section 6 of the appendices for more detailed questionnaire data.

4.1 NON-SUPPORT QUESTIONS

The non-support findings are listed under their interface sections, as in the questionnaire, and consist of the following:

The question number

The original question

An illustration or reference to an illustration of the product

A matrix display of the classified responses

An individual conclusion concerning the question result

The Matrix Display

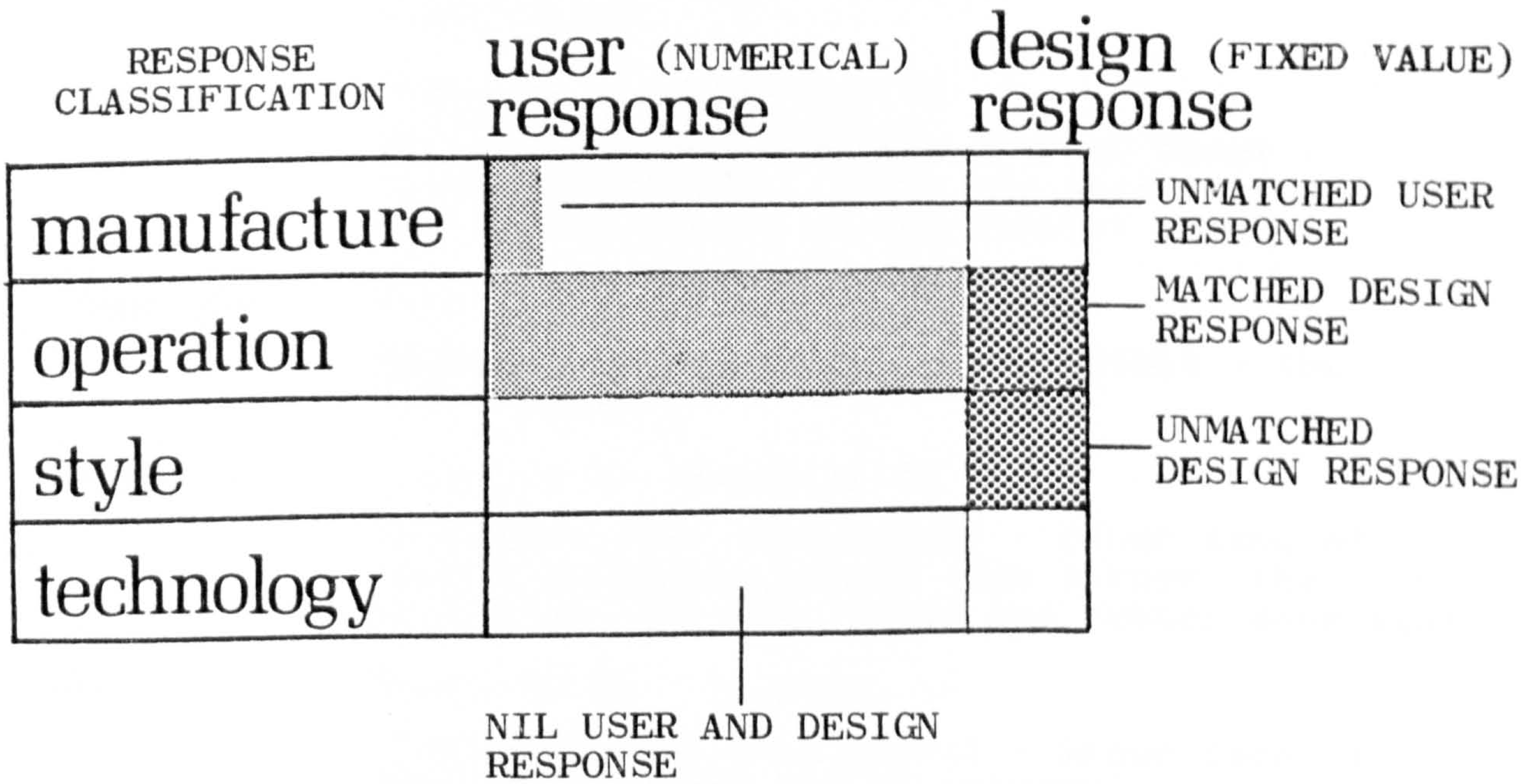
The matrix is designed to facilitate the direct comparison of user and design responses. The user responses in the dense tone represent the varying numerical responses under the appropriate Manufacturing, Operational, Stylistic and Technological classification (reference section 3.5.1.3). The length of the tone represents the proportion of responses to a particular category. A numerical value for the response is not supplied because of the limited number of interviews carried out.

The design responses are classified in the same way as the user responses but are entered on the matrix as a design team consensus of opinion. They are therefore of fixed value and vary only according to classification code (M, O, S or T).

The proximity of the tone to the design response block is therefore an indication of the degree of match/ mismatch for a particular characteristic.

T4

AN EXAMPLE OF A TYPICAL MATRIX DISPLAY (QUESTION 13)



LIST OF PLATES, ILLUSTRATING QUESTIONS, ARRANGED ACCORDING TO USER/PRODUCT INTERFACE

Product Enclosure

Page 183 Plate No 11 Question 22

Side view of microwave oven - showing the outer case.

Page 186 Plate No 12 Question 23

Microwave oven outer case detail - surface texture.

Page 188 Plate No 13 Question 24

Microwave oven front corner detail - top right corner showing the use of materials: the textured surface wrapped over the front edge of the case with PVC-coated link and the metal trim of the control panel.

Input Interface

Page 190 Plate No 14 Question 26

Microwave oven door detail - front top left door hinge.

Page 192 Plate No 15 Question 27

Microwave oven front detail - right top corner of the door and top left edge of the control panel, showing metal trim, wood-grain finish, brown glass and off-white surfaces.

Page 194 Plate No 16 Question 28

Microwave oven main body detail - top right corner showing the outer face of the door seal and door lock holes.

Page 197 Plate No 17 Question 29

Microwave oven interior space - complete view, with the door open.

Page 199 Plate No 18 Question 30

Microwave oven door detail - inner face of the door, bottom left corner, showing rubber seal and metal trim.

Page 201 Plate No 19 Question 31

Microwave oven door detail - the three door catches.

Page 203 Plate No 20 Question 32

Microwave oven - a complete view, taken from an angle, of the interior space of the oven with the door open.

Page 207 Plate No 21 Question 34

Microwave oven interior detail - oven cavity extractor vent.

Product Materials

Page 218 Plate No 22 Question 40

Microwave oven, side view of outer case.

Page 224 Plate No 23 Question 43

Microwave oven interior, ceiling detail - rear, interior light source; front, oven cavity extractor vent.

CONTROL INTERFACE

Question 1

What is the red light for?

Plate No 1

Microwave oven control panel detail - the top of the panel. A red light illuminates the oblong shape when the power is on.

	user response	design response
manufacture		
operation		
style		
technology		

Question 1 Conclusions

This question was introduced at the beginning of the questionnaire because it is one of the most simple to respond to and is intended to put the interviewees at their ease. The results confirm this intention, since there is a close matching of user and designer classifications.

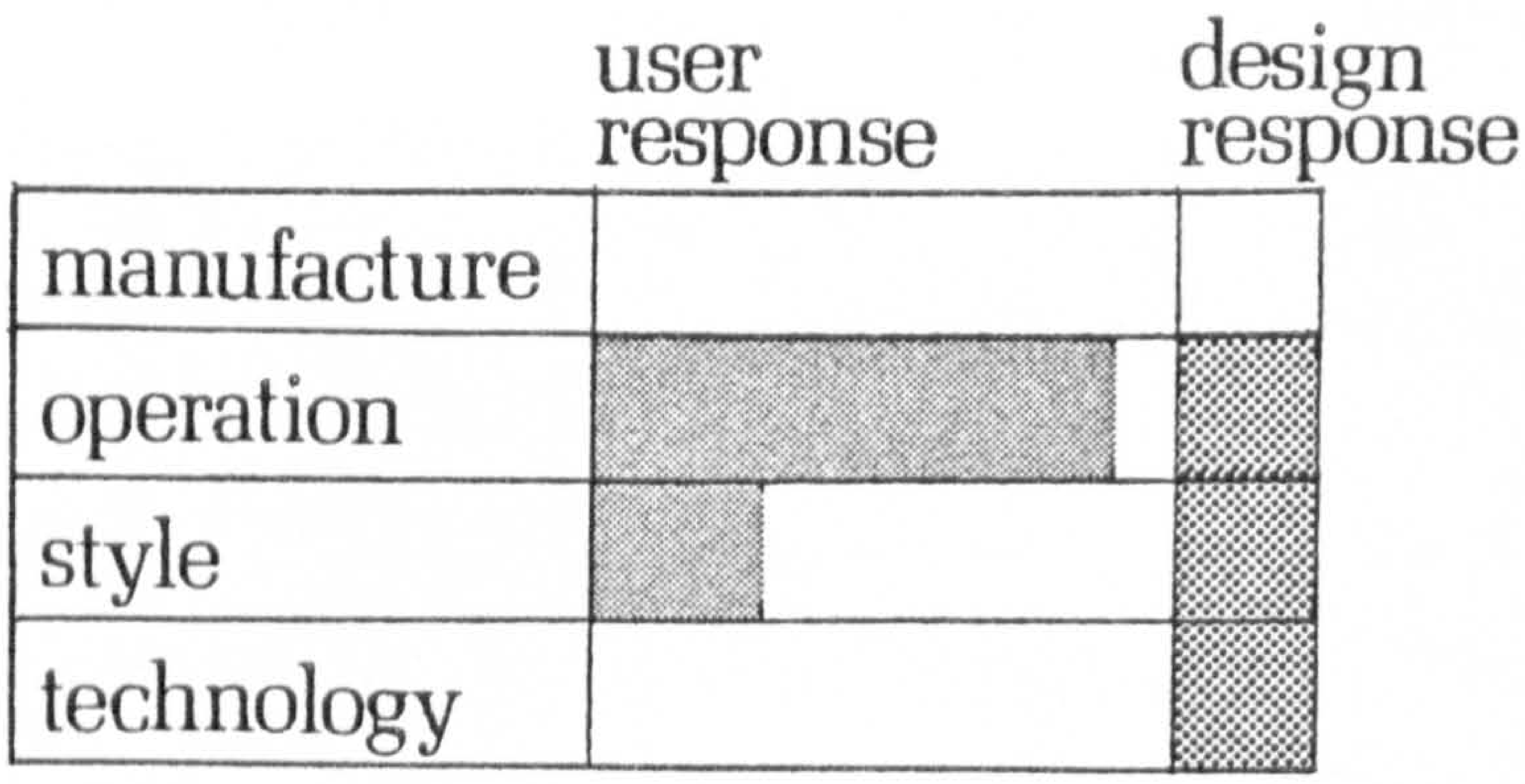
Little mention is made by either designers or users concerning the actual purpose of the warning light as an addition to the internal illumination and operating noise, to denote the oven is operating. The reply given by D3 comes closest to this in referring to it as an additional "comfort", suggesting that its function is not merely to provide basic operational information, but to provide a psychological support for the product user.

CONTROL INTERFACE

Question 2

Why is it this colour rather than any other colour?

Refer to Plate No 1.



Question 2 Conclusions

The design results indicate an inability on the part of the Creda designers to identify the crucial symbolic identity of the colour red, ie its association with danger, or 'power on'. Even D3, although concerned with the association of the colour, linked this to its relationship to other appliances rather than its direct symbolic value. Whilst there is little doubt that the designers would acknowledge the direct associations of the colour red if questioned, the results do demonstrate an inability to consider basic design decisions objectively. In terms of the Creda designers, it illustrates a tendency to accept existing design decisions at face value, without identifying their underlying motives.

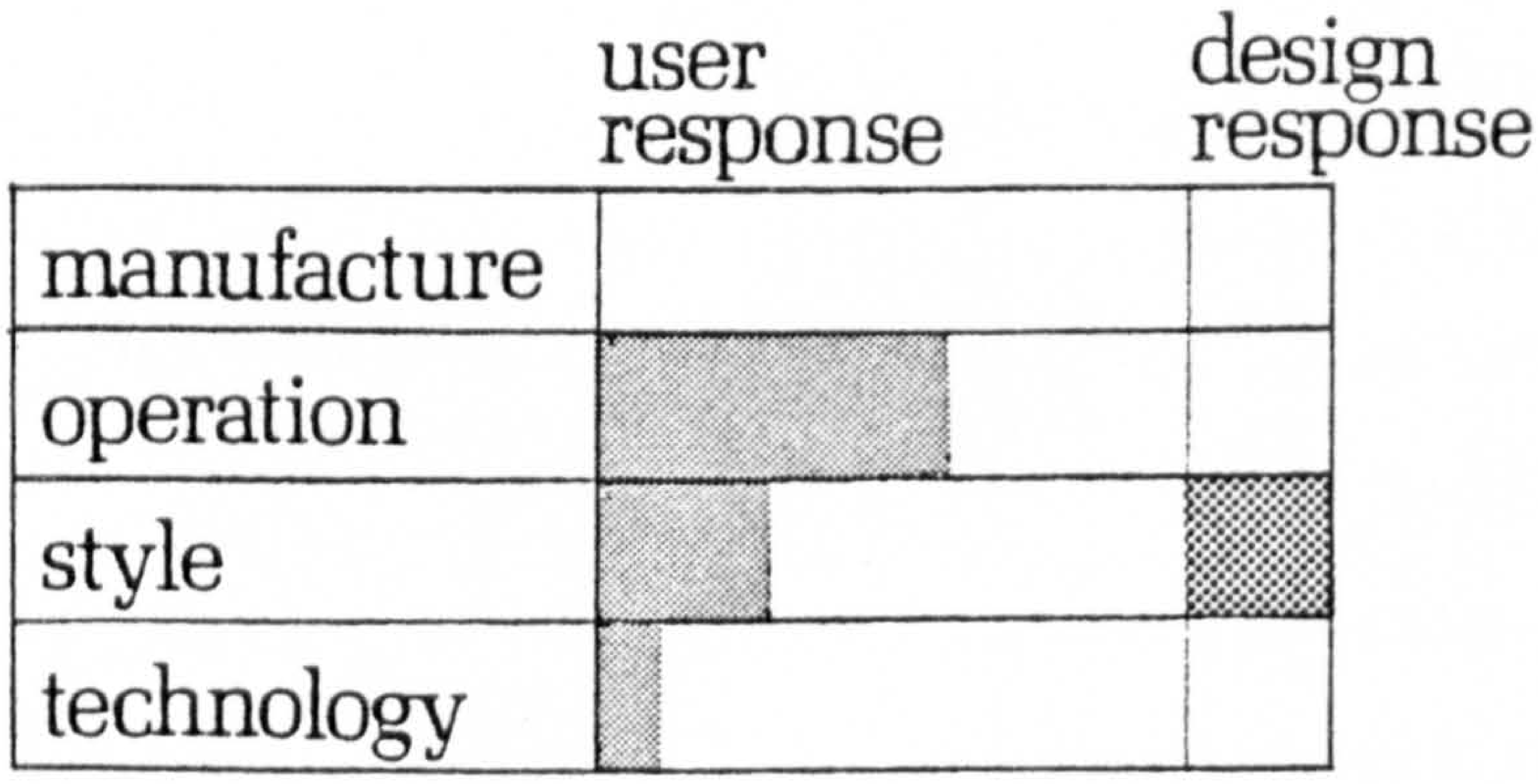
Conversely, the high number of common responses obtained from the user group shows the dominant associational value of the colour red. Significantly, U5 misinterpreted the colour red as being related to the colour surrounds of the two control switches. This might lead to operational difficulties if it is assumed to be a colour-coded system.

CONTROL INTERFACE

Question 3

Why is it rectangular and not round, for example?

Refer to Plate No 1



Question 3 Conclusions

The three designers are in agreement on the purely stylistic function of the rectangular shape. Although their responses differ slightly in the way that this role is defined, they all state a definite visual relationship with other product components. The Litton designer, D3, is the only member to refer to an overall stylistic approach to the product in terms of an emphasis on the horizontal length and reduction of the perceived height of the oven.

In contrast, the user group tended to respond to the question by differentiating between the shape and other shapes, particularly those forming the controls, to justify an operational rather than stylistic function. This represents a significant difference between designer and user perceptions; the former were concerned with matching the visual characteristic to other product characteristics, the latter with the isolation of the characteristic from a different set of product characteristics.

It would appear from this result that there is a reluctance on the part of product users to identify purely stylistic functions. This may be due to the general technological identity of the object, which conflicts with such 'non-functional' criteria.

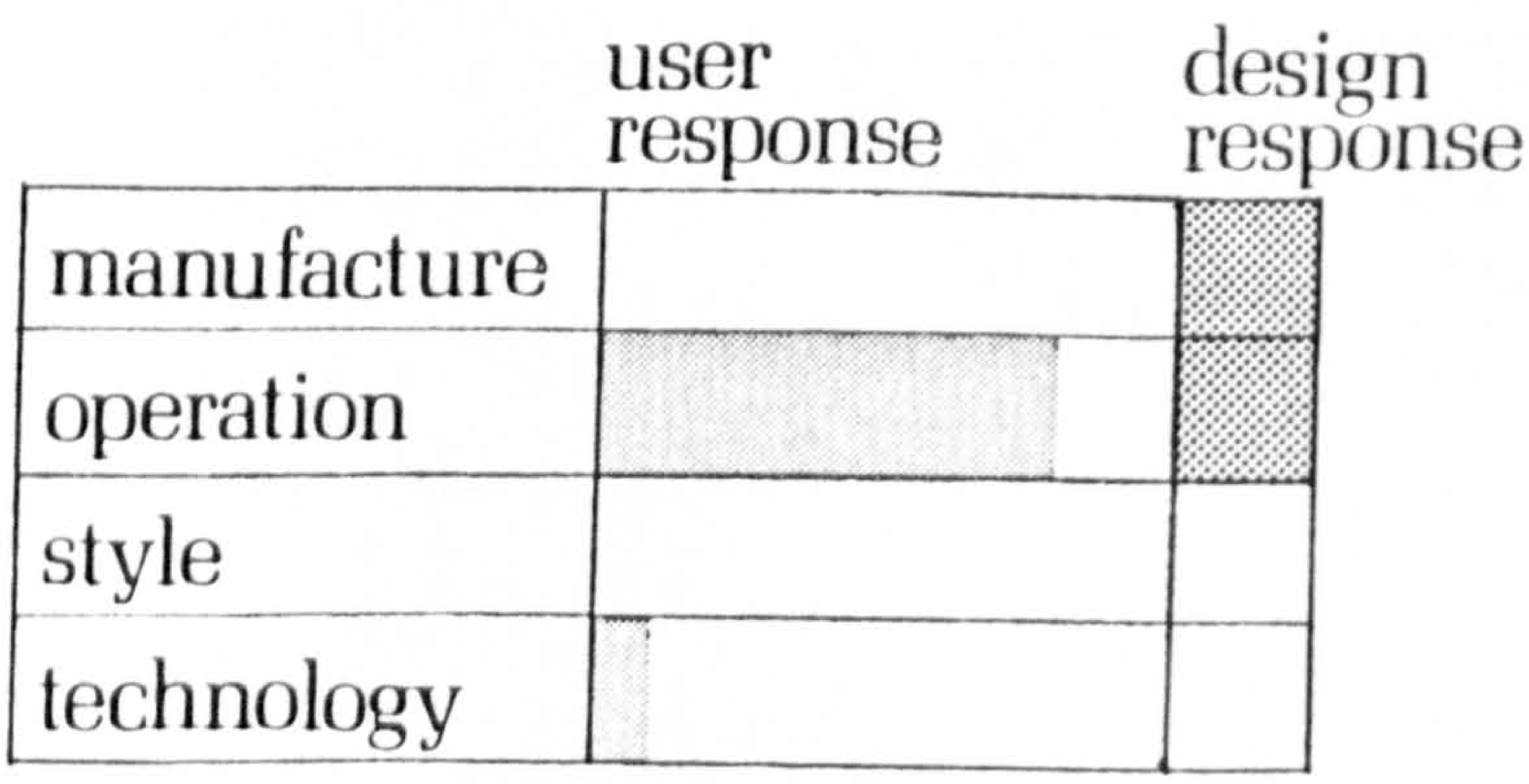
CONTROL INTERFACE

Question 4

Why is the power knob smaller than the time knob?

Plate No 2

Microwave oven control panel - time knob (above), power knob (below).



Question 4 Conclusions

The design responses indicate a lack of firm knowledge about the function of this characteristic and hence an uncritical acceptance of a design decision made remotely and concerned with a preceding model design.

This contrasts with the user responses, which show that the characteristic has an operational meaning for the majority of the interviewees. It is apparent that the difference in switch sizes, although relatively meaningless to the design team, does assume functional significance for the user group. At the very least, such a 'superfluous' presence may clutter the control interface unnecessarily.

The contrasting user/designer responses illustrate a potentially common problem with rapidly evolving t i p design. The same basic product may advance rapidly through a chain of small model adaptations, in which concern with the simple meaning of the product/user interface is considered relatively unimportant compared with the more technologically orientated decisions. Thus it is possible that redundant perceivable characteristics may not be re-evaluated correctly when model changes are made, as is probable in this case.

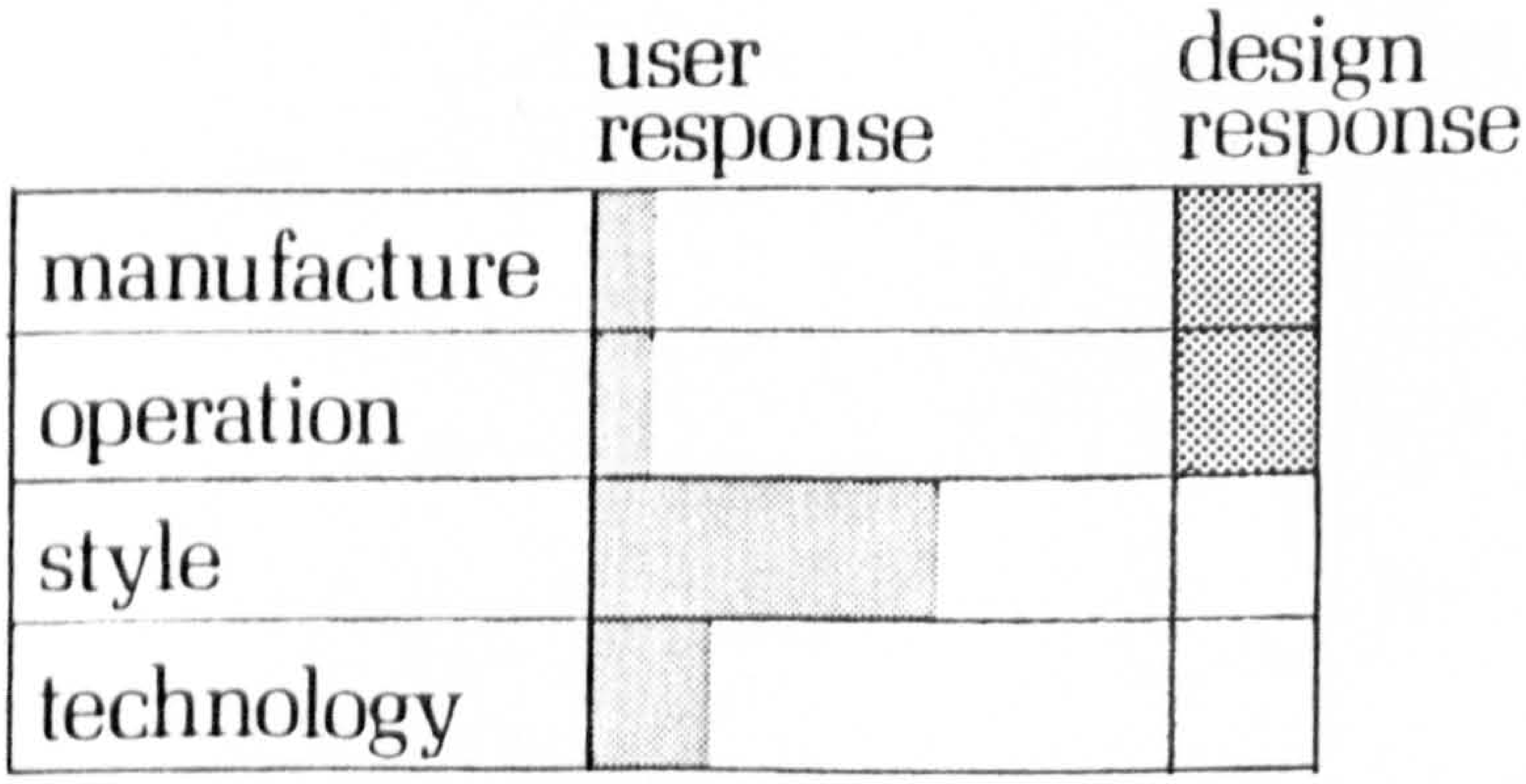
CONTROL INTERFACE

Question 5

Why does it have a metallic finish?

Plate No 3

Microwave oven control panel detail - the power knob.



Question 5 Conclusions

The design responses indicate a readiness to accept an 'off-the-shelf' solution to the problem of control knob design. Recent developments in the consumer durable sector suggest that this is an increasing design approach, with many small companies offering an off-the-shelf or sub-contracting service to provide standard control components and applied graphics. The practice is common in areas where advanced or novel technology is involved in aspects of control design; for example a number of small companies are currently offering a service which provides printed graphic overlays for touch control panels, suitable for many applications in the consumer durable area.

Whilst there are many commercial advantages for the product manufacturer in purchasing ready finished control components, there is likely to be a degree of compromise in design terms. The results of the user/designer responses in this case show clearly that there is a fundamental difference in the perceived meaning of the component. Only a single user defined a manufacturing function which came close to the replies of D1 and D3.

The majority of users gave a stylistic meaning to the characteristic, which seems to suggest that the metallic finish is known to be an applied decorative surface coating, rather than the more functional surface of a solid metal component.

Question 6

Why does the power scale only extend around part of the circle?

Microwave oven control panel detail - the power knob.

	user response	design response
manufacture		
operation		
style		
technology		

Question 6 Conclusions

The results show both a close agreement between the designers that the characteristic has technological origins and a close matching of similar responses from the majority of the user group. The small number of exceptional user responses assume that the characteristic is an operational advantage, which may indicate that the switches on many conventional cookers, which can operate from maximum to zero current both clockwise and anticlockwise, may not always be desired by the user.

The implications of this close matching of design intentions with user perception confirm that it is possible to provide simple technological information by using graphic symbols. In this case the informed user is unlikely to attempt to force the switch beyond the maximum power setting, even though there is no verbal instruction to this effect.

Two of the user group (U4 and U10) compare the characteristic with similar characteristics present in other consumer durables and appear to derive some limited understanding from this. Comments made by the Litton designer, D3, during his interview suggest that there are advantages in relating aspects of the product's identity to other traditional cooking appliances, so that the user learning process will be accelerated and there will be less inhibition about using the more visually familiar object.

CONTROL INTERFACE

Question 7

Why does the power scale have a part orange, part yellow circle around it?

Refer to Plate No 4

	user response	design response
manufacture		
operation		
style		
technology		

Question 7 Conclusions

The results show a close agreement between the three designers on an operational function for the use of colour around the power scale. This is closely matched by the user responses, the only difference being the reference by D3 to functions for the two coloured zones, which is more specific than the majority of user responses in describing the cooking methods appropriate to each zone.

The results reflect the fact that the general functions of the switch are clearly labelled: WARM and DEFROST in the yellow zone and SIMMER, ROAST, REHEAT and HIGH in the orange zone. However, reference should be made to Question 10, in which a confusing colour relationship between the two control switches is examined.

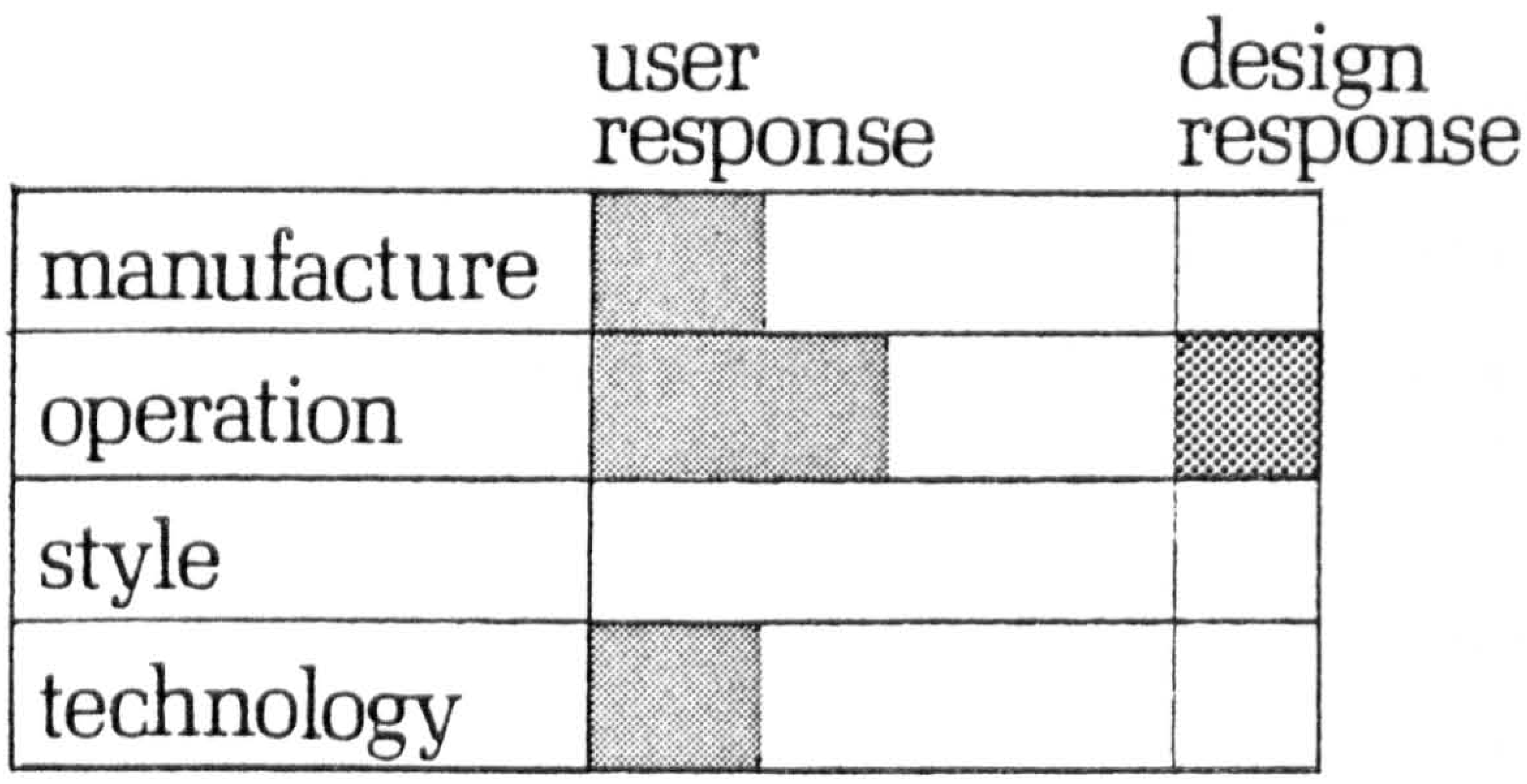
The most significant conclusion to be drawn is that secondary or re-enforced messages are often unquestioned by both designers and users. The role of the two colour zones was stated as being an indicator of energy output, but such an indicator is unnecessary when the settings are clearly labelled. In real terms, the operational role might be assumed to be purely stylistic.

CONTROL INTERFACE

Question 8

Why is the time switch above and not below the power switch?

Refer to Plate No 2



Question 8 Conclusions

There is a significant lack of knowledge on the part of the Creda designers about the relative positions of the power and timer switches. In contrast, the Litton designer, D3, quotes a number of operational advantages. The implications of this imbalance are potentially serious, since the Creda designers were responsible for decision-making on the design of the control interface. It is unlikely that this could have been carried out successfully if both D1 and D2 were unaware of the underlying ergonomic relationships involved in the existing control design.

Half the user group quoted an operational advantage, whilst the rest were divided between technological and manufacturing roles. The mismatched user responses suggest that half the users did not interpret a clear series of operational stages directly from the control design itself, ie the time, power, door switch sequence referred to by D3. As this could take the form of a simple graphic flow diagram or symbol, an expedient operational aid could have been considered by the design team.

D3 and a number of users suggest that the sequence time/power/door switch is ergonomically correct. However, the instructions[1] suggest a power/time/door switch sequence, against any logic there may be in the panel layout - a critical disparity between product and instructions.

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(1) Microwave Cooking With Creda, Instruction Manual, p 8.

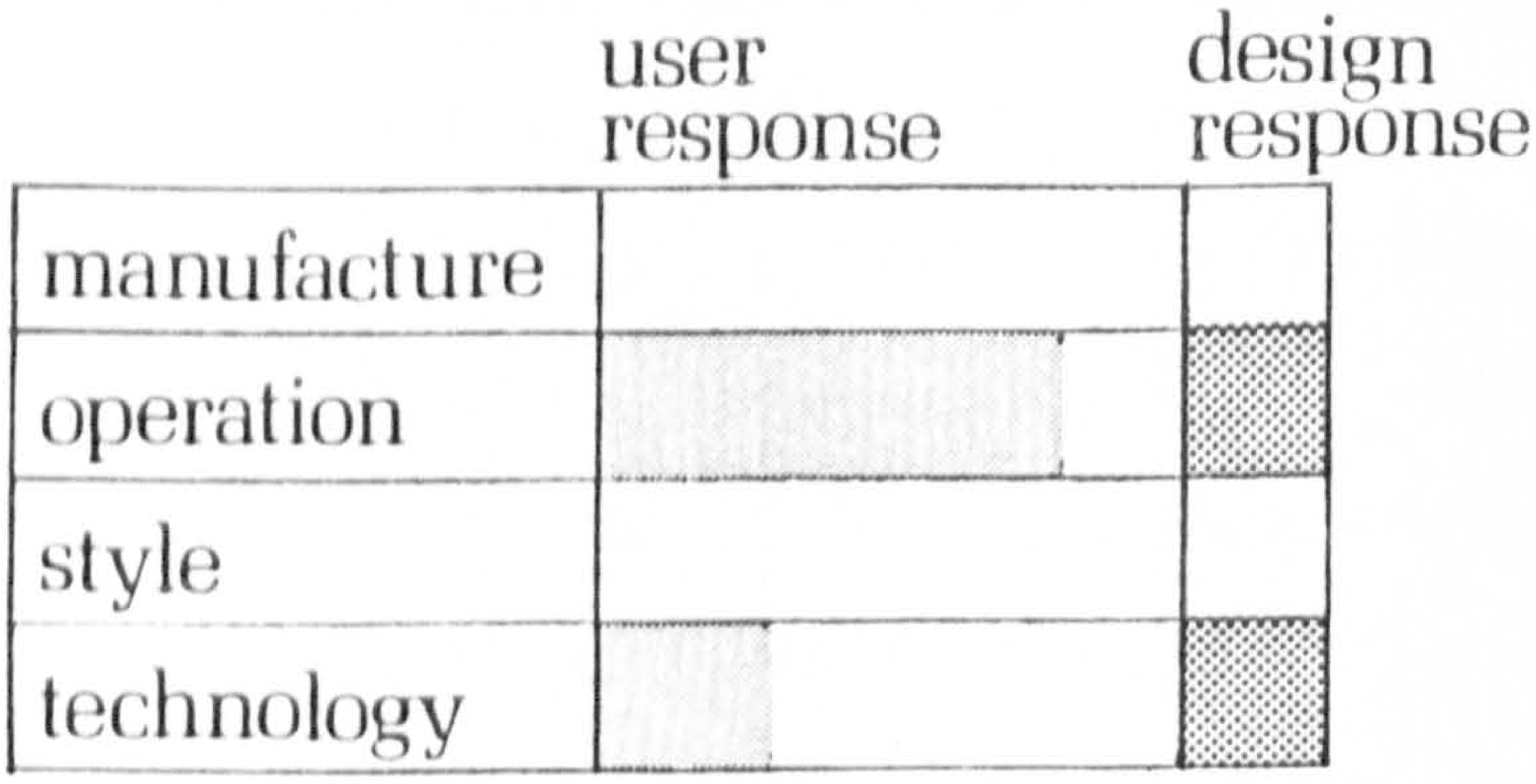
CONTROL INTERFACE

Question 9

Why does the minute scale get larger the nearer it gets to zero?

Plate No 5

Microwave oven control panel detail - the time switch.



Question 9 Conclusions

There are similar responses from the members of the design team, with the exception of the Creda designer, D2, who was unable to provide a response. (This inability is significant, since many of the users were able to identify the correct function.)

The design responses are closely matched by the user responses, with the majority of users able to clearly describe the operational advantage of the scale size, ie that increased accuracy is required for shorter time intervals. Many of the users had not consciously registered that the scale changed until their attention was directed to it by the interview question. This confirms a suspicion that certain characteristics, which have an operational advantage, may not be perceived consciously, but nevertheless perform their function effectively.(1) There is a danger, however, that in the case of the cooking timer failure to consciously observe the exponential change in scale may mean that the scale is misread and difficult to set. References to the support questionnaire show that a number of user problems, though not directly caused by the timer design, do result from general confusion over the cooking time procedure:

Support question 11: Common difficulties - four users stated "over-cooked food".

Support question 16: The least visually attractive feature - four users stated "the control knobs".

Question 20: Characteristics with a low quality finish or standard of workmanship - two users stated an "unreliable timer".

Question 24: Characteristics likely to show signs of wear and tear first - three users stated the power and timer controls.

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(1) This means that some characteristics cannot be the subject of questions, but can be investigated by direct observation methods (ref 5.6.1, paragraph 2).

CONTROL INTERFACE

Question 10

Why does it have an orange circle around it?

Plate No 6

Microwave oven control panel detail - the time switch.

	user response	design response
manufacture		
operation		
style		
technology		

Question 10 Conclusions

The results show a unanimous agreement on the part of the design team on the purely stylistic role of the orange circle which surrounds the power control. It is clearly stated by the Creda designer, D2, that there is no coded relationship between the colour and the similar colours as they appear on the timer scale and the indicator light.

The potential confusion which might have arisen from these colour relationships is not realised in the response patterns of the users, where there is no evidence of an assumed colour code.

It is apparent, however, that the user responses are scattered between three response classifications, thus the exact function of the circle is unclear and, as it is present in the control sector of the oven, is a source of operational inefficiency.

CONTROL INTERFACE

Question 11

Why does it go up to 30 minutes and not a greater or lesser time?

	user response	design response
manufacture		
operation		
style		
technology		

Question 11 Conclusions

There are dissimilar responses from the members of the design team as to why 30 minutes was chosen to be the limit of the timer range. This is partially explained by the fact that this characteristic was inherited by the Creda designers from the original Litton oven. This is indicated by the positive response of the Litton designer, D3, who stressed the operational advantage of the 30-minute period, whilst the Creda designer, D1, stated that 45 minutes was preferred for the British model but was discounted for manufacturing expediency.

The user/designer response comparison shows a unanimous user pattern in the operational classification and a nil response for the manufacturing advantage from the users.

Perhaps the most significant conclusion that can be drawn from the results is that the microwave oven operation has not been confused with other, more traditional forms which require longer cooking times and hence wider timer ranges.

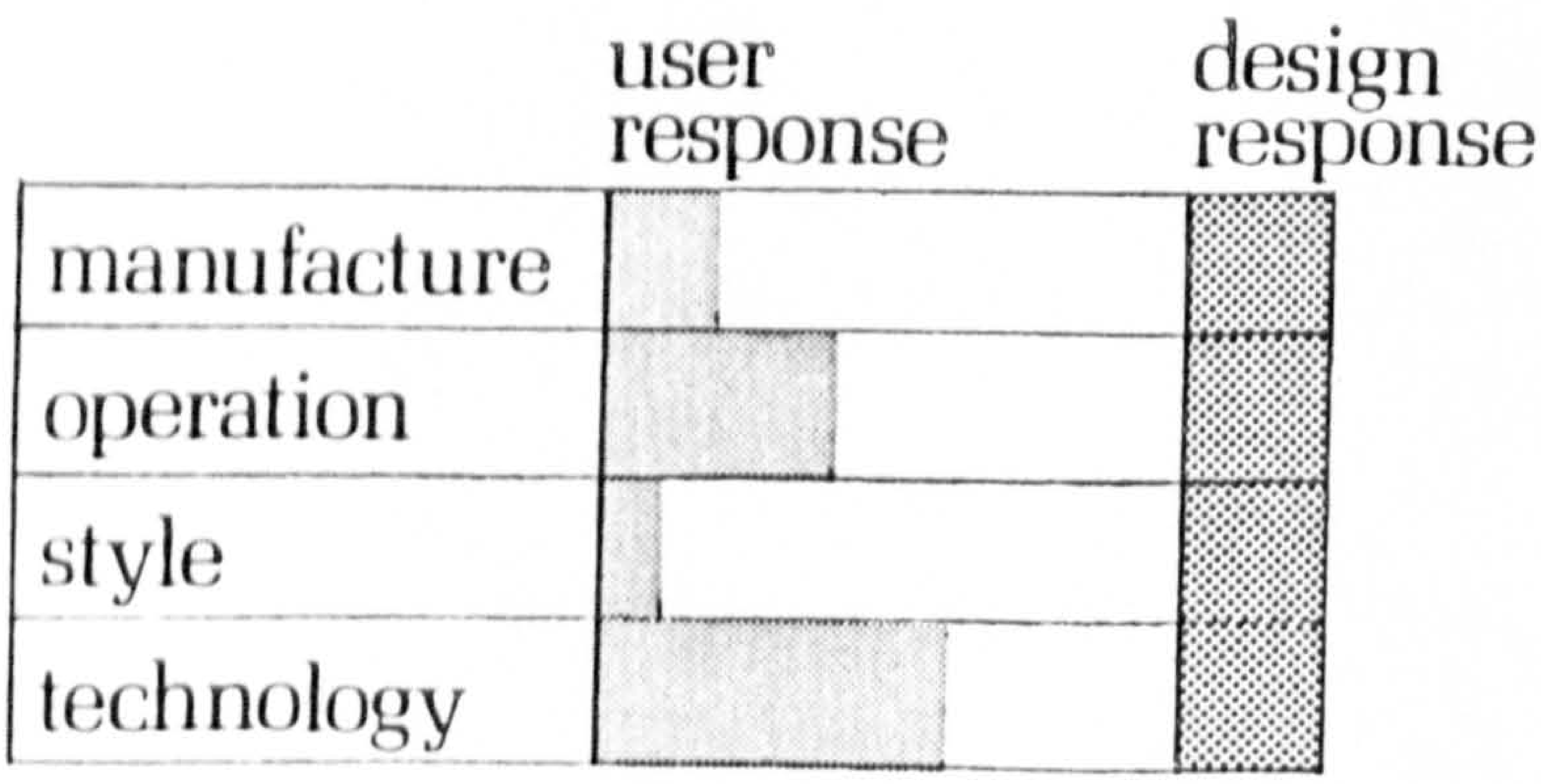
CONTROL INTERFACE

Question 12

Why is the oven door release mounted on the control panel and not on the door?

Plate No 7

Microwave oven - complete view of front showing door ajar. Note the door release bar at the bottom of the control panel.



Question 12 Conclusions

The response pattern of the design team is inconsistent and scattered between all four possible classifications. The responses of the user group are similarly scattered, with an emphasis on operational and technological functions. A high proportion of users (total 7) mention that they believed damage would be prevented to the control, the door or its hinges, which was not matched by the designers. It is therefore possible that, in terms of product identity, the positioning of the door release has led to an advantageous side-effect in the user's perception of product durability.

The stylistic response quoted by D3, concerning the "clean" door without any protrusions, is only matched by a single, less explicit user response (U4: looks neater). It is probable that this low match results from the clear identification by the user of a functional role for the door release, because it is an obvious part of the oven control components. The thought that this could be combined with a less 'practical' consideration is likely to be far from the minds of most users.

Only one user (U6) correctly identified the manufacturing advantage to be had from grouping all the controls together in one area. This probably results from a lack of awareness of the internal product technology and the consequent difficulty in the analysis of linked perceivable characteristics on the surface of the product.

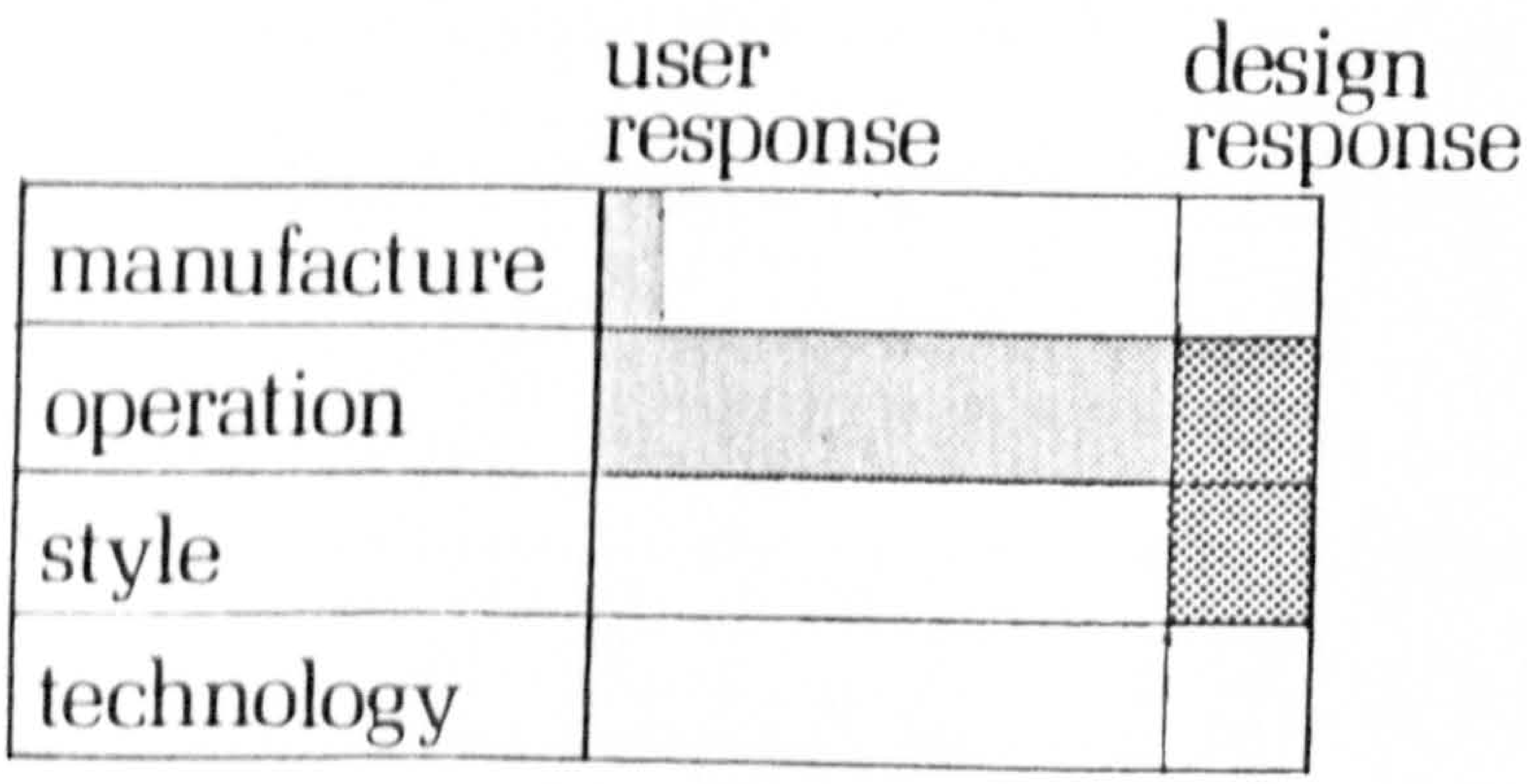
CONTROL INTERFACE

Question 13

Why is the door release this particular shape?

Plate No 8

Microwave oven control panel detail - the door release.



Question 13 Conclusions

The content of the design responses indicates a degree of uncertainty amongst all three designers as to the purpose of the door release shape. The response of the Creda designer, D2, indicates an acceptance of compromise between the Creda and Litton design intentions, which is suspect, since the Creda designers were responsible for the product/user interface design to suit the British market, not the Litton/American market.

The majority of user responses fall into an operational classification on the assumption that the shape of the release makes it easier to operate. Since this shape is a simple, rectilinear one and not a shaped 'handle' in the conventional sense, this response was provoked by a generally favourable attitude to the product, rather than a well considered judgement of the merits of the door release.

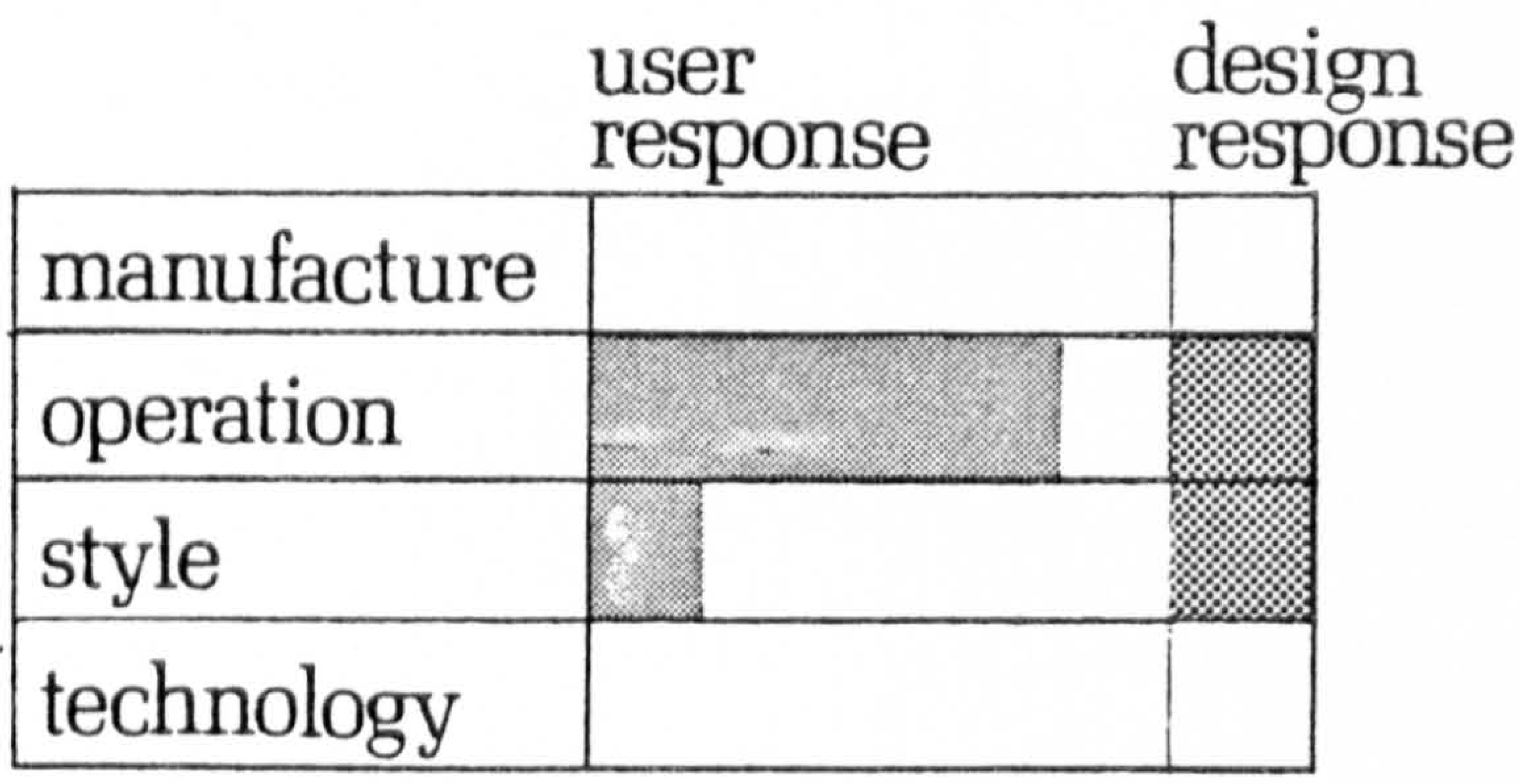
The user/designer comparison shows an inability on the part of both groups to provide a satisfactory meaning for the door release shape. It therefore contributes to a general lack of visual clarity in the control interface as a whole.

CONTROL INTERFACE

Question 14

Why does it have a textured finish?

Refer to Plate No 8



Question 14 Conclusions

The design responses show that the Creda designers were unaware of the function of the textured finish on the door release and the Litton designer, D3, was only able to state one minor explanation. It is concluded that this is another characteristic which has been translated from the Litton to the Creda product largely automatically and hence is a manifestation of a lack of thoroughness on the part of the design team.

The user responses are consistent with the view that the texture exists to prevent the fingers from slipping, which is as plausible as the functions expressed by the designers and thus illustrates that some operational advantages are unintended and go unreported once the product is in normal use. The user responses indicate a priority on non-slip controls. This could well have been discovered at the development stage by putting the same question to test subjects in the presence of the object.

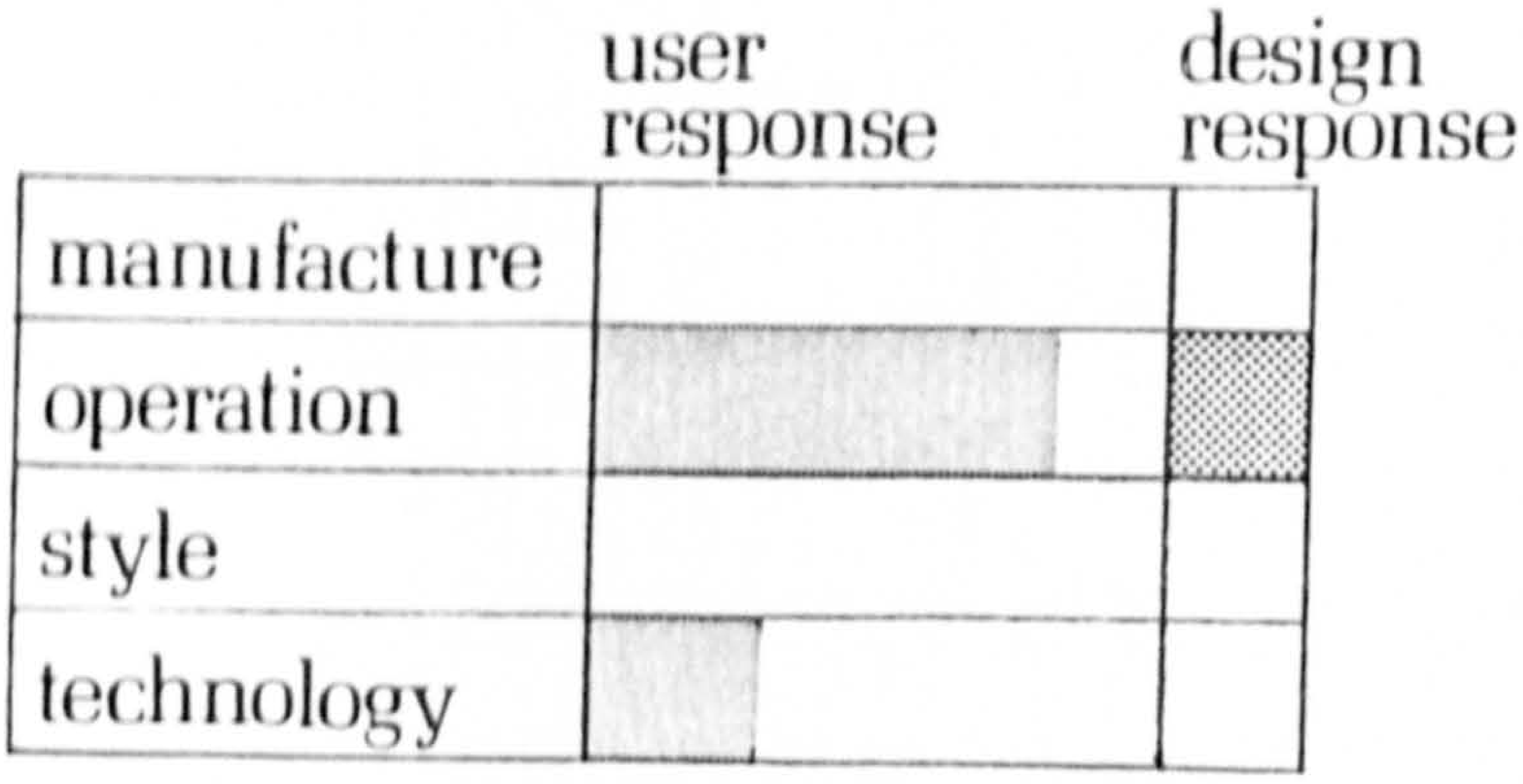
CONTROL INTERFACE

Question 15

Why does the door have a fine mesh across it?

Plate No 9

Microwave oven door detail - inner face of door showing the bottom edge corner: the wire mesh, the door frame and rubber door seal.



Question 15 Conclusions

The design responses all indicate that the door mesh is designed to screen out microwaves and D3 provided a brief explanation of how this is accomplished.

The user results show that four of the group were able to clearly state the correct explanation. The majority assumed that it either prevented the door glass from shattering (like toughened glass) or prevented the transmission of heat. This implies that, because many users do not know the vital safety role of the characteristic, they might underestimate the danger of any damage caused to the mesh screen.

The assumption that heat damage to the glass door is likely indicates a misunderstanding of the low heat conduction properties of the microwave oven and has associations with conventional, higher temperature ovens. Similarly, the mesh seemed to some users to be associated with wired safety glass and again incorrect conclusions were drawn.

In terms of design methods, it is clear that the only way to prevent such misleading associations is to identify them through user research, and secondly to attempt to disguise them visually where required. In the case of a characteristic which is important for safety reasons, it is vital that designers carry out this procedure. Like the previous question, this could be accomplished by putting very similar question forms to test subjects in the presence of a simulated model of the product.

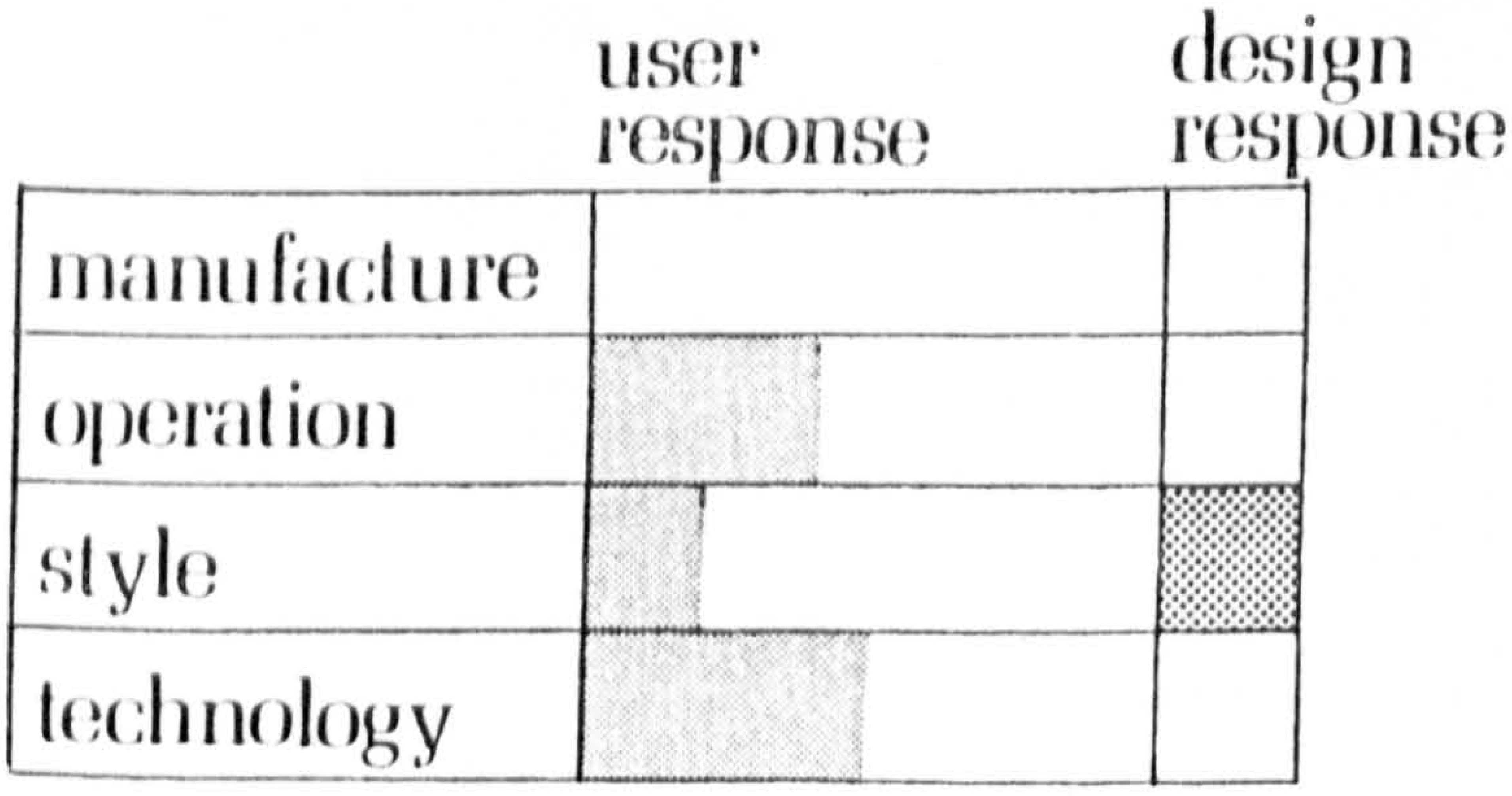
CONTROL INTERFACE

Question 16

Why does the door have a thick, dark band around it?

Plate No 10

Microwave oven door detail - inner face of door showing the use of materials in its construction.



Question 16 Conclusions

The design responses indicate a close agreement that the purpose of the dark band is purely stylistic and two of the designers, D2 and D3, further describe the function as being to hide the structural components of the inner cavity.

In contrast, the user response, with two exceptions, associates the function with oven safety and, in particular, the prevention of microwave leakage. As in the previous question concerning the function of the mesh screen, there is evidence that an aspect of the product which is directly related to user knowledge about safety constraints has been misinterpreted. As the dark band is purely stylistic detailing, it would be a simple matter to design an identity which did not have such a direct association with other, more critical factors. Alternatively, or additionally, a verbal explanation might be presented in the instruction manual.

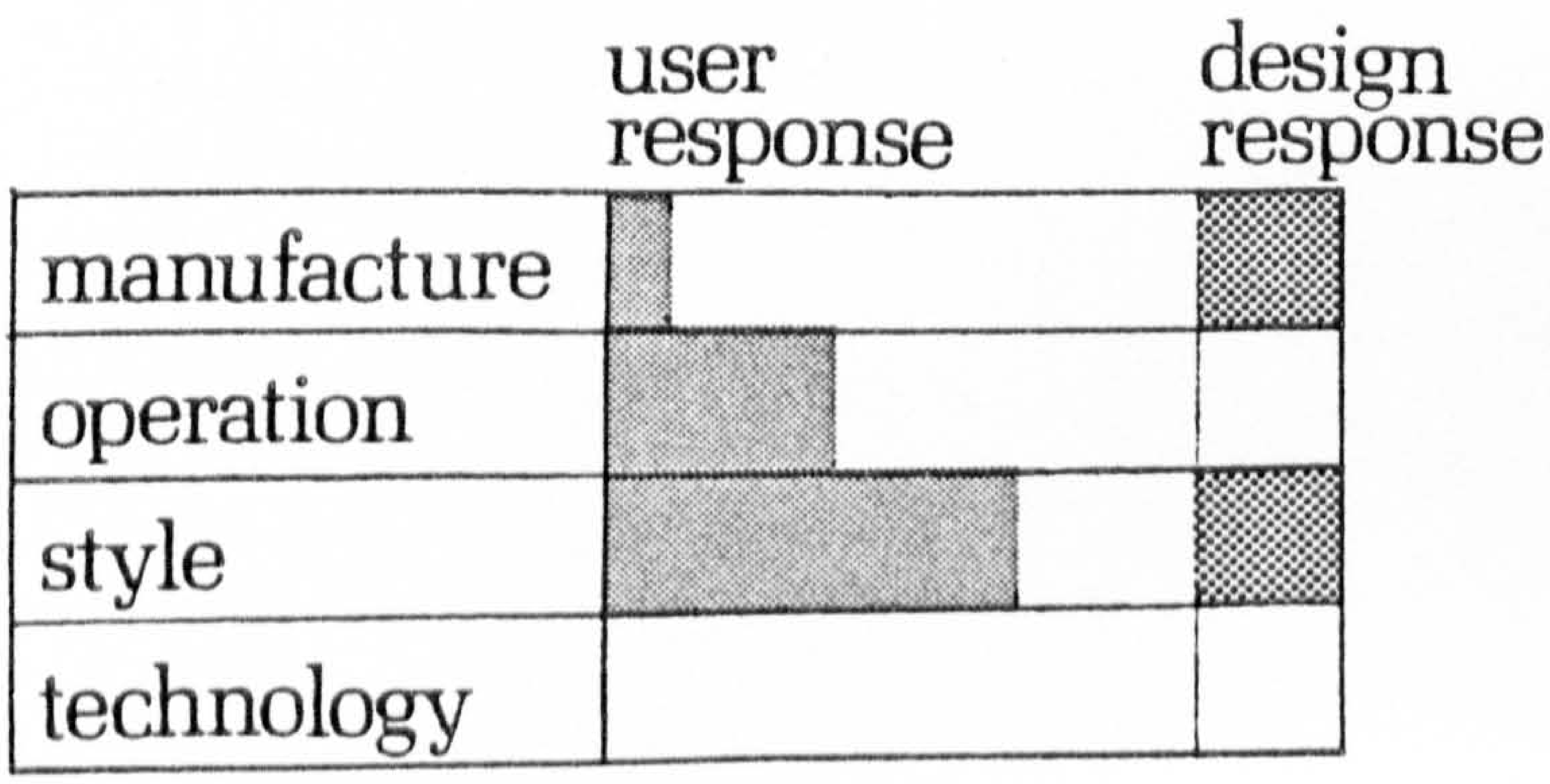
It might be thought that the stylistic function of the dark band would be obvious to most users, but it must be borne in mind that a product which, like the microwave oven, is basically a type of functional 'tool' has strong practical associations. For users to define purely stylistic additions to that identity requires that the stylistic device must be extremely easily perceived as such. Where there is room for doubt, a more utilitarian function will be sought: either real or mythical.

CONTROL INTERFACE

Question 17

Why is the control panel this colour?

Refer to Plate No 2



Question 17 Conclusions

It is clear from the design responses that the control panel colour selection was based on stylistic motives which were compromised to meet the manufacturing requirement of the use of standard colours. The quality of description about colour is similar to that of the user group, in that there is a reluctance to discuss directly the attractions of a colour. Instead, the interviewees only discuss colour in relation to what it matches, either elsewhere on the product or in the product environment and other products.

A number of users again avoid direct references to colour quality, this time by reference to ergonomic advantage, ie the colour was chosen so that the controls could be read more easily.

A single user (U10) stated that the colour was standard for other electrical goods, although no direct reference was made to the use of the colour for specifically Creda products, as stated by the designer D2. This suggests that the colour is not viewed by the consumer as a part of the Creda house-style.

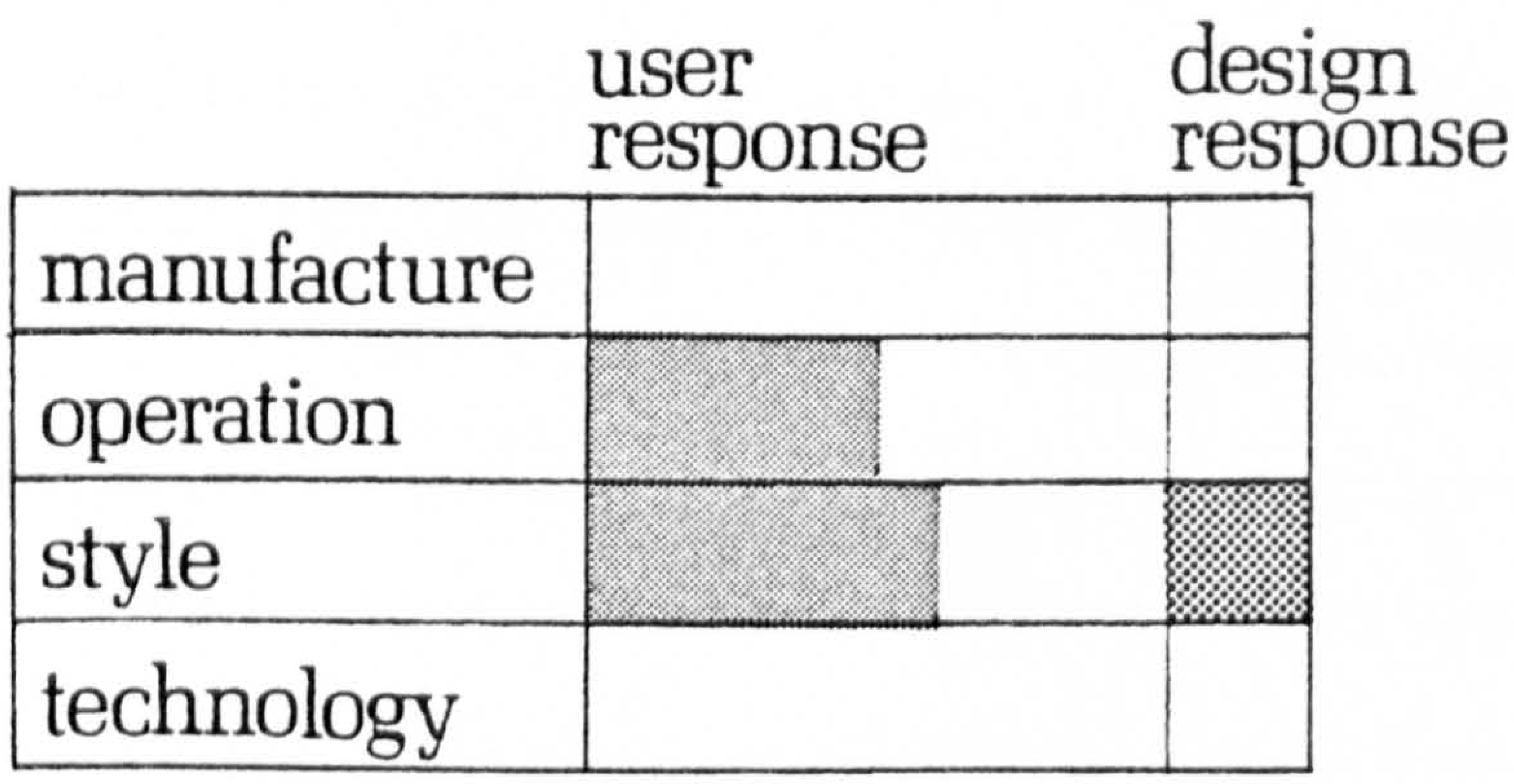
The most significant finding is the lack of descriptive analysis of the colour associations by both groups of interviewees. It is probable that if, during the design development of a product, user responses to colour are required, it would be necessary to isolate the colour from the product and other environmental influences. In this way the reliance on colour matching can be reduced and colour associations probed directly.

CONTROL INTERFACE

Question 18

What is the thin line around the panel for?

Refer to Plate No 2



Question 18 Conclusions

The design responses are all close in meaning and describe the thin graphic line around the control area as a stylistic device. The two Creda designers, D1 and D2, elaborated on this and referred to it as a visual device to match the metal trim which surrounds the control area.

The user responses are closely matched to the above although no-one specifically mentions the relationship to the metal trim. A number of operational classifications are recorded, but the mismatch is not significant since it concerns slight differences in wording, ie "isolation of the controls" might be either a decorative detail or a visual device which eases control operation - or both.

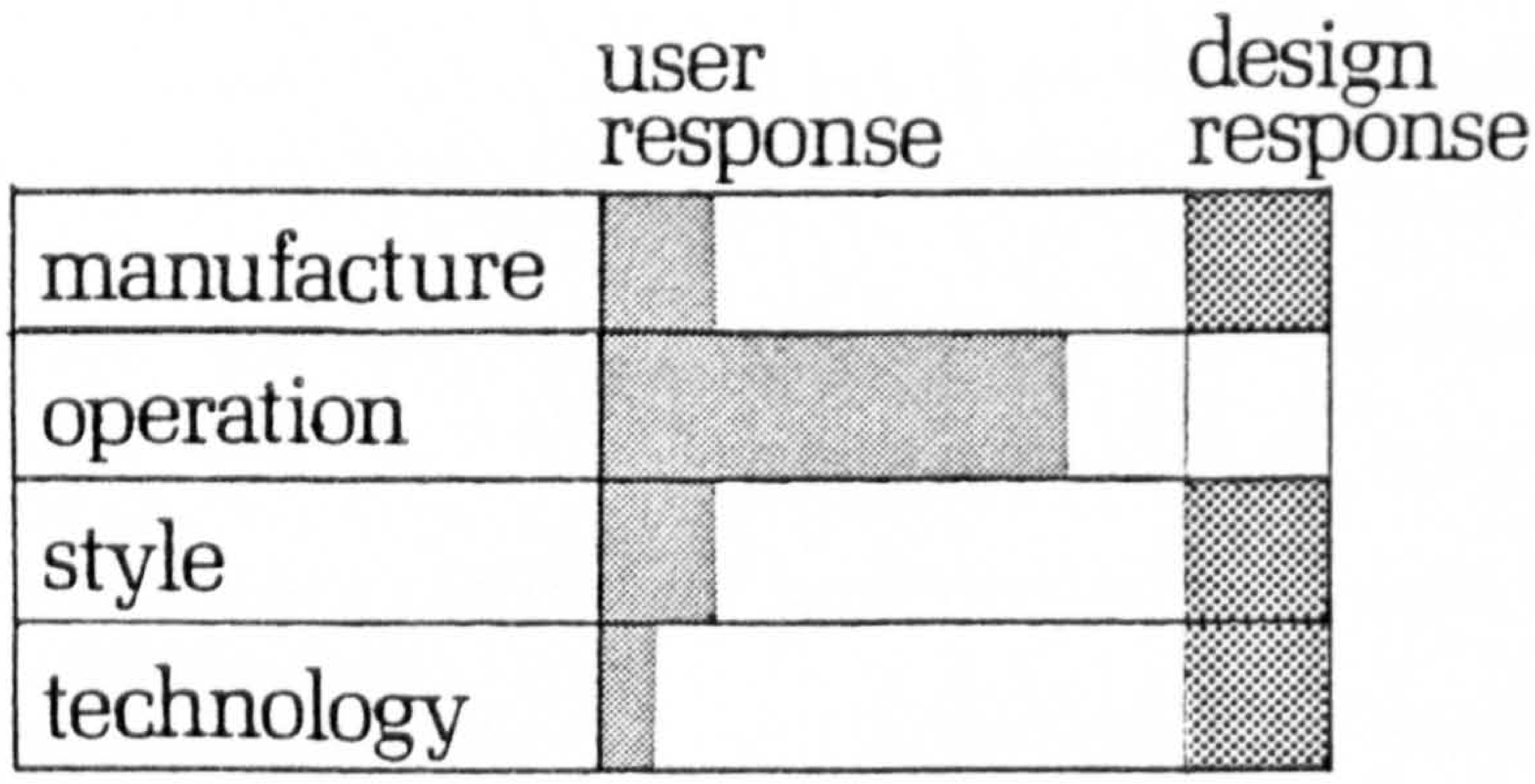
It is clear that there is a fundamental difference between user perception of flat, graphic stylistic devices and their solid, three-dimensional equivalents in the form of metal trim. The results of Question 27 show that the metal trim was perceived by the majority of users as a non-stylistic device. This would be an important criterion for t i p design if the designer is concerned with presenting a clear meaning for the user/product interface.

CONTROL INTERFACE

Question 19

Why is the control panel at the side of the door and not above or below it?

Refer to Plate No 7



Question 19 Conclusions

There is a close match of the reasons why the controls are situated at the side of the oven door, between the designers. A number of manufacturing, technological and stylistic constraints are quoted. The user group is dominated by operational responses, which state frequently that the oven is easier to operate with this particular configuration. This characteristic thus represents a significant mismatch.

It is clear that the user responses cannot be considered either inherently correct or incorrect, as the product represents a 'tool'. Thus the user relies on properties which ease or improve use but which have not been specifically designed for this purpose. In this example, a design decision was made on the basis of a number of production constraints, yet appears to be interpreted as a beneficial operational characteristic by the user group. It could be argued that this is one of the most fundamental aspirations of the designer, to turn production necessities into user advantages. However, there is little evidence from the design responses of this conscious motive. Instead the production constraints dominate and no attempt has been made to evaluate their operational suitability.

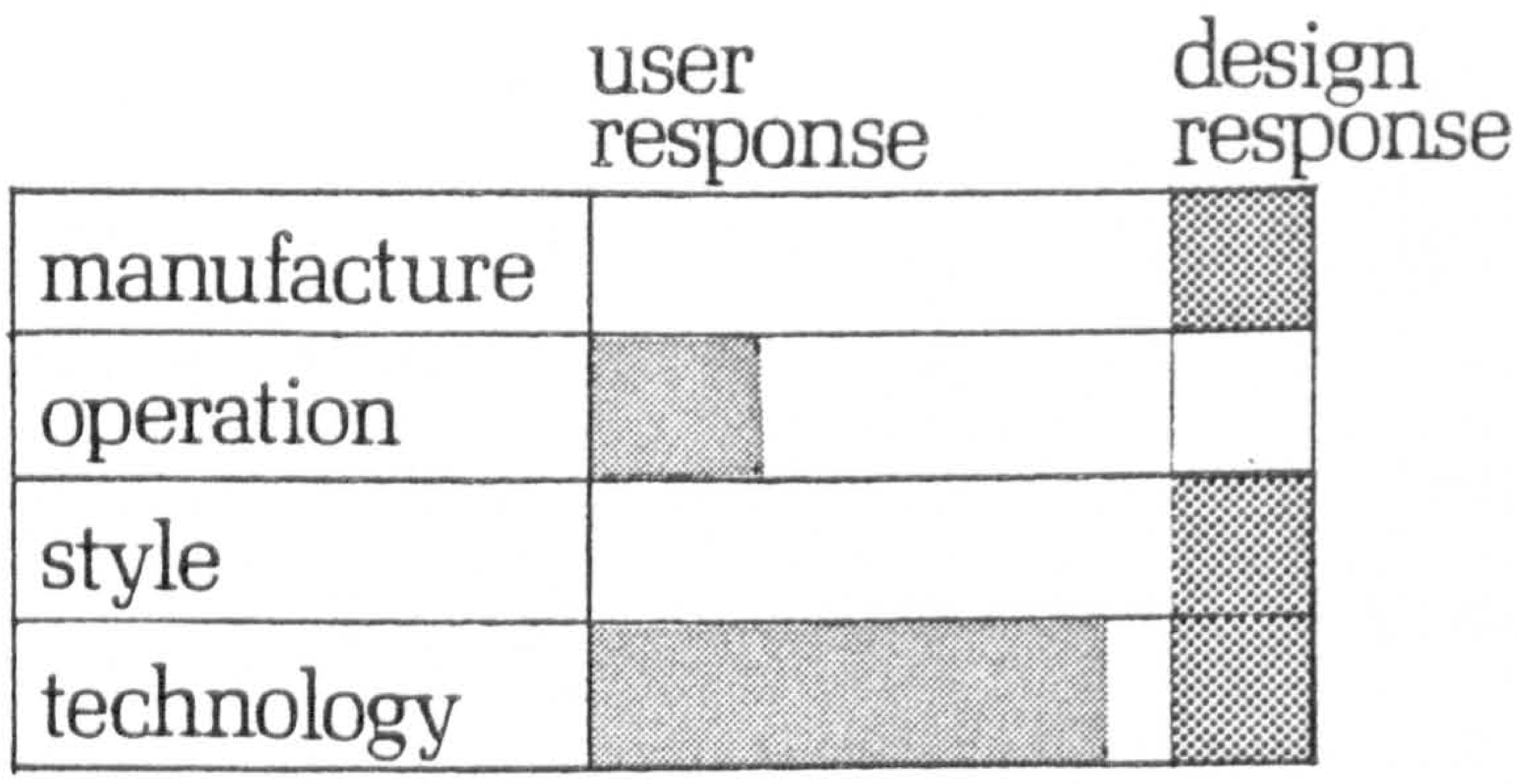
The high degree of user acceptance of the characteristic is due to an inability to visualize successful alternatives, rather than a totally objective appraisal of the control position. It is concluded that, in order to test user responses during the development stage of a t i p, it is advisable to provide alternative examples of certain characteristics, even if these are not practical for the final product. In this example, a series of models with different control configurations might have been tested in order to correctly evaluate the final choice.

CONTROL INTERFACE

Question 20

Why is there a gap between the door and the control panel?

Refer to Plate No 2



Question 20 Conclusions

There is agreement between all three designers on the purpose of the gap between the door and the control panel. The response of the Litton designer, D3, which states that the large tolerance exists to decrease the risk of the door catching, is matched by six of the user responses.

Again, of the three possible design criteria, the user group chose the one with a direct useful advantage and, in the main, discounted the possible indirect manufacturing advantages. This is an example in which favourable product attributes are responsible for an over-optimistic evaluation of characteristics which possess functions which are obscure to the majority of users.

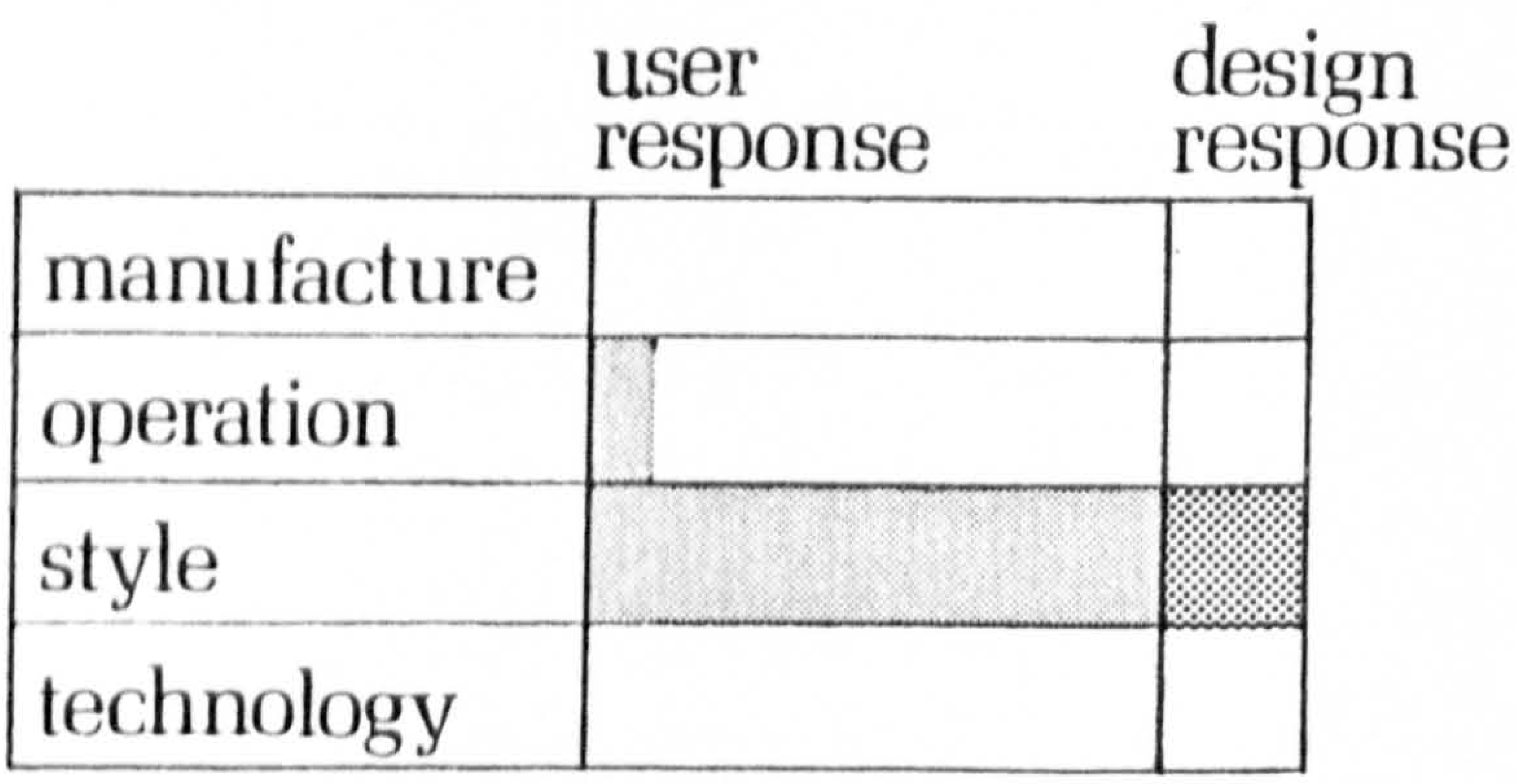
PRODUCT ENCLOSURE

Question 22

Why was off-white chosen as the colour for the outer case?

Plate No 11

Side view of microwave oven - showing the outer case.



Question 22 Conclusions

The choice of colour for the outer case of the oven was a decision taken by Creda. The previous Litton model was finished in an imitation wood-grain finish, more popular for domestic appliances in the United States than in Britain. Consequently D1 and D2 were the only designers to provide responses, which shared the same stylistic classification but varied slightly in terms of actual content. As with many of the previous questions in which colour was a consideration, there was a marked reluctance on the part of the designers to discuss the merits of the colour in isolation. D1 follows the common pattern of relying on the relationship with other colours, either those present elsewhere on the product or those experimented with on previous prototypes.

The user response pattern closely matches the design responses with almost identical classifications for each reply. The contents of responses are also very similar, in that the majority of users discuss the colour in terms of its relationship with other colours or the colour of the immediate environment. In only four cases is there any attempt to describe the inherent association of the colour - "neutral", U1; "clean", U2; "safe", U4; "pale", U5. These responses are judged to be essentially superficial and confirm the view that the translation of purely stylistic visual phenomena into verbal analogues is difficult for both ordinary consumers and trained designers.

The limitation of the verbal description tends to make confirmation of Oakley's view(1) difficult, as only one user, U2, stated clearly that the colour was associated with cleanliness. However, the fact that at least five others state that the chosen colour has strong affinities with kitchen colour schemes and appliances is consistent with Oakley's views, that kitchen appliances symbolically 'manufacture' cleanliness and the colour white is associated with this process.

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(1) Oakley, A: The Sociology of Housework, Martin Robertson, 1974.

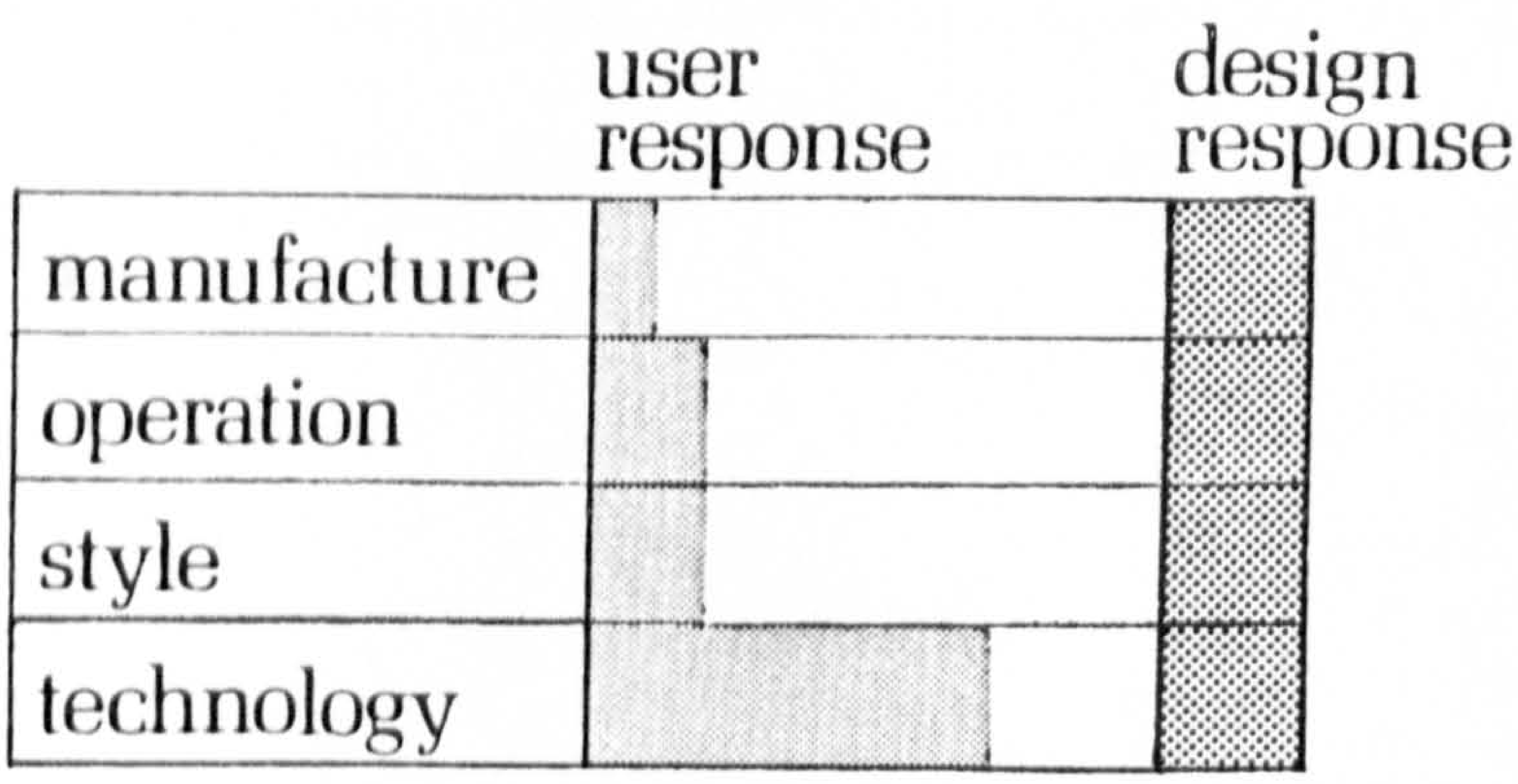
PRODUCT ENCLOSURE

Question 23

Why does it have a textured finish?

Plate No 12

Microwave oven outer case detail - surface texture.



Question 23 Conclusions

The design responses are scattered across all four possible classifications. According to D3, the Litton designer, the design decision was taken by Litton and accepted as a recommendation by Creda. However, on the evidence of the responses, it appears that the basis of the recommendation is not identified by the Creda team because the responses are different.

The user responses, although similarly distributed between all four classifications, show a bias towards a technological reason specifically concerned with the ability of the textured finish to withstand scratching. Only one user, U6, suspected that this made it cheaper to manufacture. It is significant that only two users make any mention of stylistic constraints which, allowing for the fact that most users are biased in favour of the general capabilities of the product, suggests that the characteristic is not thought to be particularly attractive.

The textured finish departs from the standard smooth white paint finish adopted for the majority of other kitchen appliances and may explain why the associations connected with the latter do not figure in the responses. None of the users indicated that the textured finish promotes the concept of cleanliness or hygiene. It is thus possible that, in adopting this textured finish, the designers have sacrificed a useful factor in the product identity which might contribute to user satisfaction.

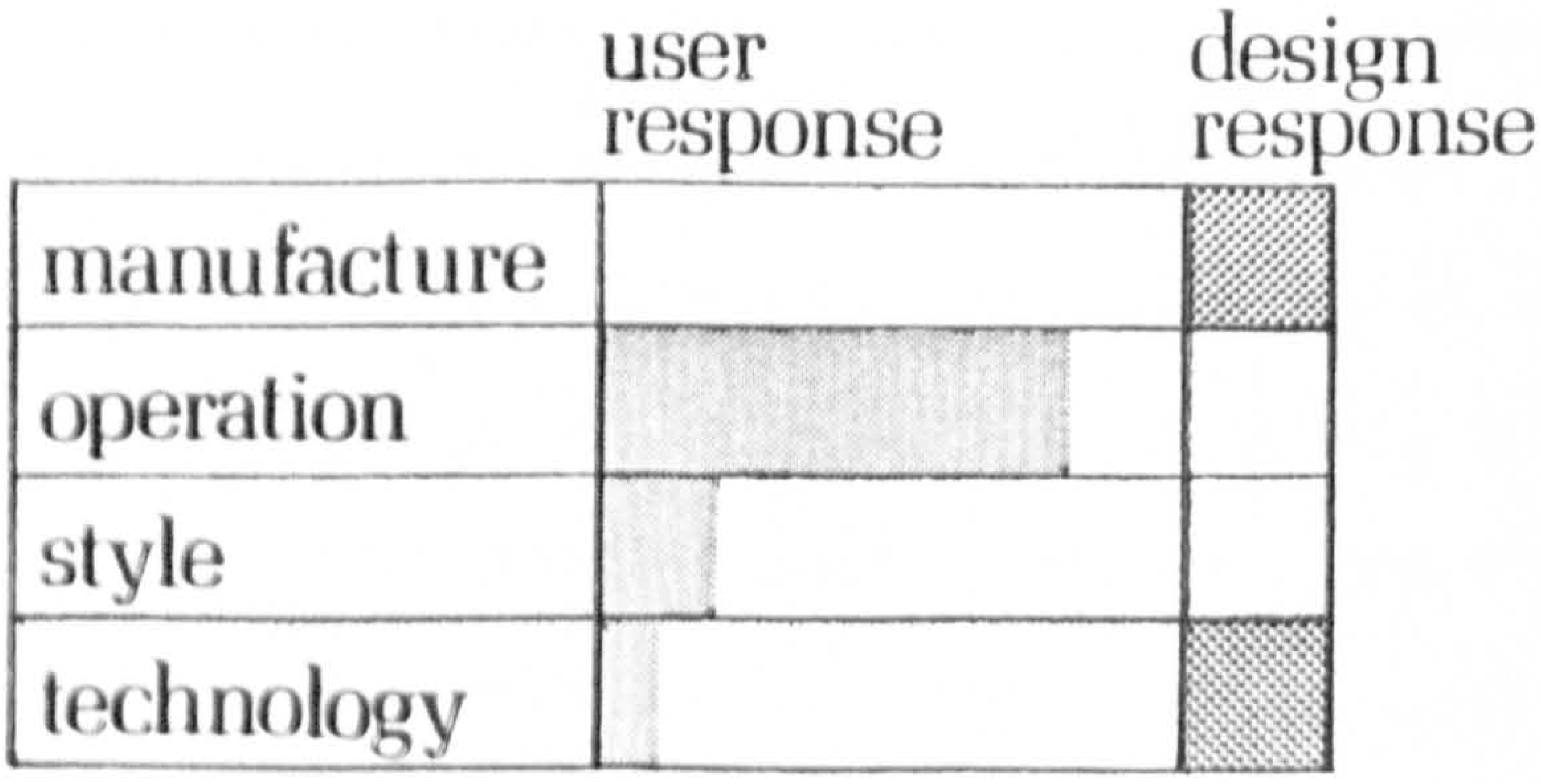
PRODUCT ENCLOSURE

Question 24

Why are the corners slightly rounded?

Plate No 13

Microwave oven front corner detail - top right corner showing the use of materials: the textured surface wrapped over the front edge of the case with PVC-coated link and the metal trim of the control panel.



Question 24 Conclusions

The design group are in close agreement as to why the outer case has rounded corners and state, in each case, that it is a by-product of the manufacturing process. D3 provides the additional statement that, without the radius, the PVC covering would be worn through when in use.

In contrast, only two of the user group provided similar matching responses, whilst the majority interpreted the characteristic as an advantageous operational function. It was generally believed that the radii were there to prevent user injury. Undoubtedly this response is just as valid as the design response in justifying the design characteristic. It should therefore be interpreted as a difference in attitude between designer and user. As such, it denotes a particularly partisan attitude to the oven, the designers being influenced by manufacturing constraints, to the exclusion of quite obvious user advantages. The users conversely are pre-occupied by their own needs and consequently tend to over-estimate the design concessions to their own requirements.

As the results of Question 40 show, a number of users were able to correctly identify the materials used to construct the shell of the oven. The results of Question 24 tend to indicate the limitations of this understanding and to identify the knowledge gap as being connected with the processing of this material, even though the fact that folded metal sheet does not form sharp edges is not a complex observation.

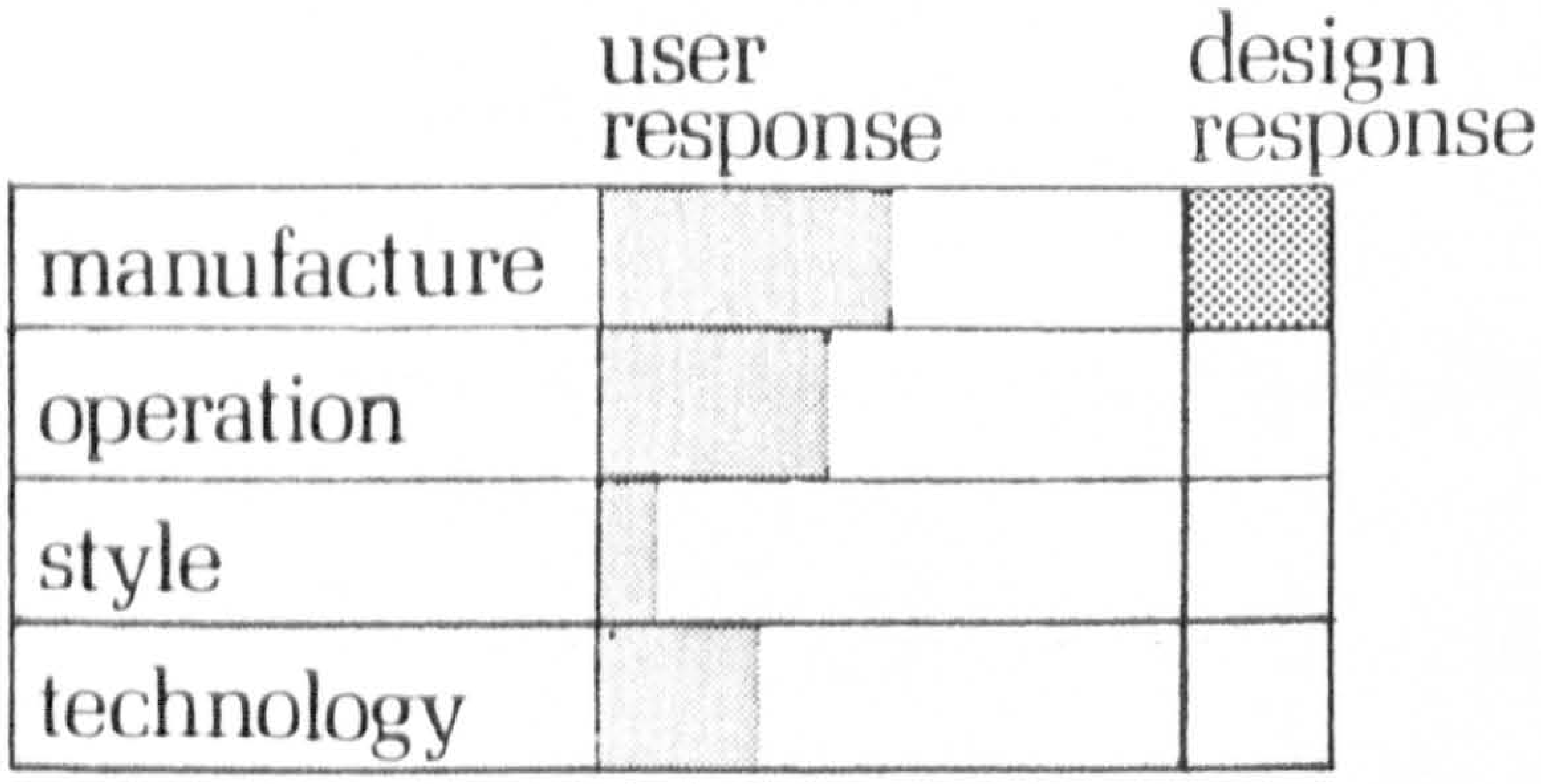
INPUT INTERFACE

Question 26

Why are the door hinges in full view and not hidden away?

Plate No 14

Microwave oven door detail - front top left door hinge.



Question 26 Conclusions

The design responses all state that the exposed door hinges were chosen to reduce costs and the two Creda designers, D1 and D2, go further in suggesting that ideally they would not have chosen this particular design solution. The response from D3 is also illuminating, in that "lack of pressure from the design staff to push it the other way" was quoted as an acceptable reason. If correct, it illustrates a narrow view of the design role, plus an inability on the part of the Creda design team to make their views felt.

There is some matching of the user/designer responses under the manufacturing classification, where there is an emphasis on the advantage of servicing the hinges in this form, rather than their cheaper manufacture. Few of the user responses indicate any directly perceivable benefit of the product in use and only a single user expressed the view that the detail was stylistically significant. It is therefore probable that the hinges are primarily associated with mechanical failure (hence the need for servicing) and, more generally, are not particularly approved of by the users (because of the lack of direct reference to user advantages).

As the hinges have a direct perceivable link with the oven door and its ability to close and seal effectively, it is probable that user doubts about safety could be partially alleviated by a more convincing hinge detail.

INPUT INTERFACE

Question 27

What is the purpose of the metal trim around the door?

Plate No 15

Microwave oven front detail - right top corner of the door and top left edge of the control panel, showing metal trim, wood-grain finish, brown glass and off-white surfaces.

	user response		design response
manufacture			
operation			
style			
technology			

Question 27 Conclusions

The classifications of the design responses are technological in all three cases, although there is some slight variation in their content. Generally, the function of the metal trim around the door is seen as structural; it keeps the door rectilinear and flat and provides a firm mounting point for the three door catches. There is no evidence from the design team that it plays a stylistic role,as well it might, having many of the qualities of 'trim' associated with the decorative application of metal surrounds on products ranging from cars to kitchen appliances.

The user responses tend to match the above, but in addition half the responses contain a stylistic classification in which the door trim is seen to be a decorative feature. This confirms the supposition that there is an association with the 'decorative trim' stylistic device used in previous appliance design and still in evidence on many of the current conventional electric ovens produced by Creda.

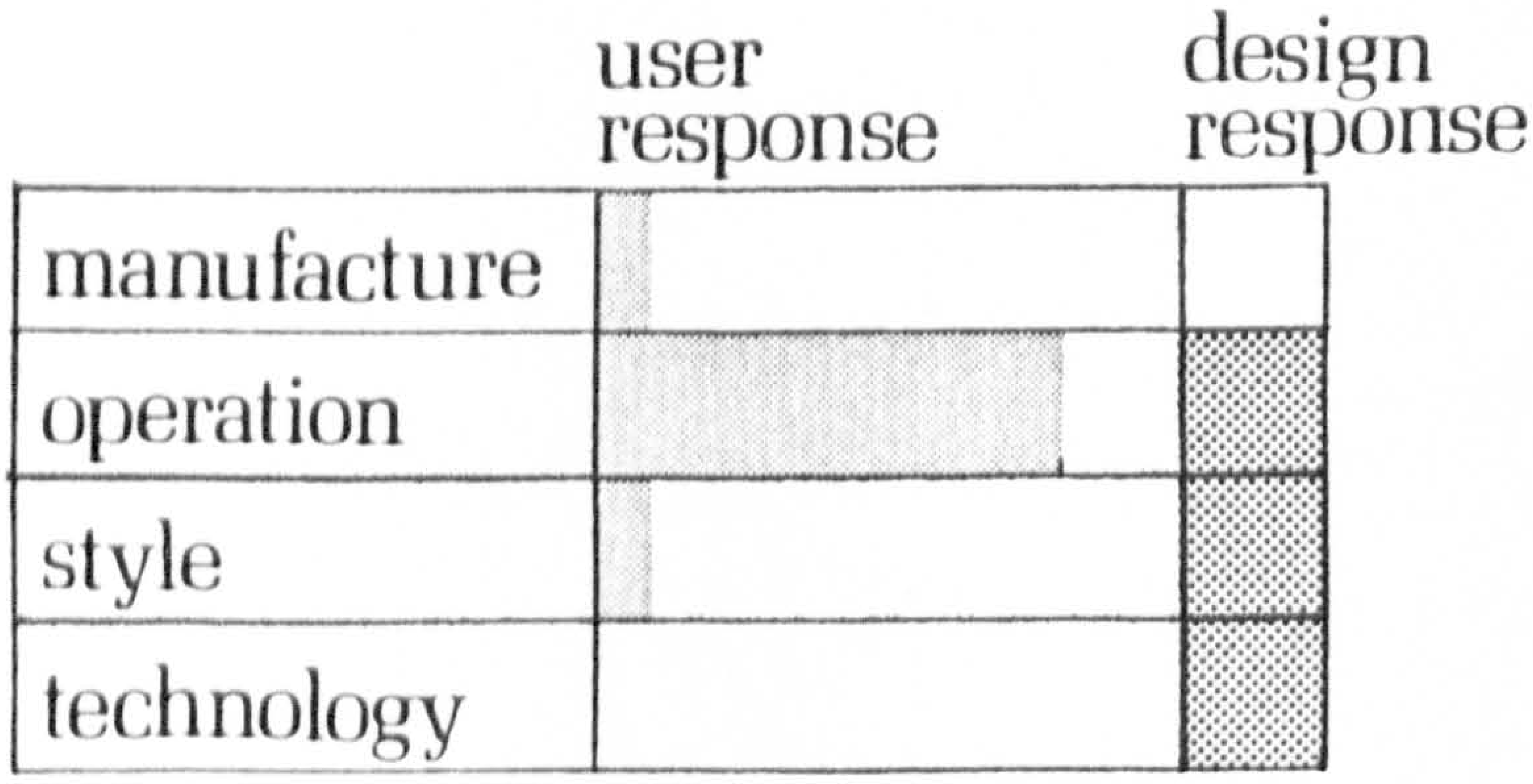
INPUT INTERFACE

Question 28

What is the purpose of the grey edging strip along the inside of the door?

Plate No 16

Microwave oven main body detail - top right corner showing the outer face of the door seal and door lock holes.



Question 28 Conclusions

There is disagreement between all three members of the design team on the purpose of the translucent strip along the inside face of the oven. As D3 was the only member of the team to have been involved in the actual design of the component, and because his response was the most detailed and convincing, it was decided that the responses of the other two should be discarded. This avoids comparing the user responses with incorrect design intentions. It is important, however, that the significance of the Creda designers' incorrect responses is understood. For both designers to be unaware of the purpose of a component which is such a fundamental aspect of oven safety is undesirable. As the Creda designers were both responsible for designing the product/user interface for the British product, part of their responsibility was to ensure the easy and safe operation of the oven. If, as the product instructions state, it is necessary to keep the seals clean, it is vital that the user recognizes what they are and where they are located. If the designer is unsure of this, it is unlikely that the user will be better informed.

In spite of this design inconsistency, eight members of the user group were able to identify the component as being the seal which, with less important characteristics, might appear to be sufficient. It must be stated, however, that where safety factors are involved, the fact that two users were unable to identify the seal has serious implications. One solution to this problem would have been to strengthen the perceivable identity of the component by symbolic or explicitly verbal means.

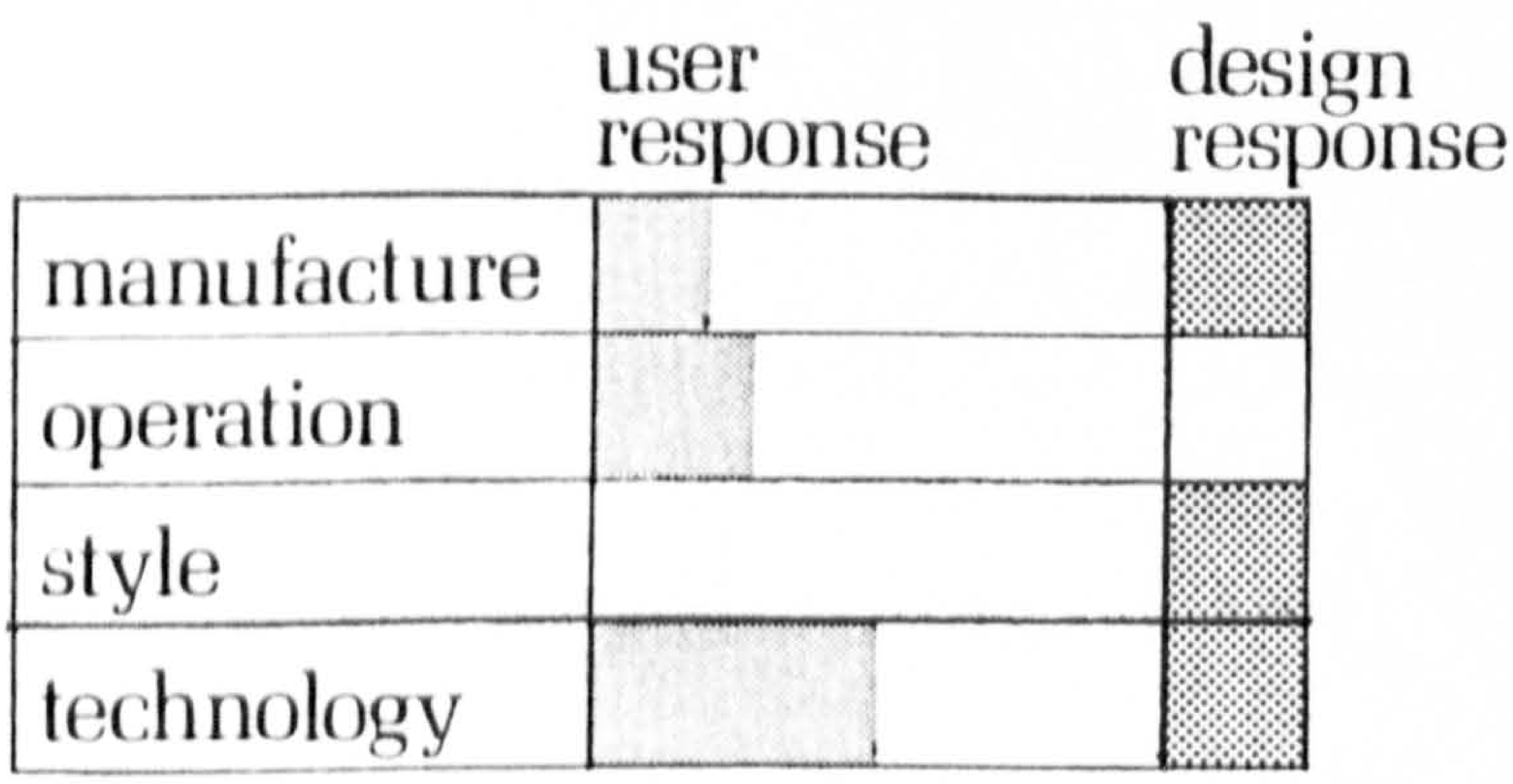
INPUT INTERFACE

Question 29

Why is it a grey colour and not white to match the rest of the interior?

Plate No 17

Microwave oven interior space - complete view, with the door open.



Question 29 Conclusions

As in the case of the previous question, the incorrect responses of D1 and D2 have been discarded, to leave a consensus of technological and manufacturing classifications from the Litton designer, D3.

The user response classifications show that there is some matching under both manufacturing and technological constraints. However, the depth of understanding present in the actual contents of the classifications is severely limited. Most users were unable to identify the material as a plastic and none were able to describe it as polypropylene. Similarly, the reasons for the colour choice, although believed to be roughly technical in nature, were not linked with any explicit technical phenomenon.

Only three users provided an operational response, believing that the colour was intended to draw attention to the component. It can be assumed that the use of a less neutral colour would result in a more positive identity for the component, as specified in the previous question (28).

Only a single user, U3, provided a stylistic response, which would suggest that the component is not particularly attractive to users. Thus even if the safety problem was non-existent, some cosmetic design work might be in order.

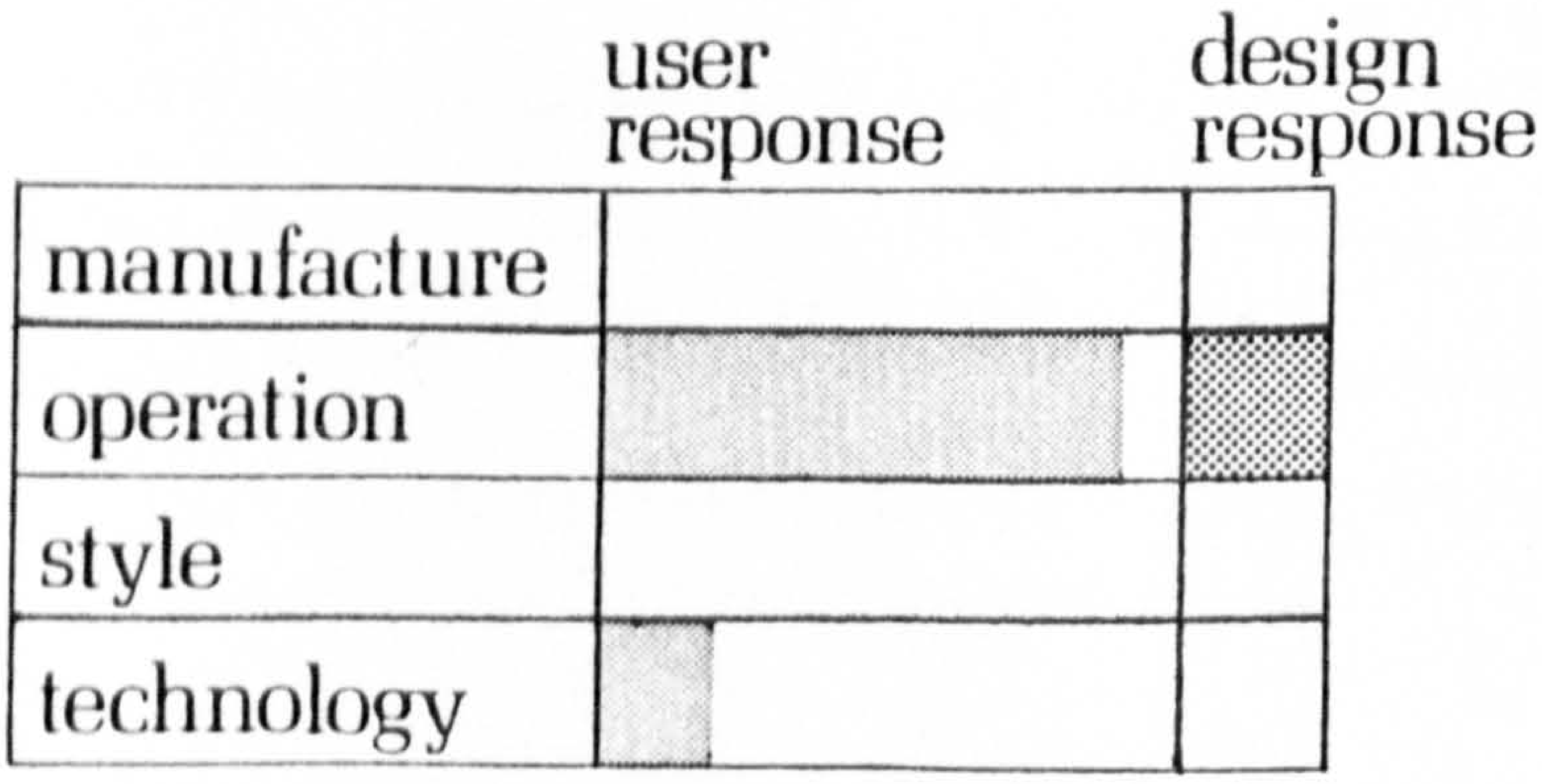
INPUT INTERFACE

Question 30

What is the purpose of the black edging along the inside of the door?

Plate No 18

Microwave oven door detail - inner face of the door, bottom left corner, showing rubber seal and metal trim.



Question 30 Conclusions

Again the information obtained from the two Creda designers was deemed to be suspect, in the light of the detailed and comprehensive response from D3. It was therefore discarded, as in the previous two questions, leaving a simple operational classification related to the screening out of secondary microwave radiation.

This was closely matched by nine of the users, which is perhaps surprising since this, the secondary microwave seal, is more clearly identified than the more important primary seal. This might be explained by the visual quality of the secondary seal, in that it closely resembles the standard seals often seen on car doors, cookers, refrigerators, etc: firstly because it is black, secondly because it is flexible to the touch, and thirdly because it is positioned around the edge of the door itself and not at some (arbitrary) point on the cavity facade. This recognition by the user group adds more weight to the argument that changes in identity can radically affect the way users respond to certain technical components.

It must again be stated that the lack of awareness shown by the Creda designers is potentially hazardous, since it could lead to incorrect identification of the safety seals (as it did in the case of user U4).

INPUT INTERFACE

Question 31

What is the reason for having three and not just one door catch?

Plate No 19

Microwave oven door detail - the three door catches.

	user response	design response
manufacture		
operation		
style		
technology		

Question 31 Conclusions

The three design responses were all classified as operational and each related to oven safety and the prevention of accidental operation.

This pattern was matched by all the user responses and a number of users were able to elaborate correctly on the safety advantages to be gained by having three catches. However, none of the users mentioned that the characteristic was a legislated safety requirement.

It would appear from this result that the function of the multiple door catches is clearly understood, even though there is no reference to their purpose in the instruction manual. It is therefore assumed that their visual identity and some basic knowledge about the properties of microwaves have enabled the consumers to correctly interpret their meaning.

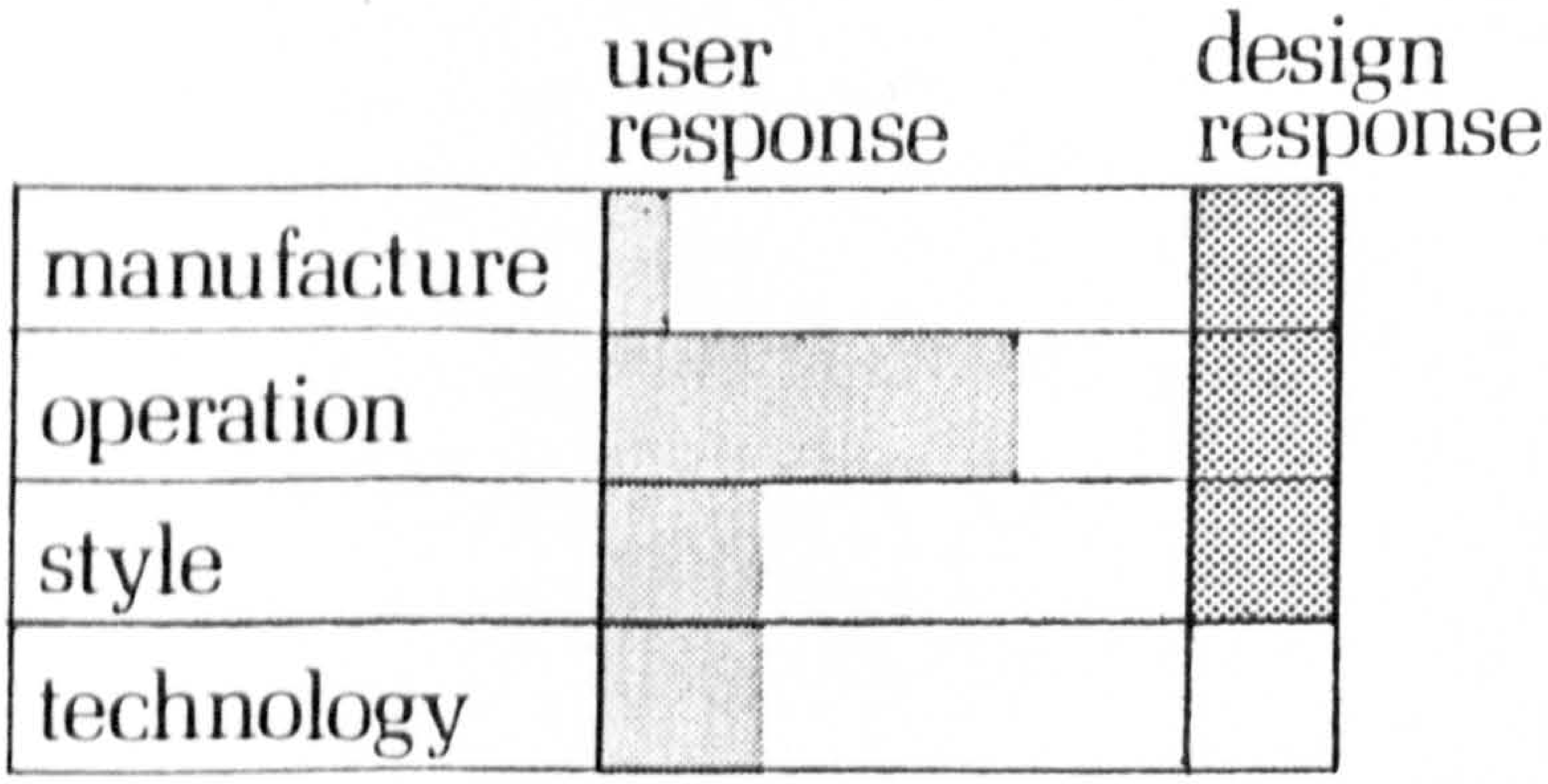
INPUT INTERFACE

Question 32

'hy is the interior coloured white?

Plate No 20

Microwave oven - a complete view, taken from an angle, of the interior space of the oven with the door open.



Question 32 Conclusions

There is a wide design consensus from the three design interviewees, with only the technological classification unmentioned. The "clean" visual identity is emphasised by two of the designers, as is the highly reflective quality. (A significant factor when viewing the contents of the oven through the mesh screen.)

The user response patterns are equally scattered, with the addition of three technological classifications which all relate to the incorrect supposition that the cavity colour has something to do with the reflection of microwaves - a clear example of innovatory technology modifying the perceived identity of visual characteristics.

The majority of user responses are classified as operational and all relate to the fact that the interior is more visible in the chosen colour.

As has been the case in previous questions, the associational values of the colour are rarely eluded to, apart from the single response, U10, who describes it as "cleaner looking", in line with the design responses.

Only a single user (U9) was able to state that it was cheaper to manufacture in this colour.

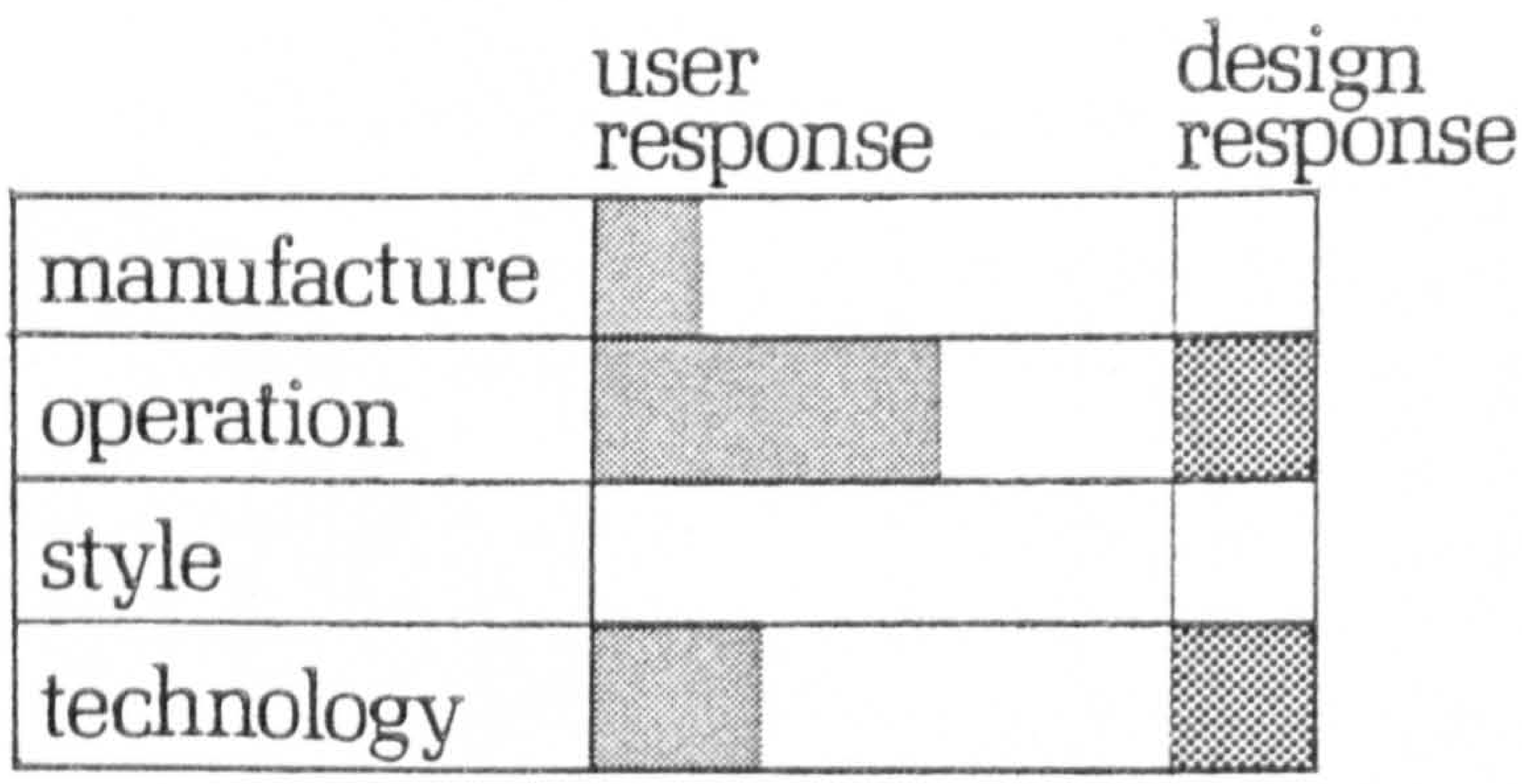
Although the dark interiors of most conventional ovens were mentioned as part of the question form, the user group did not, in general, make any direct comparison between the two sets of products.

INPUT INTERFACE

Question 33

Why is the interior space this particular size and not either larger or smaller?

Refer to Plate No 20



Question 33 Conclusions

The question as to how the size of the cavity volume was decided is a complex issue, involving a number of technological factors relating to the properties of microwave propagation and reflection and to operational demands in terms of optimum sizes required by the average user. The responses of two of the designers are consequently a mixture of both operational and technological criteria, whilst the Creda industrial designer was unable to provide any response.

The user responses follow a similar operational/ technological classification. Two of the users mention the cavity volume in relation to cooking a turkey, which is presumably the largest single item that the oven is required to contain. Only three users mention technological constraints, whilst six mention operational advantages. Again it must be assumed that little comparison between conventional cooker volumes and the microwave oven has been made.

With one exception (U5), only single classification responses were made by the user group. Thus the subtle amalgam of technological and operational constraints that was defined by the designers is not readily perceived by the user group.

INPUT INTERFACE

Question 34

What is the purpose of the series of holes in the right hand panel?

Plate No 21

Microwave oven interior detail - oven cavity extractor vent.

	user response	design response
manufacture		
operation		
style		
technology		

Question 34 Conclusions

The design responses show a level of agreement between D1 and D3, with the Creda designer, D2, unable to provide a response. This inability in the member of the team who was most clearly identified with the role of industrial design would seem to be symptomatic of the narrow range of his particular activities. These are almost exclusively connected with the visual characteristics of the control panel.

The response from D3, that the ventilation panel is an air-intake, although slightly ambiguous in meaning (ie the air intake, strictly speaking, is the intake vent located on the exterior of the oven), is a badly worded response, but not an incorrect one.

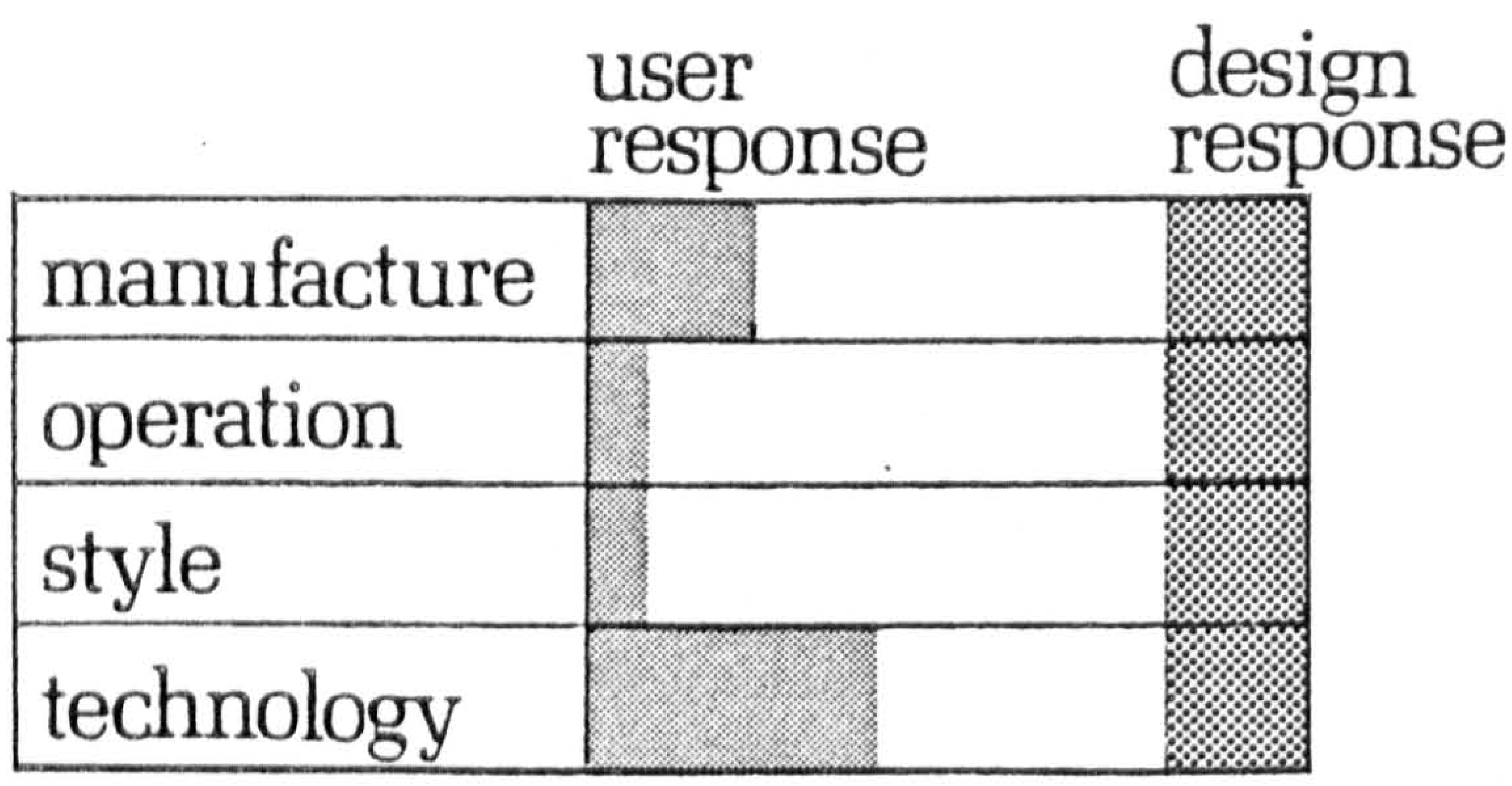
Although the responses of the user group all fall into the matching technological classification and the majority of responses indicate that the characteristic is for ventilation, two users, U4 and U6, gave incorrect responses. These supposed that the ventilation holes are there to allow the passage of the microwaves into the oven cavity. Whilst this is unlikely to have any major effect on the pattern of use, it does suggest that background knowledge about how the oven works is sketchy in some cases. However, the majority of positive user identifications must mean that the appearance of the vent, combined with the audible and other perceivable operating characteristics, explain its purpose. This might well be advantageous if the holes became blocked or soiled by food, as the majority of users would understand that they should be kept clean. The fact that there is no reference to the vent in the separate instructions makes this a significant product-based instruction, perceived through a relatively anonymous, but nevertheless self-explanatory, characteristic.

INPUT INTERFACE

Question 35

Why are the inside corners not rounded, as in most conventional ovens?

Refer to Plate No 21



Question 35 Conclusions

The design responses are scattered across all four classifications and reflect the differences between conventional and microwave oven design constraints: constraints which are frequently not apparent in the external presentation of the products.

The response from D3 states that "the stylists favoured the crisp corners . . ." as part of the reason why rounded cavity corners were not chosen. This illustrates a particular concept of the role of the designer, as being primarily concerned with stylistic attributes and remote from other, more technologically oriented problem areas. It is not surprising therefore that a decision can be made by the "stylists" which is unrelated to the functional constraints of product use.

The user responses are similarly scattered amongst all four classifications, with the emphasis on the technological and manufacturing functions. It is notable that two users, U4 and U5, at first stated that the oven was easier to clean with corners. This answer was probed and retracted in each case. It is likely that this represents another manifestation of generally favourable responses to the product, which decrease the critical objectivity of the user on points of specific detail.

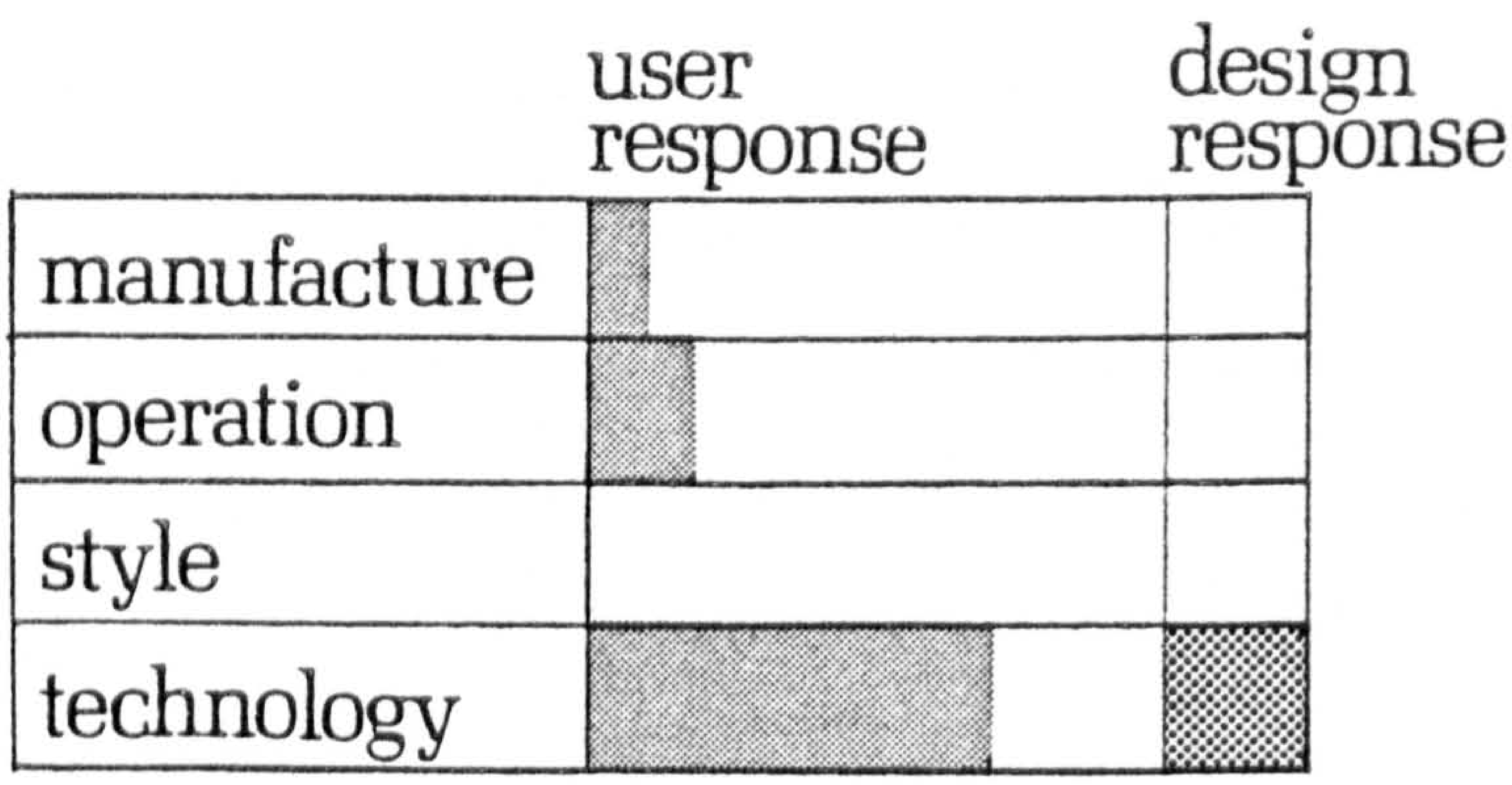
In general, the fact that only a single user believed that the characteristic was a stylistic detail tends to confirm an attitude that the corners are a largely undesired aspect of the product technology or manufacture.

INPUT INTERFACE

Question 36

Why are there no shelves in the interior, as in conventional ovens?

Refer to Plate No 20



Question 36 Conclusions

There is close agreement between all three designers as to the reason why there is no interior shelving in the oven. Whilst D2, the Creda industrial designer, provided a sketchy explanation, the other two were able to give brief but explicit descriptions. The fact that the oven floor is, in effect, a disguised 'shelf' is unmatched by any user response, suggesting that the 'disguise' is effective. The response by D3 that it has now become technologically possible to include a shelf was also unmatched by any user response, so that it can be assumed that none of the users considered the current model to be technologically outmoded on this point.

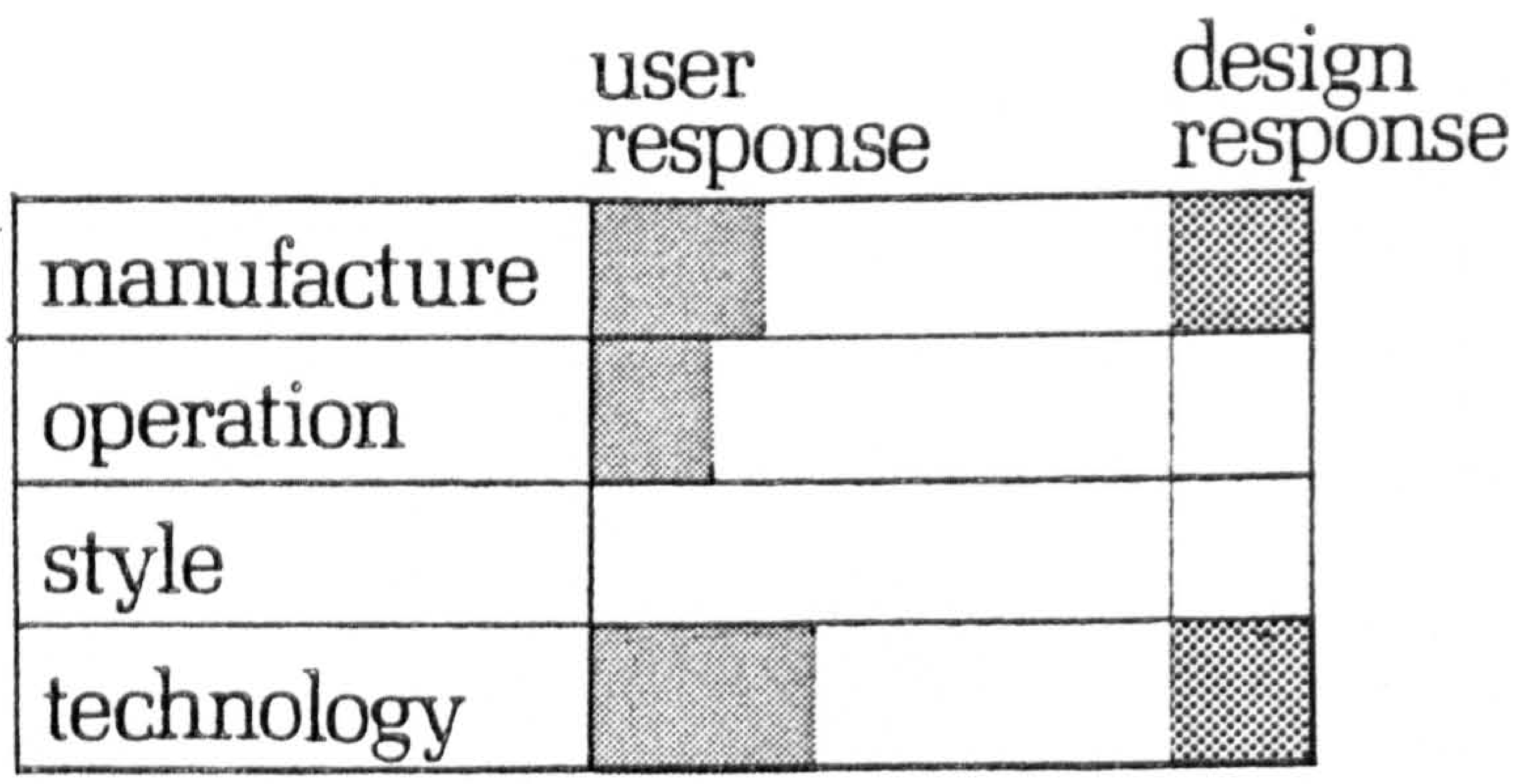
Most of the user responses have a technological classification and the majority of these relate to inadequate cooking efficiency, which closely matches the responses of the designers. This would thus appear to be a case in which there is a high level of comprehension of a relatively sophisticated technological characteristic.

PRODUCT MATERIALS

Question 38

What material is the power knob made out of, and why is it made out of this?

Refer to Plate No 4



Question 38 Conclusions

As has been previously stated, the control knobs were essentially off-the-shelf components, specified but not designed by the team. It is understandable (not necessarily desirable) that one of the designers, D3, was unable to identify the material of which they are composed. Otherwise, there is a reasonable consensus between the other two designers, with technological and manufacturing classifications.

Only half the user group was able to identify the material as plastic and, not surprisingly for a coated material, none were able to identify it as ABS. The other half of the group assumed that it was metal. Reference to the results of Question 5 shows that none of the design team identified the purpose of metal plating as being to stylistically simulate solid metal at low cost. However, the above results show that there is a strong assumption that the switches are metal. Of the group which correctly identified it as a plastic, three members, U2, U4 and U5, state that plastic is used because it is cheaper. It is certain that such a strong association with low-cost manufacture means that those users who identify the knobs as plastic link this with cheapness and hence find it undesirable.

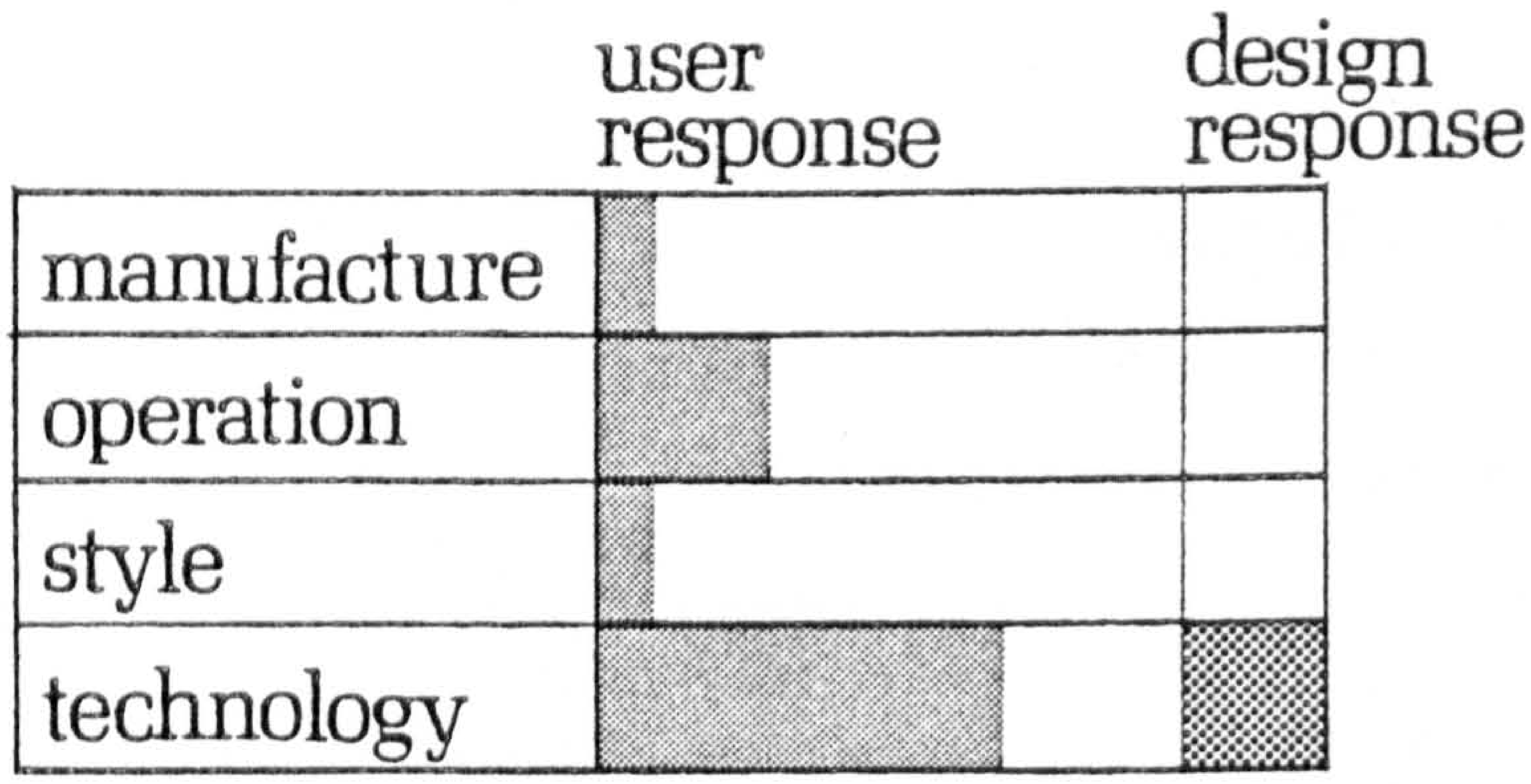
Two users, U1 and U3, associate the choice of plastic with some aspect of microwave technology, illustrating the way that misunderstood technological constraints can condition user awareness of quite unrelated perceivable characteristics.

PRODUCT MATERIALS

Question 39

What material is the door panel made out of, and why is it made out of this?

Refer to Plate No 10



Question 39 Conclusions

Although there is a high degree of consistency between the three design responses, ie they all have a technological classification and they all agree that the material for the transparent oven door was selected for its durability, there is an important difference in the actual description of the composition of the material between the Litton designer, D3, and the Creda designers, D1 and D2. The designer D3 identifies two materials, glass and a Milar film, whilst the two Creda designers identify glass only. There is no doubt that the D3 response is the correct one.

This failure to recognise the composite nature of the material is similar to the responses of the user group, where only one user, U3, correctly defined two materials. Of the remainder, half believe it to be exclusively plastic and the other half exclusively glass. As the two materials require radically different cleaning methods, it is possible that a certain amount of damage to the viewing panel could ensue from their incorrect identification. This may reduce the transparency of the panel and make the control of the cooking process more difficult.

It would be possible to correct this problem, either by written explanation or by modification to the perceivable characteristics of the door.

PRODUCT MATERIALS

Question 40

What material is the off-white case made out of, and why?

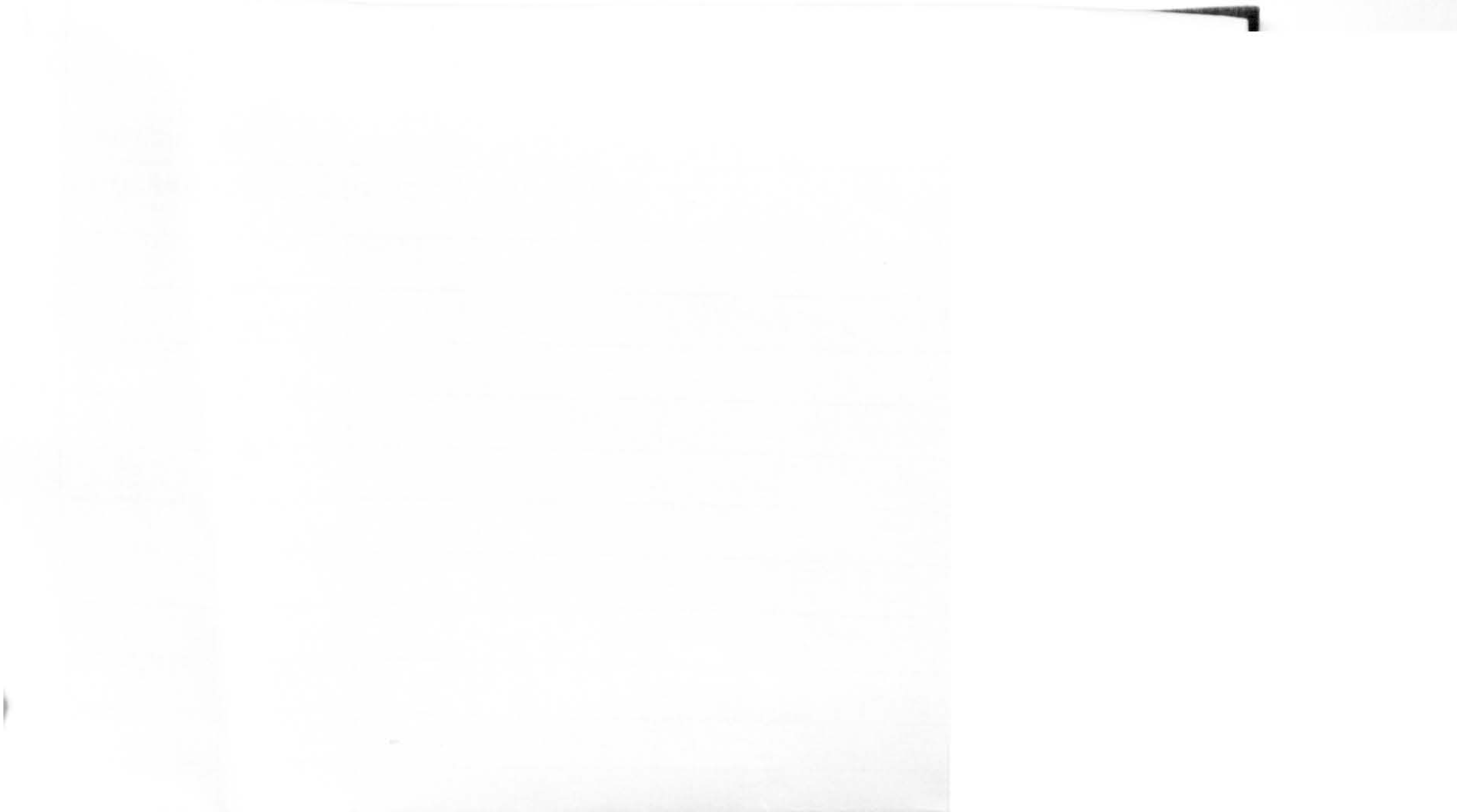
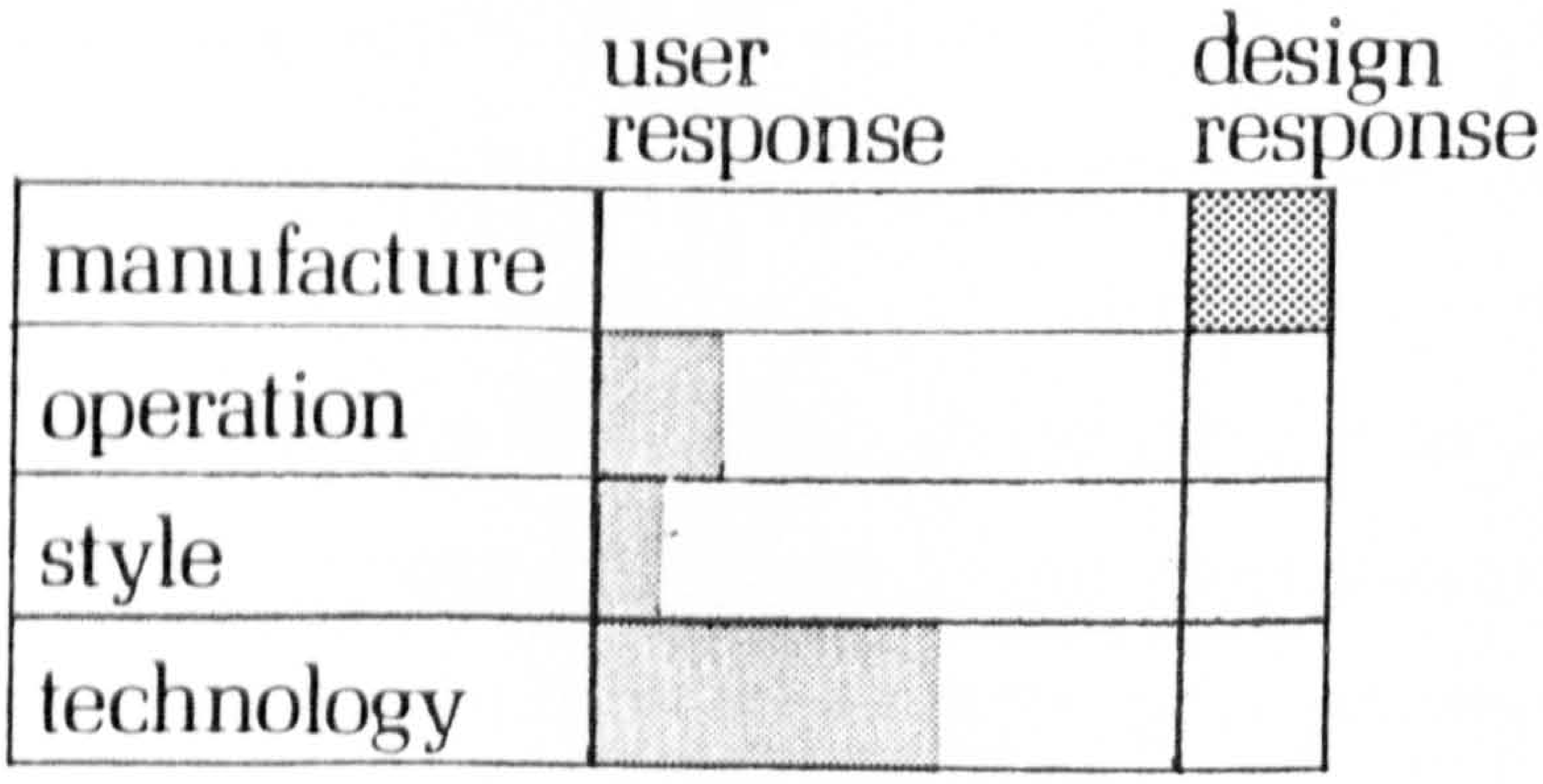


Plate No 22

Microwave oven, side view of outer case.



Question 40 Conclusions

The design group is unanimous in identifying both the material of the outer case and the reason why it was selected. It is plastic (PVC) coated steel, chosen for the low cost of production.

This is matched by the majority of users, as far as the material's identification is concerned, but mismatched as to the reason for selection, with most users classifying it as a technological constraint related to durability or the characteristics of microwave technology. It could be justifiably argued that the design process which selects a characteristic primarily for cost reduction, but which converts this to perceived consumer advantage, has been largely successful. The fact that in this particular case the material is correctly identified by the users also means that inadvertent damage through inappropriate treatment will be minimised.

The two users, U2 and U8, who assumed incorrectly that the steel outer case functioned as a microwave reflector demonstrate the recurring phenomenon of external product identity affected by misconceptions about internal product technology.

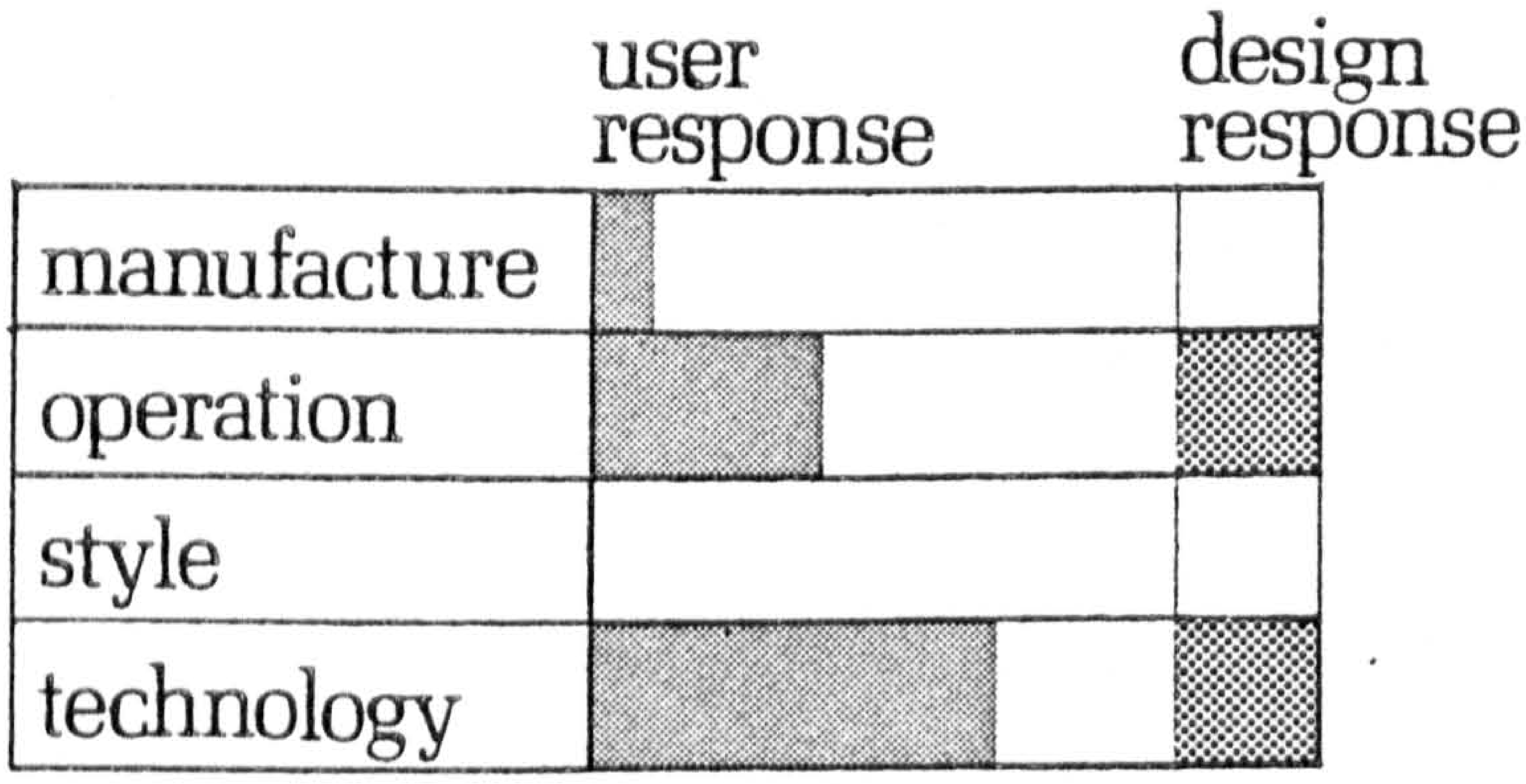
It is also important to note that the plastic-coated metal was selected on the grounds that it was cheaper than the equivalent paint or enamel finish. In spite of this, there are no critical comparative responses from those users who recognised the plastic-coated steel. In fact, most of the responses are favourable and point to possible cost reduction in future products.

PRODUCT MATERIALS

Question 41

What material is the base of the interior made of, and why?

Refer to Plate No 20



Question 41 Conclusions

As a composite glass/ceramic material, the composition of the cavity base is not easy to identify. The identity of the material and its function are made even more obscure by the fact that the base is a disguised shelf, through which microwaves pass to be reflected by the real, metal base beneath it.

Two of the three designers stated that it was a glass/ceramic composition, whilst the third, D2, was unable to answer. As in other cases, this underlines the limitations of the D2 industrial design role.

The design response classifications closely match the operational and technological classifications of the user group, but none of the users was able to correctly identify the composition of the material. A significant number (U1, U5 and U8) assumed that it was a coated metal, like the walls of the cavity, and none of the rest identified the fact that it was a false base.

A majority of users incorrectly identified the material as plastic, which may have consequences for use and maintenance, particularly as this is an obvious major area for food soiling and contact with cooking vessels.

The matching of the design criterion of "ease of cleaning" by three users, U1, U5 and U9, demonstrates some awareness of the properties of the material,drawn, it is assumed, from experience in use.

PRODUCT MATERIALS

Question 42

What materials are the walls of the interior made of, and why?

Refer to Plate No 20

	user response	design response
manufacture		
operation		
style		
technology		

Question 42 Conclusions

As with the previous question, the Creda industrial designer, D2, was unable to provide a response, whilst the other two provided slightly dissimilar definitions of the material composition of the cavity walls and the reasons for its specification.

The responses of the user group are inevitably conditioned by an explanatory statement which appears on the first page of the instruction manual:(1)

> "Metal reflects microwaves. The walls and top of the oven are made of metal so that microwaves will bounce off them into the food placed in the oven."

This explanation does not describe the type of finish on the walls, nor does it state any other reasons why the choice was made. In the light of this, it is not surprising that eight users were able to correctly identify the material as metal and five users stated that the reflection of microwaves was the primary function of the characteristic.

None of the users identified a low cost advantage, compared with the stainless steel finishes of other, competing microwave ovens. Reference to Support Question 24 should be made on this point, since it contains a design response which indicates a lack of durability connected with the coated steel cavity walls. This is not reflected in the design responses where, on the contrary, the coated surface is thought, in many cases, to be chosen for durability.

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(1) Microwave Cooking With Creda, Instruction Manual, p 1.

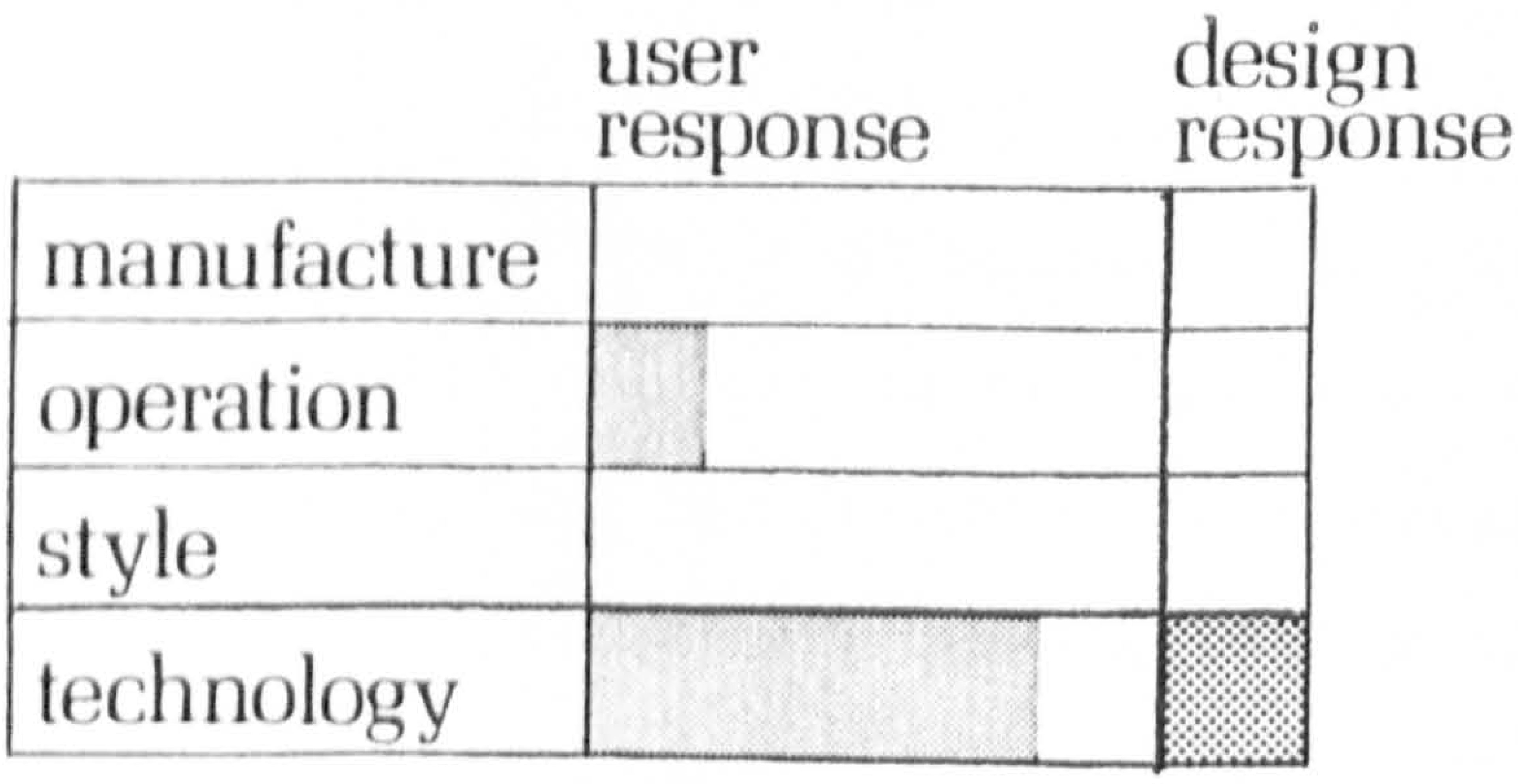
PRODUCT MATERIALS

Question 43

What materials is the roof of the interior made of, and why?

Plate No 23

Microwave oven interior, ceiling detail - rear, interior light source; front, oven cavity extractor vent.



Question 43 Conclusions

It would be unrealistic to expect a consistent response from either designers or users on the question of the construction of the cavity roof, since it is a mixture of steel sheet and plastic panels (to allow light and microwave penetration). This has resulted in an inadequate design response with a single, technological classification.

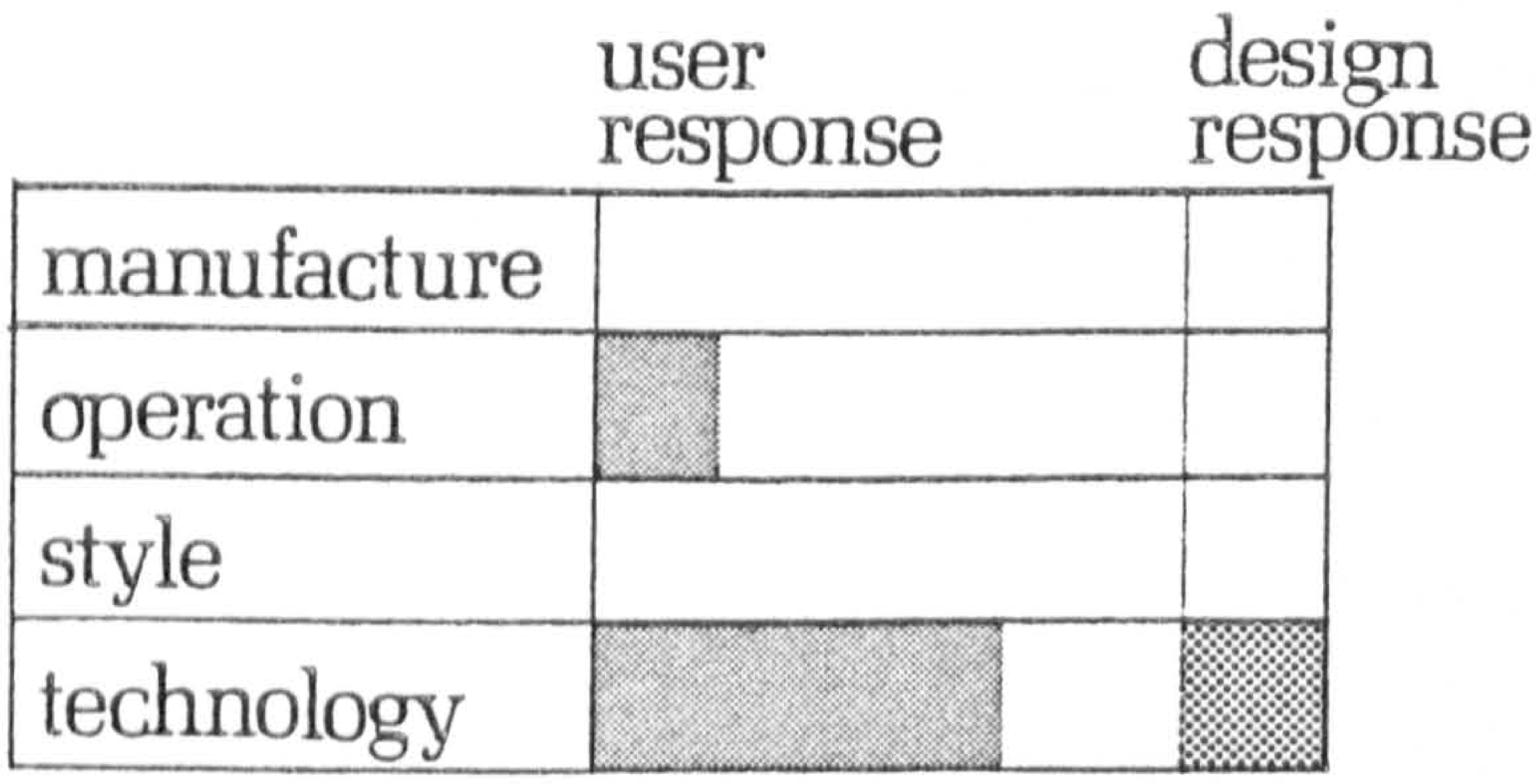
Whilst this is matched to some extent by the user responses, it is doubtful whether much significance can be attached to it, since the references are to totally dissimilar materials.

It can only be assumed that, as some confusion exists as to the materials present, cleaning methods may be incorrectly chosen by some users.

GENERAL PRODUCT

Question 45

Do you think that the oven is light or heavy to lift? Why is it so light/heavy?



Question 45 Conclusions

There is close agreement between all the members of the design group on why the microwave oven is comparatively heavy for its size. It was attributed in all three cases to the inherent weight of three sets of internal components: the control gear, the transformer and the magnetron. Thus a single, technological classification consensus was obtained.

The fact that six of the users (U1, U2, U4, U5, U7 and U9) were able to agree with this explanation in terms of references to internal components, rather than external structure, indicates that some rudimentary understanding of the internal technology exists. The added factor that four members of this group named the magnetron specifically shows quite a sophisticated understanding of the nature of this component. Response U2 is particularly noteworthy in this respect, in that the side with the magnetron was observed to be most heavy and thus the magnetron was assumed to be the heavy component.

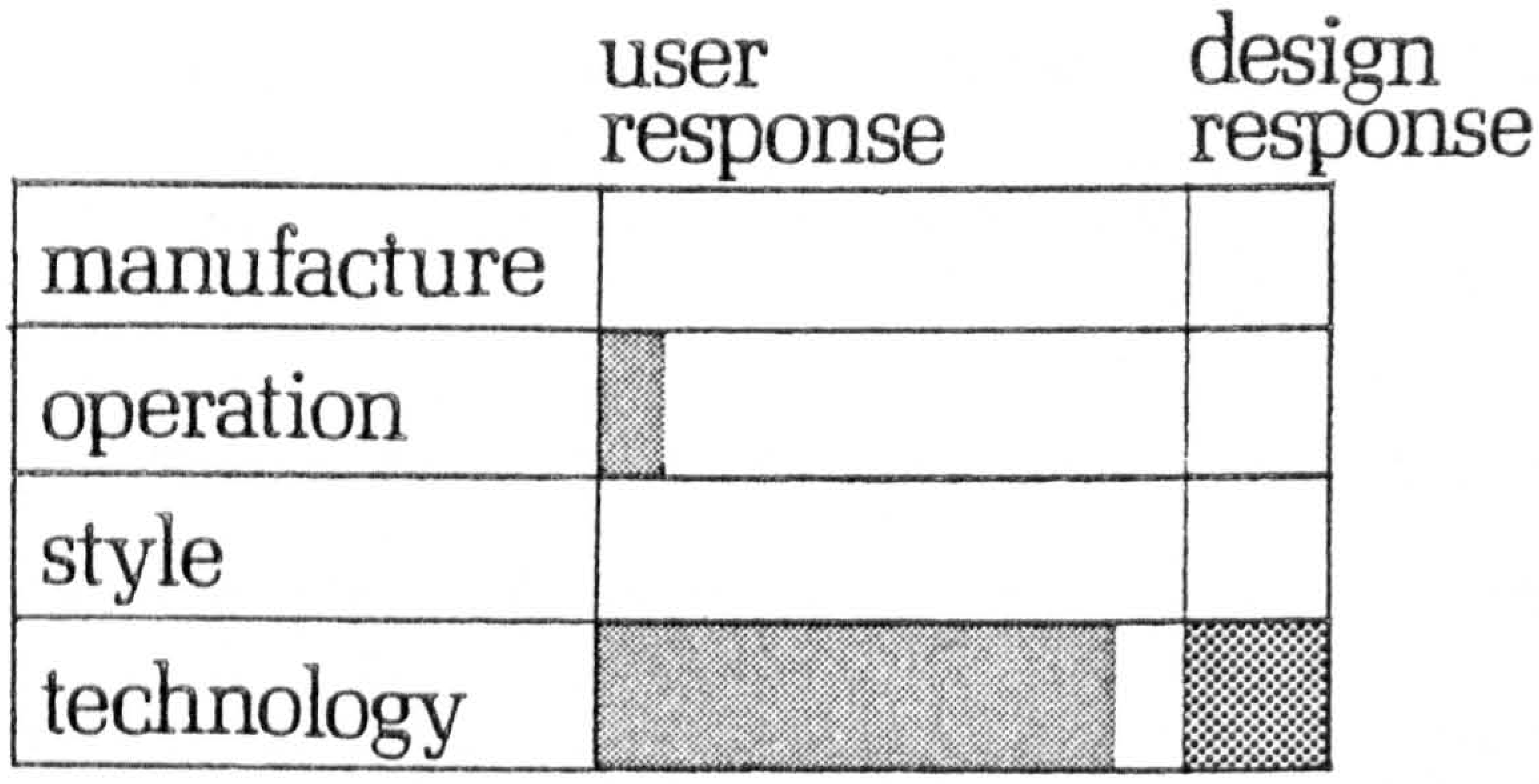
None of the user group identified the control gear or the transformer as being equally heavy components, which indicates that the identity of this particular t i p, conditioned by both correct and false assumptions about product technology, is dominated by the most innovatory internal component that is known to the user, and not by other, more traditional components. Thus it might well be that the CRT in a television set, or the microprocessor in a pocket calculator, would be thought to be the heaviest internal components by their users.

Two users, U8 and U9, assume that the unit is deliberately heavy to provide it with stability - clearly an unlikely possibility, given the relatively stable shape of the object.

GENERAL PRODUCT

Question 46

Why does the oven make a noise whilst cooking?



Question 46 Conclusions

There is a lack of agreement on the cause of the operational noise of the oven between all three members of the design team, with causes which range from the magnetron, transformer or stirrer to the extraction fan. It is not possible therefore to assume that any of these suggestions is the only correct cause, but it can be assumed that if such an unresolved disagreement does exist, it is unlikely that any serious attempt to question its necessity, level of acceptability or source has been made by the design team.

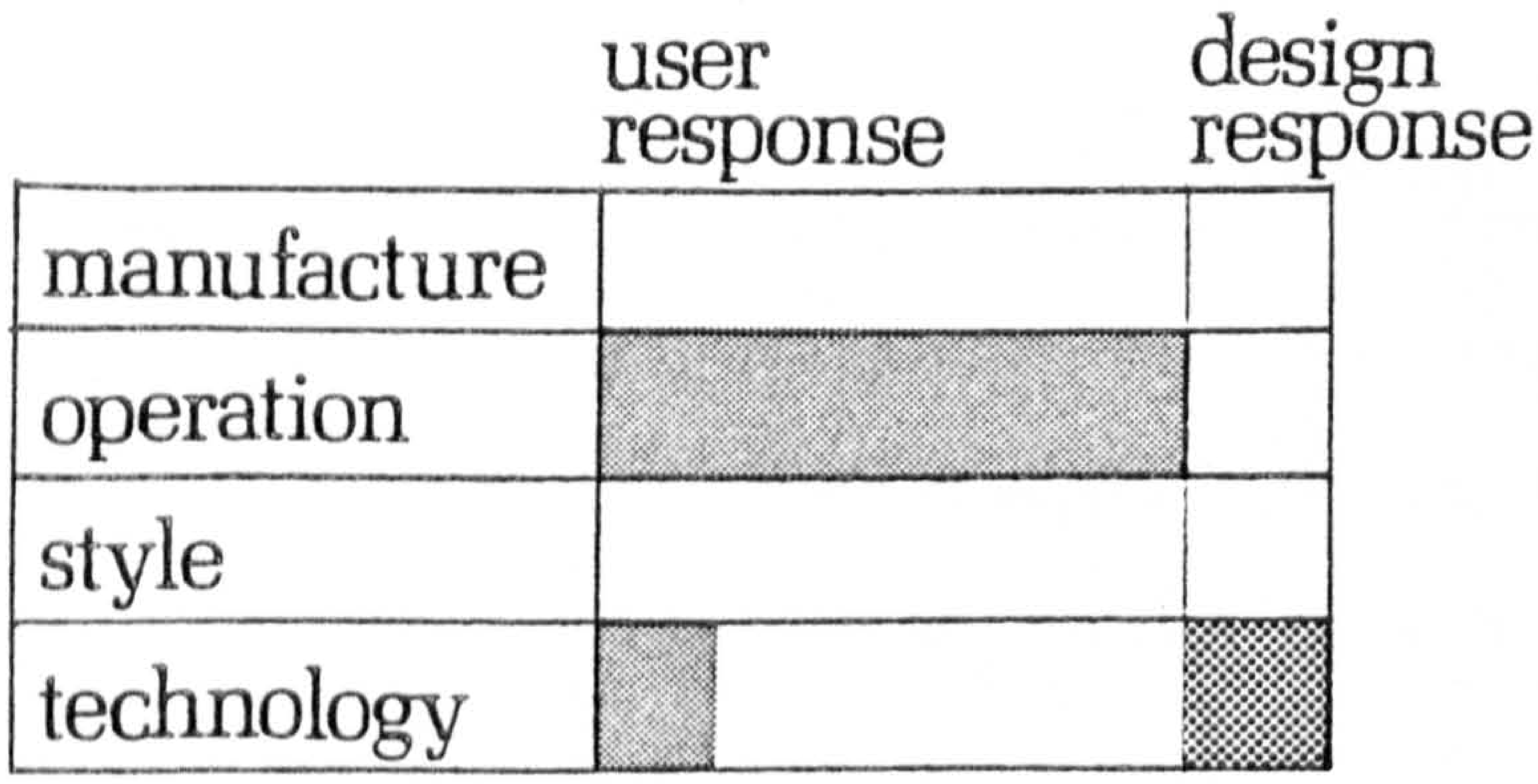
The user response pattern is similarly inconclusive, although generally related to either the fan noise or the sound of the "waves being generated". The comparison of response classification is very similar, since the function of any internal component must be technological, although one user, U3, suggests that the noise has an added operational function, to show that the oven is on. As this operational advantage is the only one, it is assumed that the noise is regarded as not particularly advantageous by the users.

GENERAL PRODUCT

Question 47

Why is the oven wall so thick?

Refer to Plate No 16



Question 47 Conclusions

There is little disagreement between the design group members on the reasons why the oven wall is as thick as it is. There is no single reason, since the wall thickness is unrelated to any microwave insulating property, but is a means of enclosing a number of components: hinge fittings, stirrer, waveguide, control gear, etc. D1 and D3 clearly describe this. However, D2 would appear to be incorrect, as the angle of reflection is related to the internal cavity dimensions and not the wall thickness.

The pattern of user responses shows a high level of mismatch, with all the users giving an operational function, related to the prevention of microwave leakage for safety reasons. This is further evidence that the facts, myths and unknowns connected with the product's safety record can strongly affect product identity by becoming associated with other unrelated product characteristics. In this case, the fact that successful design development might produce an oven with thinner walls may adversely affect user perception of product safety, because of the link between wall thickness and leakage prevention - even though this is mythical.

4.2 SUPPORT QUESTIONS

The following section contains the design and user responses to those questions designed to elicit more general information, which may contribute indirectly to the product's identity (reference 3.1, paragraph 3).

Unclassified and classified responses are included, so that particular aspects of product identity can be discussed, although they may not be representative of the group responses as a whole.

More detailed information on the support question results are housed in section 6.2 of the appendices.

QUESTION 3 PRINCIPAL PRE-PURCHASE ATTRACTIONS OF MICROWAVE COOKING FOR CONSUMERS

Classified Results

Design responses mentioning either speed, convenience or both: D1, D2, D3.

User responses mentioning either speed, convenience or both: U1, U2, U4, U5, U6, U7, U8, U10.

Design responses not matched by user responses:

nutritional value of cooked food;

user safety, especially children;

improved taste;

energy saving.

User responses not matched by design responses:

the blanching of home-grown vegetables.

General Conclusions

The degree of match between design and user responses is sufficiently high to indicate a significant result. The design group stated consistently that "speed and convenience" were the main attractions and these were mentioned by the majority of the user group. A high proportion of the latter used the actual words 'speed' or 'convenience'.

There are two ways of viewing this result. Firstly the user responses may be a result of the marketing/publicity strategy that was adopted for microwave ovens in general, ie speed and convenience were the attributes that were most frequently stressed by manufacturers and hence adopted by consumers as being the most important benefits. Secondly, it might be concluded that the close match is representative of the actual product capabilities in use. In either case, it is correct to assume that the identity of the product in terms of its general function is common to both designers and users.

QUESTION 4 PRE-PURCHASE ATTRACTION OF THE CREDA MICROWAVE OVEN, AS OPPOSED TO OTHER OVENS

Classified Results

Design responses stressing the variable power control: D1, D2, D3.

User responses stressing the variable power control: U3, U6, U7, U8, U9.

Design responses stressing the large cavity volume: D1, D2.

User responses stressing the large cavity volume: U1, U2, U4, U5, U7, U8, U10.

Price factor as a consumer response (unmatched):
U2, U4, U5, U9.

Miscellaneous unmatched user responses:

Creda brand name, U5.

Simplicity, U5.

Visual attractiveness, U10.

Browning tray, U7, U10.

"Solidity", U5.

Conclusions

There is a significantly close matching of variable power control and large internal size between designer and user responses.

The comment by D3 that the variable control would be associated with conventional cooking, whilst not specifically mentioned by the users, appears to be more important as a characteristic than is warranted in practice. This is because when the microwave oven is used at lower power settings, the advantage of speed which it has over conventional cooking diminishes. Similarly, the large internal volume, if related to conventional cooking, appears to be desirable. However, the greater the volume and mass of food cooked at one time, the less is the advantage of speed over conventional methods.

It is possible, therefore, that if an innovatory product exists which has a relationship to a previous user activity, it can be drawn closer to the activity by enhancing characteristics which are similar to the previous, traditional products. It is possible that a pre-purchase advantage is produced which may be unwanted at a later stage, when in use.

The comment by D2, that the oven is APPARENTLY larger than most, is also significant. The table of microwave oven volumes shows that the Creda internal volume is only slightly above average, as is the external volume. The relative wall thickness indicated by the volume ratio external divided by internal shows the Creda to have a below average value compared with other microwave ovens on the UK market.

The results of Question 36 show that the user group contained five people who recognised that an interior shelf could not be utilised for technological reasons related to microwave distribution. It is unlikely that this information was known at the pre-purchase stage. It is therefore probable that the interior size was preferred purely on factors which relate to conventional cookers, rather than the microwave oven.

QUESTION 6 SOURCES OF INFORMATION AT THE PRE-PURCHASE STAGE

<u>Classified Results</u>

Magazines - designers: D1, D2.

Magazines - users: none.

Sales literature - designers: none.

Sales literature - users: U1, U4.

Books on the subject - designers: D1.

TABLE T5

TABLE OF MICROWAVE OVEN VOLUMES[1]

Internal Volume	m^3	
Toshiba ER766ET	0.055	
Moffat 4001	0.042	
Sanyo EM9003T2	0.041	
Sharp R6750E	0.041	
Moffat 4100	0.039	
AEG Micromat ML760	0.034	
Creda 40131	0.032	
Belling MW1	0.028	
Sanyo EM8205	0.025	
Tricity 2000	0.024	
Toshiba ER558ET	0.023	
Hitachi MR6050	0.018	
Philips 610D	0.018	Average internal
Toshiba ER558ET	0.018	volume = 0.0314 m^3

External Volume	m^3	
Toshiba ER766ET	0.126	
Sanyo EM9003T2	0.124	
Sharp R6750E	0.118	
AEG Micromat ML760	0.109	
Creda 40131	0.108	
Moffat 4001	0.099	
Moffat 4100	0.096	
Tricity 2000	0.079	
Belling MW1	0.078	
Sanyo EM8205	0.078	
Toshiba ER558ET	0.075	
Hitachi MR6050	0.074	
Toshiba ER638ET	0.072	Average external
Philips 610D	0.066	volume = 0.0931 m^3

Ratio - External Volume Divided by Internal Volume

Toshiba ER558ET	4.17	
Hitachi MR6050	4.10	
Philips 610D	3.55	
Creda 40131	3.34	
Tricity 2000	3.31	
AEG Micromat ML760	3.20	
Toshiba ER638ET	3.14	
Sanyo EM8205	3.12	
Sanyo EM9003T2	2.99	
Sharp R6750E	2.92	
Belling MW1	2.73	
Moffat 4100	2.47	
Moffat 4001	2.35	
Toshiba ER766ET	2.28	Average ratio = 3.12

(1) Based on figures which appeared in Which Magazine, November 1979.

Books on the subject - users: U6, U10.

Word of mouth - designers: D3.

Word of mouth - users: U3, U4.

Sales demonstration - designers: D3.

Sales demonstration - users: U2, U6, U7, U8, U9, U10.

Enquiries at sales outlets - designers: none.

Enquiries at sales outlets - users: U1, U2, U3, U4, U5, U6, U7, U8, U9.

Conclusions

The most significant mismatch concerns the enquiries made at sales outlets, followed by the importance of sales demonstrations.

Both these mismatches suggest that the designers have viewed the two-dimensional graphic presentation of the product through advertising media as being more influential at the pre-purchase stage than the presence of the three-dimensional object itself at retail outlets. This may have a significant effect on the form of the product.

Response D1, in which the periodical Which is mentioned, has no equivalent user response. Thus none of the interviewees could be said to have consulted this objective information source.

In general, the most important sources of information are those from within the manufacturing industry itself. Hence users will have restricted knowledge about inadequacies, drawbacks or limitations of the product, at the pre-purchase stage.

QUESTION 7 INFLUENTIAL MEDIA ON PRE-PURCHASE DECISION

Classified Results

Points awarded thus: most important 3, next 2, least 1.

Design results:

(i) Listening - 8

(ii) Reading - 5

(iii) Looking - nil

User results:

(i) Listening - 20

(ii) Reading - 22

(iii) Looking - 18

Conclusions

The results are generally too inconsistent and scattered to provide conclusive evidence as to which is the most influential.

It is significant that the design group, who have a degree of involvement in the visual presentation of the product, place little importance on the effects of looking at the product at the pre-purchase stage.

The importance of the verbal source, via friends or salesmen, is seen by both users and designers as the most important source of the three, confirming the role of the innovator adopter.

QUESTION 8 EASE OF PRE-PURCHASE CHOICE COMPARED WITH OTHER DURABLES

Classified Results

Design group - unanimously more difficult

User group - more difficult: 2

about the same: 6

easier: 2

Conclusions

The results indicate that the design group assumed the selection process was more difficult, whilst the user group thought it very similar to any other purchasing process for durables.

It is possible to draw two alternative, opposing conclusions from this. Firstly that the selection process for innovatory products appears simplified because of the probable lack of comparable information; or, secondly, it is simpler, in spite of the probable lack of comparable information.

The judgement of the 'ease' with which the product is chosen is subjective and may be determined by a variety of factors: the amount of disposable income, the skill of the user, the degree of exposure to product ranges and information, competing interests within the user's social group, available time, the degree to which competing products fill distinct market segments or overlap in similar ways, etc. It is impossible to determine the cause of the above results from the data obtained, because of this wide range of options. It is concluded from the mismatch that, as the design group believes that choice is more difficult than it appears to the user, the design group may be influenced to make decisions about the product's identity which would incorrectly attempt to rectify this situation.

QUESTION 10 REFERENCE TO INSTRUCTIONS PRIOR TO USE

Classified Results

Design response: D1, D3 - Read all the instructions before use. D2 - Read a few of the instructions before use.

User response: Read all the instructions before use - 8 users. Read a few of the instructions prior to use - 2 users. Read none of the instructions before use - none.

Conclusions

The user responses to this question are conditioned by the challenge that it represents to the user's competence, and so cannot be considered a reliable guide to the patterns of use of the instruction manual. However, a more reliable indication can be obtained by referring to those questions in the first part of the questionnaire which cover topics referred to in the manual. Clearly, if a high proportion of users has consulted the manual and read all the instructions, such questions should be answered accurately.

The most significant aspect of the results is the high expectation of the design group that users will have read the instructions. The implication for the product's identity is that the self-explanatory role of the product may be thought relatively unimportant. If the Creda oven is compared with several other models, it possesses relatively few product-based instructions, cooking times for various foods and their weights being an obvious lack.

QUESTION 11 COMMON DIFFICULTIES AND MISTAKES DURING INITIAL PERIOD OF USE

Classified Results

Design response:

D1 Preplanning and organising menus.

D2 Over-estimation of product capabilities (instructions not studied correctly).

D3 Overcooking and difficulties in estimating cooking times.

User response:

U1 Difficulty in estimating thawing time.
Suspected machine fault.

U2 Relating general literature on the subject to the use of the Creda.
Difficulty with a specific dish.

U3 Overcooked food.
Melted food containers.

U4 Difficulty with a specific dish.
Container used too small.

U5 Overcooked food.

U6 Undercooked food.

U7 Difficulty with a specific dish.

U8 Difficulty with a specific dish.

Difficulty in using the roasting tray.

Fear of safety factors.

U9 Difficulties with two specific dishes.

Unable to gather adequate information about product use.

U10 Overcooked food.

Container used too small.

Difficulties with roasting tray.

Over-cooked food - 4 users.

Over-estimation of product capabilities (attempts to prepare unsuitable dishes) - 5 users.

Problems with roasting tray - 2 users.

Size of cooking containers too small - 2 users.

Conclusions

A close match of two main problem areas is evident: over-estimation of product capabilities and over-cooking food. It is probable that both these problems are rooted in comparisons that the users have made with the operation and capabilities of traditional cooking equipment. Paradoxically, although linking the product identity to a previous traditional identity has an advantage, in enabling the user to identify common factors, it also has the capacity to mislead by causing the user to identify traditional product capabilities which do not apply. This is a fundamental problem for the t i p designer.

QUESTION 12 MODIFICATIONS TO PRODUCT TO MAKE IT EASIER TO LEARN

Classified Results

Design response:

Meat probe - D1

More accurate digital timer - D1, D2

Improved instructions - D1, D3

Touch controls - D2

Visible cooking guide - D3

Improved browning - D3

User response:

Visible cooking guide - U3, U8

No visible cooking guide - U2, U4, U6, U7, U10

Improved instructions - U3, U4, U6, U8

Meat probe - nil

More accurate digital timer - nil

Touch controls - nil

Improved browning - nil

Visible warning for the use of the roasting tray - U10

Conclusions

It is significant that none of the technological innovations suggested by the design group was matched by the user responses, although it is debatable in what ways such devices would improve the learning process. There would appear to be an inconsistency of approach within the design group between traditional identity (D3 - a browning effect associated with the traditional appearance of cooked food) and innovatory characteristics (digital and touch controls).

The response pattern of the user group is limited to verbal instructions and demonstrates an inability to project learning patterns into more abstracted product characteristics.

QUESTION 13 VERBAL DESCRIPTIONS OF PRODUCT STYLE

Classified Results

Design response:

D1 De luxe, modern.

D2 Reasonably smart.

D3 Comfortable, not as functional-looking as many German products. Appearance of having value.

User response:

Nil response or vague preference - U1, U10.

Visual product analogy, "like a television" - U6, U9.

Size related: bigger - U3; compact - U4, U5; a bit big - U6.

General visual attraction: quite elegant - U2; neat, attractive - U4; fits in well - U8, U10; all right - U9.

Visual simplicity: simple, with simple control layout - U5; simple dials - U7; plain - U8.

Abstracted stylistic descriptions: solid looking - U2; modern - U5; not sleek, usable - U6; cold - U9.

Conclusions

Both design and user responses are limited in descriptive scope, despite consistent attempts to provoke more lucid comments. The fact that the design group was almost as unresponsive as the user group suggests that the problem has other causes than the simple inability to convey visual meaning through verbal expression. This is because much of the design group's communication concerns verbal description of aesthetic characteristics.

One possible explanation is probably related to the visual anonymity of the product and the comparatively limited use of the term "functional" in common language. If the product had been a highly stylised object, it is likely that a descriptive language would be more accessible to users. The lack of stylistic detail on this and other kitchen appliances (not to be confused with the overall linked 'white goods' style) causes the basic control characteristics to be major stylistic determinants. The term "functional" has few alternatives with the same meaning. User responses such as compact, modern, straightforward, usable, simple, plain or cold may all be attempts to approximate to this meaning.

In terms of match between design/user responses, it is understood that both reflect a similar shortage of terms which adequately describe an abstracted design style which is closer to simple functionalism than to applied decoration. It is probable that many objects designed in the spirit of the modern movement may be similarly difficult to describe.

QUESTION 14 VISUAL PREFERENCES RELATED TO TWO COMPETING MODELS

Classified Results

Design responses:

Total preference for oven A, the Philips Cooktronic 7915, because: D2 - it is a designer's design, better integrated, more sophisticated, rather like hi-fi equipment; D3 - continental styling.

Dislike B, the Toshiba, because: D1 - looks out of date; D3 - it is "busy".

User responses:

Still expressed preference for the Creda (C) - U1, U6, U7, U8, U10.

Preference for A over B - U4, U9.

Preference for B over A - U2, U3, U5.

Expression of preference for simplicity associated with C - U1, U5, U6, U8, U9, U10.

Functional rather than visual references - U2, U5, U7.

References to control layout - U2, U3, U5, U6, U8, U10.

Conclusions

Unlike the previous question, the design responses are directly concerned with visual qualities. As would be expected with product users, who may have selected their product from amongst the two models pictured, about half expressed a preference for the visual qualities of the Creda. The clearest reference to visual qualities was to the control layouts of the three models and it is concluded that a major part of the visual assessment of these products is centred on the control panel. In particular, amongst the user group, there was a preference for the visual simplicity of the Creda, compared with the other two models, which was matched by the reference of D3 to the "busy" appearance of B, but not strongly matched by any of the other design responses.

Amongst the design responses, there was a unanimous preference for model A over model B, unmatched by the user responses, where a minority expressed the same, unsolicited comments and a similar minority expressed the reverse preference. The statement by D2 that the oven is a "designer's design" suggests that this difference in attitude is anticipated by D2. If the description of oven A, expressed by D3, is accepted and linked to his statement in the research records that the company would be moving toward a more 'continental' style, then the move would be made in opposition to existing user preference.

QUESTION 15 METHODS OF IMPROVING THE VISUAL QUALITIES OF THE PRODUCT

Classified Results

Design responses:

Colour changes - D1, D3.

Control panel - D1.

More three-dimensional frontal design - D2.

User responses:

No response - U2, U4, U5, U7, U9.

Inappropriate functional response - U3, U8, U10.

Colour changes - U6, U1.

Modifications to the control switches - U9, U10.

Conclusions

The high number of nil or incorrect responses to the question expressed by the user group demonstrates the problem that users have in describing and speculating about purely visual phenomena in functional objects. A response is frequently lacking or linked into functional characteristics, eg U10 - "Bigger writing spread out from the control knob" could be interpreted as a purely aesthetic consideration or a control function to read the graphic instructions more clearly.

This user limitation is not reflected in the design responses, where all three designers were able to reply positively. It would appear that the design group is able to abstract aesthetic considerations,whilst the user group requires a functional 'peg' on which to base them.

The user response, U9, in which a change in switch design is required, which would make it look more like the user's conventional oven, matches the intentions expressed by D3 in previous questioning, that the company was intending to make the product look and perform as close to conventional ovens as possible.

Apart from U9, the user responses do not describe three-dimensional qualities, as do the design responses.

QUESTION 16   THE LEAST VISUALLY ATTRACTIVE FEATURE OF THE PRODUCT

Classified Results

Design responses:

The controls - D1, D3.

The door handle - D2.

User responses:

No response - U4.

Control knobs - U2, U7, U8, U9.

The front to back distance is too great - U1.

Metal rim surrounding door panel - U3.

The piece of wood on the door edge - U5.

The colour - U6.

The projecting door hinges - U10.

Conclusions

The closest match appears to be in the control panel/ control switch area, which is mentioned by 2 out of 3 designers and 4 out of 10 users. However, there is some difference in the nature of the response between the two. The design responses are less explicit in reference to specific control details, whilst the user responses are concerned solely with the switches and not the entire control panel.

Unlike many of the previous questions, there is a high degree of scatter in the user responses, ie a number of details which differ from each other and, in many cases, from the design responses. The quality of the user responses is more highly detailed and therefore of greater significance in any design re-evaluation.

QUESTION 17 GENERAL ATTITUDE TO PRODUCT APPEARANCE

<u>Classified Results</u>

Design responses:

Average - D1, D2.

Attractive - D3.

User responses:

Average - U1, U3, U4, U6, U9.

Attractive - U2, U5, U7, U8, U10.

Ugly - none.

<u>Conclusions</u>

A reasonably close match of responses was obtained, particularly in the "ugly" category, which was unrecorded in both design and user results. More significant is the relatively high number of both groups who described the visual attractiveness of the product as average. This indicates a somewhat critical attitude - and almost amounts, in the case of designers, to an admission of failure.

QUESTION 18 COMPATIBILITY WITH ENVIRONMENT/OTHER APPLIANCES

<u>Classified Results</u>

Design response:

Incompatible controls - D1.

No response - D2, D3.

User response:

No response - U1, U2, U3, U5, U8, U9.

Off-white case colour - U4, U7.

The size - U6.

Bigger inside cavity space, smaller outside walls - U10.

Conclusions

There is a high degree of match reflected in the nil response, ie there are no aspects of the appearance which are generally incompatible with the user environment or other appliances. Of the positive responses, all are unmatched. Two sets of responses - the incompatible controls and the case colour - could be rectified by simple aesthetic modification, whilst the size and cavity/outer volume ratio clearly require more complex, technology-related modification.

QUESTION 19 GENERAL ATTITUDE TO COMPATIBILITY WITH THE USER ENVIRONMENT

Classified Results

Design responses:

Moderately well - D1, D2.

No response - D3.

User responses:

Very well - U1, U2, U4, U5, U7, U8, U9, U10.

Moderately well - U3, U6.

Not well - nil.

Conclusions

There is a significant difference between the design and user response pattern to this question, the former being less optimistic than the latter about the product's visual compatibility. Both sets of results are consistent with the responses to the previous question (18), in which 6 users were unable to pinpoint any incompatibility and go on to form 6 out of 8 users who rate the general compatibility as "very well".

QUESTION 20 PRODUCT CHARACTERISTICS WITH LOW QUALITY FINISH OR STANDARD OF WORKMANSHIP

Classified Results

Design responses:

No response - D3.

The plated knobs - D1.

Gaps between the outer case and the front - D2.

The way that the hinges are screwed on - D2.

The feel of the door handle - D2.

User responses:

No response - U1, U4, U5, U7, U10.

Gap between outer case and front - U3.

Taper on gap between door and control panel - U2.

Unreliable timer - U2, U8.

Play in the door - U9.

The texture of the outer case - U6.

Conclusions

The inability of half of the users to identify a critical feature may be caused by a number of possible factors: the relatively anonymous design identity of the product, general satisfaction with its functional attributes, or general effects associated with cognitive dissonance exaggerated by the relatively high cost of the product. This does not, however, explain the D3 design response, where the quality of the nil response "of course not" reflects a company loyalty rather than an objective assessment.

Apart from the nil responses, the closest match occurs in relation to the gap between the outer case and the front (D2 and U3). The association between quality and certain types of finish is reflected in two differing responses: D1, the plated control knobs and U6, the textured PVC case finish.

The two user responses which concern the accuracy of the timing device are not identified by the designers and it is significant that these two responses are concerned with a non-visual phenomenon.

QUESTION 21 GENERAL ATTITUDE TO QUALITY OF FINISH/ STANDARD OF WORKMANSHIP

Classified Results

Design responses:

High quality - D1, D3.

Average quality - D2.

Low quality - nil.

User responses:

High quality - U3, U4, U5, U7, U8, U10.

Average quality - U1, U2, U6, U9.

Low quality - nil.

Conclusions

A close match of design and user responses,with no "low quality" responses in either category and the bulk of responses in the "high quality" section. Given the design loyalty and the user's likely commitment to the product, the single design response and four user responses in the average category might well be more significant than they appear. During the interviews it was obvious that some of the user group associated the process of mass-producing goods with an inevitable and inherent lack of quality in finish. It is therefore likely that the "average quality" responses are, in some sense, relating the quality of finish of the oven to an average (low) quality standard set by the majority of other mass-produced goods.

QUESTION 22 PARTS OF THE PRODUCT THAT ARE THE MOST DIFFICULT TO CLEAN

Classified Results

Design responses:

Interior roof - D1.

Interior corners - D1.

Door seals - D2.

Control panel - D3.

User responses:

Door seals - U1, U2, U3.

Interior roof - U4, U5, U6, U7, U10.

Interior corners - U3.

Control panel - U8.

Glass door - U1, U2.

Textured case finish - U6.

General splashes on cavity walls - U5.

Conclusions

There is a close matching of all four design responses with the user responses, although the former give no indication of the magnitude of the user responses. For example, half the users refer to the cavity roof with its lighting and ventilation grills, whilst only one third of the designers did so.

QUESTION 23 GENERAL ATTITUDE TO CLEANING THE PRODUCT

Classified Results

Design responses:

Quick and easy to clean - D1, D2, D3.

User responses:

Quick and easy to clean - U1, U2, U3, U4, U5, U6, U7, U8, U9, U10.

Conclusions

A total match of design and user responses is related to the comparison of the cleaning process with other cooking products and the advantage that the microwave oven has over conventional methods in heating only the food and not the cavity walls. This means that any soiling does not get burnt on to the walls. Other factors, such as the light coloured interior, the fact that the unit is usually mounted closer to eye level than many conventional ovens, the relatively small interior size and the lack of shelving, may all contribute to the ease of cleaning.

With such a unanimously favourable response, it is clear that this attribute makes a significant contribution to the perceived identity of the product when in use, but not at the pre-purchase stage, as it goes unmentioned as a significant purchase factor by the user group.

QUESTION 24 ANTICIPATION OF CHARACTERISTICS TO EXHIBIT SIGNS OF WEAR AND TEAR FIRST

Classified Results

Design responses:

The cavity wall finish - D1.

The controls: power and timer - D3.

Door release bar - D3.

Plastic inner door panel - D1.

Perspex control panel - D2.

User responses:

Door release bar - U1, U3, U4.

The controls: power and timer - U5, U8, U10.

Door hinges - U2, U7, U9.

Door locks - U2, U9.

Door panel - U6.

Door seals - U9.

Conclusions

The design responses concentrate on both the wear of panel finishes and individual components, whilst the user responses, with the exception of the door panel, are concentrated on individual components.

There are matches between the user and design responses in terms of wear and tear to the power and timer controls and the door release bar, which are the only two areas of the product where prolonged user contact might be expected. It can thus be assumed that, amongst both users and designers, wear and tear is associated with direct user contact via hand operation, rather than wear as a result of mechanical operation, the movement of foods, containers, etc.

The unmatched user responses concern hinges, locks, door panel and seals. It is clear that, as there are underlying safety issues connected with such details, they may either cause anxiety or be the result of anxiety about safety factors.

QUESTION 25 GENERAL ATTITUDE TO PRODUCT DURABILITY

Classified Results

Design responses:

Robust and durable - D1, D3.

Between robust and durable, and of average durability - D2.

User responses:

Robust and durable - U1, U2, U3, U4, U5, U6, U7, U8, U10.

Of average durability - U9.

Not particularly durable - nil.

Conclusions

There is a close match in attitudes to product durability expressed by designers and users.

QUESTION 26 LEAST SAFE ASPECT OF THE PRODUCT

Classified Results

Design responses:

The door seal - D1.

The projecting door when open: danger of physical collision - D3.

No response - D2.

User responses:

Microwave leakage - U1, U2, U3, U7, U8, U9.

Operation by children - U1, U3, U5, U10.

Door seal/fit specifically referred to - U5, U7, U9.

Oven still on when timer indicates zero - U6.

Nil response - U4.

Leaving unit plugged into the mains supply - U3.

Conclusions

With the exception of the single response, D1, the design responses are not concerned with microwave leakage, unlike 6 out of 10 of the user group. This factor may be considered to be an unproven but important contribution to the product's overall identity.

Operation of the product by children is not considered by the designers to be a safety problem, as it is by 4 out of 10 users - indeed, the D3 interview contains references to operation of the product by children as being an important user asset in marketing terms.

QUESTION 27 GENERAL ATTITUDE TO PRODUCT SAFETY

Classified Results

Design response:

Very safe - D1, D2, D3.

User response:

Very safe - U2, U3, U4, U5, U6, U7.

Moderately safe - U1, U9.

Unsafe - nil.

No response - U8.

Conclusions

There is a reasonably close match of design and user attitudes to product safety, with a generally favourable response. In the case of the users, this is in conflict with some of the responses to other questions, where concern about product safety is expressed (eg Question 28 viii), albeit in an indirect manner.

QUESTION 28 ATTITUDE TO EXTRA PRODUCT CAPABILITIES

Combined Table of Classified Results

(i) Oven automatically detects spillage and switches off

Design response	2 no	1 yes
User response	8 no	2 yes

(ii) Oven cannot be switched on when empty

Design response	2 no	1 yes
User response	2 no	8 yes

(iii) Oven cannot be operated with metal objects in the cavity

Design response	1 no	2 yes

User response	3 no	7 yes

(iv) The oven is self-cleaning

Design response	2 no	1 yes
User response	8 no	2 yes

(v) The oven has a built-in thermometer

Design response	0 no	3 yes
User response	4 no	6 yes

(vi) Power cycle can be changed automatically

Design response	1 no	2 yes
User response	5 no	5 yes

(vii) Turntable for food rotation

Design response	2 no	1 yes
User response	6 no	4 yes

(viii) Microwave leakage indicator

Design response	0 no	3 yes
User response	0 no	10 yes

(ix) The oven can be set to stir liquids whilst cooking

Design response	0 no	3 yes
User response	5 no	5 yes

TABLE T6 TABLE OF PREFERENCE ORDER

Design Response	User Response
1 Leakage indicator	1 (Leakage indicator ((Liquid stirrer ((Thermometer
2 Non-operation when empty	2 (Power cycle automated ((Non-operation with metal (objects

3 Non-operation with metal objects	3 (Turntable ((Non-operation when empty ((Spillage detector ((Self-cleaning
4 Thermometer	
5 (Liquid stirrer ((Automated power cycle	
6 Turntable	
7 (Self-cleaning ((Spillage detector	

Conclusions

The preferences expressed by users and designers for extra product capabilities are similar. The desirability of a leakage indicator is important in both groups. This is consistent with the findings of support questions 26 and 27, that superficially the identity of the oven is associated with safe operation, but there is an underlying requirement for reassurance that all is operationally normal. A number of similar appliances provide this (for example, the odour of leakage in the gas oven) and it may well be desirable for the designer to provide a synthetic indication of safe operation because of the lack of visible, tactile and odorous properties of microwave radiation. This would probably have to be carried out unobtrusively, in design terms, in order not to overstate the safety problem. An obvious solution would be an imperceivable technology which would operate an automatic cut-out if leakage was detected.

At the bottom of the user/designer preference list is the hypothetical "self-cleaning" function, consistent with the findings in support question 23, that the product is already perceived as being easy to clean. This is qualified by the responses to support question 22, which indicate a strong belief that the interior cavity is still the most difficult area to clean.

In general, the design group shows a slightly higher regard for automated operational devices (eg a non-operation when empty or when containing metal objects) than do users.

Further analysis of support question 28 can be found in Section 6.2.

QUESTION 29 WOULD YOU SAY THAT THE MAJORITY OF USERS ARE THE KIND OF PEOPLE WHO TEND TO BUY NEW OR INNOVATIVE PRODUCTS BEFORE EVERYONE ELSE?

Response:

D1 Yes.

D2 Not particularly.

D3 Yes.

QUESTION 30 WHAT AGE GROUP OR GROUPS WOULD YOU EXPECT TO BE THE MOST COMMON USERS OF THE OVEN?

Response:

D1 30 to 45.

D2 A wide cross-section, which does not include the younger generation.

D3 The disposable income groups are the most significant in the USA. This includes an older age group and single unmarrieds.

QUESTION 31 WHAT PERCENTAGE OF COOKED FOOD WOULD THE AVERAGE USER PREPARE IN THE MICROWAVE OVEN, AS OPPOSED TO THE CONVENTIONAL OVEN? WOULD YOU EXPECT THERE TO BE A WIDE VARIATION IN THIS?

Response:

D1 Very little: 15 to 20%.

D2 A low percentage: about 20%.

D3 This increases from about 10 to 50% in use.

QUESTION 32 IN GENERAL, WOULD YOU EXPECT THAT USERS WOULD GET MORE, LESS OR THE SAME USE OUT OF THE OVEN THAN THEY ANTICIPATED BEFORE PURCHASE?

Response:

D1 Less.

D2 Less.

D3 More - Depends on their motives for purchase. I think they would be surprised by the greater use they get out of it than expected.

QUESTION 33 COULD YOU DESCRIBE THE KIND OF BACKGROUND, OCCUPATION, SOCIAL GROUPING, ETC, OF THE TYPICAL USER GROUP OR GROUPS?

Response:

D1 No comment.

D2 A wide cross-section.

D3 Singles and older age groups.

CHAPTER 5 GENERAL CONCLUSIONS

5.1 CONCERNING THE TREATMENT OF RESULTS

This section sets out the approach to the treatment of the experimental results. In many research experiments it is possible to determine the treatment before the findings have emerged. In the case of this experiment, the span of the subject and the lack of previous work in the area have meant that some decisions which concern the analytical method have had to be made on the basis of the pilot results.

At the outset of the research programme it was surmised that mismatches were likely between the intentions and meanings expressed by designers and the perceptions and meanings as expressed by users about common product attributes. This was probable, since the design process usually involves compromise between production and user requirements. Also errors occur, due to misinterpretation of requirements, and simple mismatches may occur, due to the relative lack of expertise of the untrained consumer, as compared with the professional knowledge of the designer. It was less clear in what ways such potential mismatches and matches would be linked and how the relationship between them might be interpreted. It was therefore important that the drawing of any conclusions was not formulated in terms of method, prior to a general evaluation of such relationships.

In debugging and developing the pilot questionnaire, a new question type was introduced to form the initial section, which was concerned with the perceived functional meanings of product attributes. This addition, although expanding the information output, also broadened the type of information obtained which already consisted of a wide range of differing responses. Thus the final questionnaire included a number of radically different types of question, which elicited equally different types of response. These can be summarised as follows:

Questions about the functions of specific product details, eg Question 1 "What is the red light for?".

Questions to test the validity of the interviewee's experience, eg Support Question 1 "The length of the period of use".

Questions designed to probe the associations connected with purchase and general use of the product, eg Support Question 4 "What attracted you to the Creda, as opposed to other makes or models?".

Questions designed to elicit a general appraisal of a particular attribute, eg Support Question 17 "Would you say that the oven is generally (i) ugly, (ii) good looking, (iii) of average looks?".

Questions designed to provide information about the interviewee, eg "Socio-economic classification".

There cannot be a high degree of compatibility between the resultant information obtained from these different question groups. The immediate response is to devise strong analytical bonds between those question types which appear to be interconnected. For example, it is probable that there is a relationship between Support Question 26, "What aspects of the oven would you consider to be least safe?", and Question 27, "In general, would you say that the oven is (i) very safe, . . .", and Question 28 (viii), the desirability of a microwave leakage detector, etc. However, the construction of such relationships has certain important drawbacks, which may well distort the overall findings of this experiment.

Firstly, the breadth of the method means that the range of potential linkages is vast and subjective. For example, the above series of questions concerned with product safety could well be linked to other questions about product perception, eg Question 20 "Why is there a gap between the oven and the control panel?", if the responses to that question indicate a misunderstanding which could cause misuse. It would thus be possible to produce hybrid results by the subjective comparison of the initial results which, whilst possessing some objective base, would be conditioned by the aspirations of the author.

Secondly, the relatively small size of the interview sample means that the potential for unrepresentative results is high and cross-connecting the results from different questions will serve to increase this potential source of error.

It is necessary to strike a balance between allowing the results to speak for themselves,with the consequent lack of conclusion and clarity,and a form of analysis which produces a distorted view of perceived meaning.

In attempting to provide such a balanced approach, the concept of product meaning must itself be clarified and the limitations that exist,within the methodology in defining it, stated.

5.1.1 Product Meaning and the Experimental Method

At the outset of this research programme it was assumed that the meaning of products could be defined by subdividing their associational values, functional capabilities and symbolic roles into a series of categories which would form an analytical tool. Thus products, rather like living species, could be grouped into families by allocating their observed properties to the appropriate categories and linking groups of products with similar category patterns together. It was envisaged that such a tool would provide the means whereby questions could be formulated which would relate to each subdivided category and hence be used to evaluate the perceived meaning of products amongst varied groups of users and non-users.

After devoting research resources to the classification of general product attributes, it became clear that the variables involved were more diverse and unquantifiable than had at first been envisaged. It was evident that even if such a classification system were possible, the relative importance of each subdivision would be impossible to gauge and hence its contribution to the general perceived meaning of the product would remain unknown.

In order to resolve the difficulty of the analysis of product meaning, a compromise had to be devised, whereby the parameters of product meaning were reduced to those which were of greatest significance to the t i p designer/user. It was also equally evident that this selection process would produce a set of important parameters, which would only be of relevance to individual t i p's. (Thus, for example, the importance of safety factors in the microwave oven evaluation is far more significant than in an evaluation of the pocket calculator.)

The final questionnaire framework, whilst it does not attempt to encompass all the variables that may combine to form the meaning or identity of the product, does, by examining a variety of characteristics systematically, aim to identify those most commonly held by both the design and user groups. In the first section (Questions 1 to 47) the general functional domains of a product (control interface, enclosure, input interface, output interface, product materials and general product attributes) are used as a basis by which significant visible product details are identified. These are then used to explore the meanings that users and designers place on them. In the second or support section, three periods in time are given special attention: the pre-purchase and purchase phases and the time when the user first learned to operate the product. The purpose of focusing on these three periods is to document information about initial responses, unconditioned by full use. In the final section of the support questionnaire, the current attitudes of the user and designer are examined on a range of topics related to function and visual style, the purpose being to provide background information linked to the closed-ended non-support responses.

The final questionnaire form is necessarily lengthy, since it is designed to provoke a wide range of comparable reactions. It might be argued that, if the research method is concerned with unquantifiable responses, then an interactive group interview technique would be most suitable. However, this would be to ignore the need for comparable data, so that user and designer responses can be contrasted. In order to make such a comparison possible, it is necessary to standardise the data from both parties to make them directly comparable, both quantitatively and qualitatively. With an open-ended group interview technique, this would be difficult.

5.1.2 The Difference Between Perceived or Decoded Meaning and Encoded Meaning

In assessing the results of the experiment, a distinction is made between perceived or decoded meaning and encoded meaning. In the case of decoded meaning, the concern is with what the product expresses to the interviewee, correctly or incorrectly. In the case of encoded meaning, the concern is with those associations of the product that have been deliberately designed into it. This distinction is over-simplified, when one considers the nature of those symbols that are built into the product unwittingly by the designer.

In the case of the user interviews, all the questions invite uninformed and subjective replies. The design interviews differ because informed and objective information is sought and therefore true meaning determined. If this view is taken to its logical conclusion, the act of comparing the perceived user responses with the "true" design responses must be one in which the reality in user perceptions is separated out from mythical values.

This theory formed the basis of the pilot research method but the results of design interviews revealed an unforseen problem. Many of the responses were as inconsistent and subjective as the users' and, in some cases, particularly those related to performance in use, were less realistic. Thus the supposition that the accuracy of user responses could be determined by comparison with the "truth" of the design responses was proved false. In reality, the method generally compares one set of perceived meanings with another, whether these have any factual basis or not.

There are some exceptions to this, in connection with technical detail, where it can be assumed that the design responses are frequently factual. Yet in this relatively clear-cut area, a consensus of opinion is not always apparent.

The reasons for such a discrepancy are relatively easy to identify with hindsight. Initially the designer was assumed to understand the factual make-up of the product, unlike the user, who is much less well informed at all levels about the product. However, it was incorrect to assume that the individual designer is well informed about a wide range of product characteristics, when design by teamwork may well mean that he is only aware of a narrow spectrum of product characteristics. If a comparison is made of this view of the design activity with the activity and related knowledge of the long-term product user, it is unclear which party constitutes the product 'expert'.

This has implications for the design consensus. Previously it was assumed that it would be possible to arrive at an agreement between the design group on the reasons why design decisions were made. Individual specialisation within the design team means that a single designer knows the correct reason behind a decision whereas other designers may not, or worse, may have an incorrect view of the reason. In this case reliance on numerical superiority to determine the true answer could be misleading.

Within the limitations of the experiment, it follows that there may be differences between encoded and decoded meaning which are non-demonstrable, both for design and user responses.

The factors which have been outlined in this section of the research condition the list of experimental conclusions which follows.

5.2 RESEARCH CONCLUSIONS AND THE HYPOTHESES

The four research hypotheses have been described in Chapter 2 of this thesis. The following section outlines their relationship to both the findings and individual conclusions of the experimental methodology.

<u>That a series of differentials exists between product design intentions and medium to long term user needs and requirements</u>

The single application of the research questionnaire has shown that, in the case of the Creda microwave oven, a number of differentials exist, with particular reference to product identity. The intended meanings encoded in product characteristics are in some cases decoded incorrectly by users.

It can be demonstrated that this misinterpretation by users is not always undesirable from the point of view of the producer - for example, the results of Question 40, in which the selection of outer case material, which was based primarily on cost reduction, was viewed by users as having non-manufacturing advantages. In Question 47 the thickness of the oven cavity wall, which was primarily a result of technological considerations, was perceived by users as an operational safety feature. This result was similar to the users' perception of the purely stylistic band around the door in Question 16 and the purpose of the rounded case corners in Question 24. It is probable that such positive misinterpretations may also be in the interests of the product users. However, a number of mismatches were identified which were clearly not advantageous.

The results of Question 8, for example, show that half the users do not associate the layout of the control panel with an ideal operational procedure as defined in the instruction manual. In Question 15 the users, whilst correctly ascribing an operational function to the mesh screen on the door, do not always identify it as a microwave screen. Similarly, in Question 28, the majority of users failed to associate the grey door seal with microwave protection. The implications of these last two findings are serious, since they may result in incorrect maintenance and ultimately unsafe product use.

An important group of questions was devoted to the users' understanding of the materials visible on the product. In Question 38 a number of users incorrectly identified the material that the control knobs were made of. Similarly, the door panel (Question 39) and the floor of the cavity (Question 41) are incorrectly identified, with the possible consequence of incorrect maintenance and operation. Such findings are consistent with the views discussed in Section 1.1, page 14, that a particular problem exists for the t i p user in identifying and dealing with new or 'disguised' materials.

As a by-product of this investigation it has become apparent that significant mismatches exist between the responses of the individual members of the design team concerning the function and meaning of almost half the product characteristics (see the results of Questions 2, 4, 5, 9, 11, 12, 13, 14, 17, 19, 20, 23, 24, 28, 29, 30, 32, 35, 38, 41 and 42). A number of causes for this are discussed in Section 5.4.4 and it is concluded that the lack of shared knowledge amongst the team has contributed to illogical and confusing elements in the product's identity. This, in turn, has contributed to the differentials which exist between design intentions and user needs and requirements.

It would require a number of repeated applications of this research methodology to a wide range of t i p's before it could be assumed that this hypothesis has general relevance.

<u>That some of these differentials are wide in products which are technologically innovatory</u>

The Creda microwave oven was selected for the application of the research methodology partly because it obeyed the t i p selection criteria, stated in Section 3.2. According to the research definition, the microwave oven is technologically innovatory and the differentials described under the previous hypothesis are thereby consistent with this second hypothesis. Similarly, subsequent applications of the research methodology would be required to verify the hypothesis.

The research methodology has not been previously applied to a range of products which are not technologically innovatory. A comparison between t i p's and non-t i p's cannot therefore be made, from which it might be inferred that technological innovation is the major cause of the differentials.

It has been assumed that innovative activity demands a degree of experiment and risk-taking (ref Section 2.2.2) and that these demands are common to both the producer and the user groups. It was argued that this unpredictable element was the basis of the second hypothesis. Evidence concerning the hypothesis, drawn from the research methodology, is limited to that which has been described under the first hypothesis. However, there are conclusions that can be drawn from the background interviews with Creda personnel and the support questions which demonstrate that a degree of unpredictability was present for both users and producers.

The initial Creda design interviews (ref research interviews RM1, RM25, RM26 and RM29) show clearly that the product technology, relationship with a collaborating company (Litton), and understanding of the potential market were all factors which involved an experimental commitment from Creda. The joint development venture was described as a "learning process" by D2.

Similarly, a number of findings in the user support questionnaire point to the unpredictable aspect of product purchase. Support Question 6 shows that, in general, access to information sources prior to purchase was limited to sales demonstration and enquiries, without recourse to less partial sources. Question 11 shows that most users were able to recall significant difficulties with the product during the initial period of use. Support Question 6 also shows that only a small number of users were in contact with other product users prior to purchase. Thus the majority were also involved in a 'learning process' at the pre-purchase stage which depended on fragmented and unsubstantiated sources of information.

It is probable that, under such circumstances, the users' selection criteria for the Creda model, as opposed to other available models, would be suspect. The findings of Support Question 4 show a marked preference for the large cavity volume and the variable power control. Both of these characteristics, although extremely advantageous in conventional cooking equipment, are of limited advantage in microwave cooking.

Both the user and designer evidence does not, therefore, disprove the assumption that their initial involvement with the product was characterised by a degree of risk, consistent with the basis of the second hypothesis.

<u>That a methodology may be devised which can be used to evaluate the series of differentials for a wide range of t i p attributes and characteristics</u>

The third hypothesis is perhaps the least significant of the four, since it depends on the progress of the investigation and not on external factors.

The methodology which has been developed has demonstrated that differentials exist (the classification and matrix systems) and has been used to evaluate them (cross-referenced data from the matrix system, plus support question data). Although only a single application has so far been carried out, the range of characteristics that have been evaluated is wide. It has investigated responses to colour, texture, shape, volume, control mode, safety, durability, weight, materials, etc. A general method of analysis has been used to form a basis for all the questions asked. Thus the product was reduced to common interfaces (input, output, control, etc), the responses reduced to common classifications (stylistic, technological, manufacturing and operational) and the support questions based on properties attributable to the majority of t i p's (durability, ease of use, learning process, pre-purchase expectations, etc). In this way a wide range of t i p's can be investigated, although the product's specific characteristics may vary considerably.

<u>That this methodology, if applied to a sufficient number and variety of t i p's, will yield knowledge which will enable the t i p designer to reduce the differentials and hence produce more successful product design solutions</u>

The final hypothesis is intended to become the object of further research based on the methodology and, as such, cannot be verified or falsified on the basis of the single application. If subsequent research reveals that there are similar differentials in perceived meaning between designers and users, amongst a variety of t i p's, the methods of improving the design process (ref 5.6) could be implemented by design practitioners.

The research has identified a number of factors which, if they had been identified at the pre-marketing stage, would have led to a more successful design solution. These include:

Misinterpreted control functions.

Misinterpreted visual characteristics, which may result in incorrect maintenance procedures.

Incorrectly identified materials, which may result in incorrect treatment by the user.

A lack of knowledge about external product technology, which can result in incorrect operation and maintenance.

(Detailed analysis of the above factors is contained in Section 5.3.)

Section 5.6 describes how the research methodology can be modified to become a design research tool for use during the development of t i p's, which is one means of producing the "more successful product design solutions" of the final hypothesis. A second method would involve the analysis of the data which would result from further academic applications of the methodology. This data can be used to determine the relationship between t i p's and their patterns of use, as discussed in Section 1.7. Thus guidelines could be established for the design of t i p's, based on an understanding of the link between product identity and the role of products in the work/leisure spectrum (1.7.2). This would yield again the "more successful product design solutions" of the final hypothesis.

5.3 PRINCIPAL RESEARCH CONCLUSIONS

5.3.1 Response Totals

The sum of all the design responses shows that the order of priority of the functions of the various perceivable characteristics was, in decreasing order, technological, operational,manufacturing and stylistic,

or: T
O
M
S

In the case of the user responses, it was operational, technological, stylistic and manufacturing, in decreasing order, or: O
T
S
M

Thus:

Designers place relatively more emphasis on manufacturing functions than do users.

Users place relatively more emphasis on operational functions than do designers.

Designers place relatively more emphasis on technological functions than do users.

Users place relatively more emphasis on stylistic functions than do designers.

5.3.2 Matched Responses

Where overlaps between user and design responses occurred, these were totalled for each function group, then divided by the total number of overlaps to find an average value (ref Table T7).

The order of averages was as follows: operational responses 6.6, technological responses 5.5, stylistic responses 3.3 and manufacturing responses 1.4, or, in decreasing order: O
T
S
M

(This is identical to the order of user responses in 5.3.1 above.)

Thus:

The most frequent matching occurs between operational functions, followed by technological functions, then stylistic functions. The least frequent matching occurs between manufacturing responses.

5.3.3 Product Materials

There is an inconclusive and even spread of responses to questions about the function of product materials throughout the M/U table (ref Table T7).

Thus there is no general pattern of mismatch concerned with materials functions.

5.3.4 User Attitude to the Safety of the Microwave Oven has both Factual and Mythical Roots

On occasion the user will impose subjective observations on characteristics to which, in reality, they are unrelated.

In particular, the user responses to the 'unknown' safety constraints of microwave radiation have conditioned attitudes to a number of unrelated product characteristics.

For example, Question 16, where the 'cosmetic' door band is thought to prevent microwave leakage; Question 40, in which two users assumed the outer metal case material was chosen to reflect radiation; and Question 47, in which the majority of users assume that the thickness of the oven wall is related to radiation leakage prevention. The support question 26 result is consistent with this view, in that microwave leakage is seen as the least safe aspect of the product, even though it is thought to be generally safe (Support Question 27). Support Question 28, in which a leakage detector is seen as the most desirable extra product facility, is also consistent with this conclusion.

5.3.5 There is a Tendency to View the Majority of the Characteristics of the Product Favourably and Indiscriminately, if the General View of the Product is that it Fulfils a Useful Role

The most significant consequence of this is a user emphasis on operational advantage as being the criterion by which designers make their choice. This also results in an under-identification of manufacturing constraints (especially production cost reduction) by the user. This is most clearly demonstrated by comparing the total responses for each group and comparing their order (ref page 283), the design order being T and the user order O
O T
M S
S M

This favourable attitude to the product is indicated in a number of support question responses. In Support Question 14 the product is preferred to two competing models; in Support Question 17 it is generally thought to be attractive; in Support Question 19 it is thought to be compatible with the environment; in Support Question 21 it is believed to possess a high quality of finish; and in Support Question 25 it is believed to be durable.

5.3.6 It Cannot be Assumed that the Design Responses Represent an Accurate Description of Product Characteristics, Their Role or Purpose

Several factors have contributed to a lack of shared knowledge about the product by members of the design team, the most significant being the fragmentation of the decision-making process. This originates in the nature of the collaboration between Litton and Creda, which caused the design role at Creda to have distinct limitations, concerned with matching of the product's outer applied design to an acceptable appearance for the British market. Many of the responses of the two Creda designers confirm this when compared with the more factual accounts of the Litton designer. The responses of D2 (ostensibly the industrial designer at the Creda office) are particularly suspect, because of the large number of nil responses, and illustrate the limitations that characterise the actual, as opposed to the desired, status of the profession (ref Table of Classified Design Responses, page 308).

In particular, 12 of the non-support question responses are consistent with the view that there is a lack of agreement on the function of particular design characteristics (ref non-support questions 8, 9, 11, 12, 13, 14, 23, 28, 29, 30, 35 and 46).

5.3.7 Design Responses do not Necessarily Describe the Functions of Characteristics which Simulate the Qualities of Other Materials in Terms of a Synthesis but rather Tend to Define a More Functional Motive for their Inclusion in the Product

The user responses seldom mention simulation directly, although it is hinted at by remarks on the relatively low cost for the manufacturer - the response to Question 14, in which the textured finish of the door release is given a functional role, as is the mock-leather PVC case cover in Question 23. Similarly, the metallic finish on the control knob in Question 38 is not seen as a direct attempt to simulate solid metal.

5.3.8 There is Confusion over the User's Identification of Materials which may Affect the Way that they are Cleaned or Maintained and Affect the Durability and, in Extreme Cases, the Safety of Use

Several non-support question responses are consistent with this view: Question 38, in which a number of users misinterpreted the switch control material; Question 39, in which the door panel material was incorrectly identified;

Question 41, in which the cavity floor is wrongly identified; and Question 43, in which the materials of the cavity roof are incorrectly identified.

5.3.9 Explanatory Details in the Product Manual Partially Inform the User about the Product Technology. However, a Number of Findings Indicate that Users will Elaborate on this Incorrectly, in Order to Explain those Characteristics about which Little is Known

A number of non-support responses are consistent with this statement. Question 8 shows some confusion about the switch sequence on the control panel, assuming an operational advantage when there may well not be one. Question 15, concerning the function of the door mesh, has drawn a number of responses related, correctly, to operational safety but, incorrectly, to the protection of glass at high temperature. Question 33, which concerns the cavity volume, has a number of responses which relate the decision to traditional cooking technology and not the microwave oven. Question 40, concerned with the selection of a metal outer case material, has a number of responses which elaborate on the statement in the manual that "metal reflects microwaves", incorrectly, to suggest that this is the function of the outer case. This is similar to a number of the responses to Question 41, the cavity floor material, where metal is incorrectly identified, for the same reason.

5.3.10 There is a General Tendency to Describe Colour by Comparison with other Products or Aspects of the Environment

It is rare for either the user or the designer to speak about the 'function' of a colour in abstracted terms.

A number of non-support and support questions are consistent with this: Question 2, in which the symbolic association of the colour red is not stated by the designers; Question 10, in which there is no use of descriptive language to describe the predominantly stylistic orange band around the timer switch; Question 17, where there are similar limitations in connection with the colour of the control panel itself; Question 22, in which limited vocabulary is employed to describe the outer case colour; Support Question 13, in which verbal descriptions of product style are, in most cases, related to functional values - colour being rarely mentioned. Similarly, the responses to Question 18, concerning compatibility with the product environment, have only two comments on case colour.

5.3.11 The Adjectives Associated with the Use of the Colour White are Consistent with Oakley's[1] View that Kitchen Equipment is Associated with the Symbolic 'Production' of Cleanliness

Non-support Question 22, in which a user describes the colour as clean and five others link it to kitchen colour schemes.

Support Question 13, in which the product is described as cold, usable. Question 32, in which two designers use the word "clean" to describe the cavity colour.

5.3.12 Both the Creda Designers' and the Users' Understanding of the Microwave Seals was Confused and Could Lead to Product Misuse with Associated Safety Hazards

Four non-support question responses are consistent with this view: Question 15, concerning the incorrectly identified function of the door mesh; Question 16, concerning the misinterpreted door band, believed to be a seal by a number of users; Question 28, where the primary door seal is incorrectly identified; and Question 30, where the secondary door seal is normally assumed to be the primary seal.

5.3.13 There is a Lack of Design Knowledge about the Differing Sizes of the Power and Timer Switches

It is a point of criticism that the characteristic which is the subject of Question 4, and is clearly the responsibility of the industrial designer, should have no identifiable function. This is an indication that not all the characteristics obey an ordered, logical design plan. Where a product is a hybrid, evolving in one company and continuing to evolve in another, vestigial characteristics may remain which are inappropriate to the new market or whose function is long forgotten. As the commercial trend is still towards the complex interaction between companies to produce rationalised products, this type of fragmented development is likely to be common (see Section 5.3.1).

5.3.14 Characteristics which are Defined as Stylistic by the Design Group Tend to be Interpreted as Operational by the Users

It is probable that this occurs because there is a user attitude which regards applied decoration as illogical. It is therefore necessary to invent a more functional (usually ergonomic) benefit. The following characteristics are consistent with the above statement:

Question 3 - the rectangular warning light
Question 10 - the orange circle around the timer
Question 16 - the dark band around the door panel
Question 18 - the thin line around the control panel
Question 22 - the colour of the outer case.

5.3.15 Manufacturing Roles are Least Readily Identified by Users

See Sections 5.3.1 and 5.3.2. This final conclusion is particularly significant for the design activity, since it can represent a potential goal of the designer: to manipulate manufacturing advantages so that they appear to be of more direct benefit to the user.

NOTES

1 Oakley, A: The Sociology of Housework, Martin Robertson, 1974.

The Table of Classified Designer/User Questionnaire Results

The table overleaf (ref T7) shows the numerical classification of the user responses to the non-support questions. These are listed under their appropriate M, O, S, T category in the first four columns. In a number of cases the sum of the user responses exceeds the total number of interviewees. This occurs because the users were allowed to make multiple responses to individual questions. A yellow square indicates a design response, so that a number on a yellow square indicates a matched user response. A number on a white square indicates an unmatched user response. An unnumbered yellow square represents an unmatched design response.

Where a user has failed to provide a response, this is shown in the fifth column, the value indicating the number of users failing to provide a response to the particular question.

The sixth and seventh columns show the total number of matched responses and unmatched responses respectively. A nil response is assumed to be an unmatched response. The final column is the value of the matched responses divided by the unmatched responses, or the Ma/Un value. These values are then placed in order, from zero to infinity, and shown on the following table (ref T8), the Product Characteristic Spectrum.

TABLE T7

TABLE OF CLASSIFIED DESIGNER/USER QUESTIONNAIRE RESULTS

CLASSIFICATION TOTALS

		MANUFACTURING	OPERATIONAL	STYLISTIC	TECHNOLOGICAL	NIL RESPONSE	MATCHED	UNMATCHED	MATCHED ÷ UNMATCHED
1	Function of red light		9			1	9	1	9.00
2	The colour red		9	3			12	0	Inf.
3	Rectangular shape		6	3	1		3	7	0.43
4	Sizes of switches		8		1	1	8	2	4.00
5	Metallic finish	1	1	6	2		2	8	0.25
6	Power Scale, part circle		3		7		7	3	2.33
7	Orange/yellow circle		10				10	0	Inf.
8	Timer above power switch	3	5		3		5	6	0.83
9	Timer scale, larger at zero		8		3		11	0	Inf.
10	Timer, orange circle		4	4	2		4	6	0.67
11	Timer limit of 30 minutes		10				10	0	Inf.
12	Door release position	2	4	1	6		13	0	Inf.
13	Shape of door release	1	10				10	1	10.00
14	Textured finish of door release		8	2			10	0	Inf.
15	Function of the door mesh		8		3		8	3	2.67
16	Dark band on door		4	2	5		2	9	0.22

		MANUFACTURING	OPERATIONAL	STYLISTIC	TECHNOLOGICAL	NIL RESPONSE	MATCHED	UNMATCHED	MATCHED ÷ UNMATCHED
17	Colour of control panel	1	4	7			8	4	2.00
18	Control panel graphic line		5	6			6	5	1.20
19	Position of controls	2	8	2	1		5	8	0.62
20	Gap between panel and door		3		9		9	3	3.00
21									
22	Off-white case colour		1	10			10	1	10.00
23	Textured case finish	1	2	2	6		5	6	0.83
24	Rounded corners on case	2	8		1		3	8	0.37
25									
26	Exposed door hinges	5	4	1	3		5	8	0.62
27	Metal door trim		5	5	5		5	10	0.50
28	Internal grey strip	1	8	1			9	1	9.00
29	Colour grey of strip	2	3	1	5	1	8	4	2.00
30	Black door trim		9		2		9	2	4.50
31	Three door catches		10				10	0	Inf.
32	Cavity colour white	1	7	3	3		11	3	3.67
33	Size of cavity	2	6		3		9	2	4.50

		MANUFACTURING	OPERATIONAL	STYLISTIC	TECHNOLOGICAL	NIL RESPONSES	MATCHED	UNMATCHED	MATCHED ÷ UNMATCHED
34	Cavity ventilation panel				10		10	0	Inf.
35	Rectangular cavity corners	3	1	1	5	1	10	1	10.00
36	Lack of shelving	1	2		7		7	3	2.33
37									
38	Power knob material	3	2		4	2	7	4	1.75
39	Door panel materials	1	3	1	7		7	5	1.40
40	Outer case material		2	1	6	1	0	10	0.00
41	Cavity floor material	1	4		7		11	1	11.00
42	Cavity wall material				10		10	0	Inf.
43	Cavity roof material		2		8	1	8	3	2.67
44									
45	Weight of oven		2		7	1	7	3	2.33
46	Operating noise		1		9	1	9	2	4.50
47	Cavity wall thickness		10		2		2	10	0.20
USER RESPONSE TOTALS		33	219	62	153	10			
DESIGN RESPONSE TOTALS		16	20	17	22				

Note: Inf. means Infinity

TABLE T8

PRODUCT CHARACTERISTIC SPECTRUM

The table is an ordered listing of product characteristics based on the Matched score divided by the Unmatched score, classified in the previous table.

INCREASING DESIGNER/USER RESPONSE MATCH

Ma divided by Un value		Characteristic
Infinity	2	The colour red of the warning light
	7	The orange/yellow circle around power switch
	9	Timer, scale larger at zero
	11	30-minute timer limit
	12	Door release position
	14	Textured finish of release
	31	Three door catches
	34	Cavity ventilation panel
	42	Cavity wall material
11.00	41	Cavity floor material
10.00	13	Shape of the door release
	22	Off-white case colour
	35	Rectangular cavity corners
9.00	1	Function of the red light
	28	Internal grey strip
4.50	30	Black door trim
	33	Size of the cavity
	46	Operating noise
4.00	4	Sizes of the power and timer controls
3.67	32	Cavity colour white
3.00	20	Gap between panel and door
2.67	15	Function of the door mesh
	43	Cavity roof material
2.33	6	Power scale, part circle
	36	The lack of shelving
	45	The weight of the product
2.00	17	The colour of the control panel
	29	The colour of the internal grey strip
1.75	38	Power knob material
1.40	39	Door panel material

INCREASING DESIGNER/USER RESPONSE MATCH

Ma divided by Un value	Characteristic	
1.20	18	Graphic line on the control panel
0.83	8	Timer position above the power switch
	23	Textured case finish
0.67	10	Timer, orange circle
0.62	19	Position of the controls
	26	Exposed door hinges
0.50	27	Metal door trim
0.43	3	Rectangular shape of the red light
0.37	24	Rounded corners of the outer case
0.25	5	Metallic finish of the power and timer controls
0.22	16	Dark band on the door
0.20	47	Cavity wall thickness
0.00	40	Outer case material

5.4 THE DESIGN ROLE

It is apparent from the design responses in both the support and non-support sections of the questionnaire that there are dissimilar responses amongst the designers interviewed. This is not of significance in the case of the support questions, since they are concerned with the largely hypothetical responses of product users, where the designers are expected to respond by degrees of informed or uninformed guesswork. The support questions probe the largely intuitive understanding of user behaviour after the product has been designed and marketed.

Conversely, the non-support questions probe the reasons why the product has been designed in the way it has and record the functions that the design team expect the product characteristics to fulfil. As the questions were further biased to include only those characteristics which are perceivable, the question topics dealt with an area that is fundamental to the industrial design role. Although the functions of several characteristics are related to purely technological constraints (for example, the microwave screening properties of the door seals), their presence at the product/user interface means that they are as important a part of the product presentation as is a purely stylistic characteristic. Thus their significance for the user should be clearly understood by the industrial designer, if his contribution is to be effective.

The following section examines the results of the design responses in the non-support section and then discusses why these unmatched design responses have occurred.

5.4.1 Analysis of the Design Responses to Non-Support Questions

1 The purpose of the red light

D1 and D3 are in close agreement, although D3 shows a greater understanding of the additional 'comfort' value of the warning light. D2 has little understanding of the purpose of the light.

2 Why it is red rather than any other colour

All three designers have provided different, although equally plausible, answers. It is significant, however, that no single designer referred to all three functions.

3 Why the light is rectangular and not round, for example

All three responses are classified as Stylistic, although the stylistic role, in each case, is slightly different.

4 Why the power control knob is smaller than the time knob

All three designers stated initially that they were unaware of the full reason for this, although D1 and D3 went on to give differently classified responses. Thus a significant perceivable characteristic has a function which is largely unknown to the design team.

5 Why the control knobs have a metallic finish

D2 was unable to respond to this. D1 and D3 both state that the control switches were "off the shelf", although only D3 states that they have an operational advantage. Note that the term "off the shelf", in this context, refers to components which are not manufactured or designed within the company and are intended for a wide range of product applications and not just the specific product under examination.

6 Why the power scale only extends around part of the circle

D2 is unable to provide a definite response, whilst the response of D3 is very limited in content. Only D1 is able to provide an explicit and convincing response.

7 Why it has a part-yellow, part-orange circle around it

All three designers gave a consistent Operational response. This degree of agreement may be partially explained by the fact that the colour of the circle is a purely graphic device and hence represents an isolated and fundamental aspect of the industrial design activity. Note that the question refers specifically to the yellow/ orange significance and not the circle itself, which is covered by Question 10 for the time control.

8 The position of the time switch above the power switch

Both D1 and D2 were unable to provide satisfactory answers to this question and it is perhaps remarkable that D2 suggests that the positioning is "not critical", since it is probable that there is an ergonomic advantage in one orientation of the switches compared with the other. D3 is the only designer to give a plausible response under the Operational classification.

9 The minute scale increases as it approaches zero

Again D2 was unable to provide a satisfactory response. Both D1 and D3 stated the same Operational function, whilst D3 gave a further Technological response.

10 Why it has an orange circle around it

All three designers provided a response in the Stylistic classification, although the actual details varied, in common with other purely Stylistic responses. D3 admitted that his knowledge was limited, because this was a purely Creda decision and had nothing to do with decision-making at Litton.

11 30 minutes chosen as the limit of the timer

Again D2 was unable to provide a satisfactory response to the question, whilst D1 and D3 responded under different classifications. D1 stated that the decision was a compromise, presumably on the grounds of costs and availability, whilst D3 gave a response with a plausible Operational classification.

12 Oven door release mounted on the control panel and not on the door

The responses to this question are scattered amongst all four classifications, with almost total mismatch between each of the designers. This pattern highlights the limitations of the design team's approach to the ergonomic logic of the control layout (of which the door release is one element, since it both allows the door to open and switches the power on and off).

13 The shape of the door release

D1 was unable to provide a response to this and D2 and D3 both give guessed replies. This uncertainty by the design team represents a significant gap in design control, as the door release shape is a fundamental aspect of the user/product interface and comparatively unrelated to any internal technology.

14 The textured finish on the door handle

D2 was unable to provide a response, whilst D1 appeared to guess at the answer. D3 provided a plausible, though rather limited, Stylistic response.

15 Purpose of the fine mesh on the door

All three designers gave the same Operational response, that it screened out microwaves, although D3 was the only interviewee to discuss this in depth.

16 The thick dark band around the door

All three designers provided a Stylistic response, with close agreement between D2 and D3 on the Stylistic role.

17 The colour of the control panel

D3 was unable to provide a response, since this was a "Creda" decision, whilst D1 and D2 both gave satisfactory replies. D2 went on to describe a Manufacturing role.

18 The graphic line around the control panel

All three designers are in agreement on the Stylistic role of the line. Both D1 and D2 continue to agree on this in specific detail.

19 The position of the control panel at the side of the door

There is a wide span of responses across Manufacturing, Technological and Stylistic classifications. All three designers agreed on the Technological purpose, whilst D1 and D3 add a Manufacturing and Stylistic response respectively.

20 The gap between the door and the control panel

All three designers provided conflicting responses to this question, all of which were plausible.

22 The off-white colour of the outer case

There was close agreement on the Stylistic function of this colour choice between D1 and D2. D3 was unable to comment, as this was a Creda decision.

23 The textured finish on the outer case

There is a wide variation in the responses, which indicate a firm decision by Litton and an acceptance by the Creda designers.

24 The rounded corners of the outer case

All three designers provided similar satisfactory Manufacturing responses, with D3 providing an extra Technological function.

26 The exposed door hinges

There was close agreement between all three designers on the Manufacturing role of the characteristic, which is based on cost reduction only.

27 The purpose of the metal trim around the door

All three designers are in close agreement on the function of this characteristic, giving it a single Technological function.

28 Purpose of the translucent strip along the inside face of the oven cavity

All three design responses conflict but the depth of response and involvement of D3 indicates that his response is correct and the other two incorrect.

The incorrect responses of D1 and D2 show a clear inability to recognise the microwave seals.

29 The colour of the translucent strip

There are again three differing responses to this question, which provide further evidence that there is a lack of knowledge about the microwave seals.

30 The flexible strip along the inside of the door

Two designers provide conflicting responses,with D2 unable to give any response. D3 again appears to provide the correct response, because of the depth and clarity of his reply and the knowledge that he was directly involved at an early stage in the product development.

31 The purpose of the three door catches

There is a close agreement between all three designers who gave the characteristic an Operational classification related to user safety.

32 The colour white of the oven interior

There is agreement between D1 and D2 on the reflective properties of the colour and agreement between D2 and D3 on the "clean" visual identity that is associated with the colour white.

D1 mentions the relatively low cost of white stove-enamelling, compared with the stainless steel used in other ovens.

33 The size of the oven interior

Designer D2 was unable to provide a response to this question, whilst both D1 and D3 provide similar Technological and Operational responses, D3 providing the most detailed explanation.

34 The purpose of the series of holes in the interior right-hand panel

D2 was unable to comment on this characteristic, which is significant, since a high proportion of product users was able to correctly identify its purpose. Both D1 and D3 identify it as an air vent.

35 The rounded interior corners

The responses of D1 and D3 show a common Technological response, with differing added responses, whilst D2 provides an alternative Manufacturing response.

36 The lack of interior shelving

There is close agreement between all the designers on a Technological classification. D1 and D3 provide explicit responses, whilst D2 is vague.

38 The material that the power and timer switches are made of

All three designers stated that it is a plastic and D1 and D2 state that it is ABS. D3 did not provide a satisfactory reason for the choice, although D1 and D2 provide a common Technological function.

<u>39 The material that the transparent door is constructed from</u>

Both D1 and D2 only state that glass was used, whilst D3 mentions both glass and 'Milar' film. All three gave Technological classifications for the choice.

It is significant that the two designers, D1 and D2, identified only one of the two materials used, since both materials have a direct effect on the user/product interface.

<u>40 The material from which the white outer case is constructed</u>

There is close agreement between all three designers, both on the type of material used (PVC-coated steel sheet) and the reason for the choice. All provided a Manufacturing classification for this.

<u>41 The material from which the interior base is constructed</u>

D2 was unable to identify the material, whilst both D1 and D3 stated that it was glass/ceramic, chosen for largely Technological motives, with an additional Operational response from D1 related to user cleaning.

<u>42 The choice of materials for the internal walls of the oven</u>

D2 was unable to identify the material, whilst D1 and D3 identify it but provide conflicting explanations for the choice.

43 The choice of material for the interior roof

All three designers gave conflicting responses to the question, which may be partially explained by the fact that the roof, although constructed in the same material as the cavity walls, also contains some plastic inserts and a lighting panel.

45 The weight of the oven

A common response was obtained from all three designers, with a clear single Technological classification.

46 The operational noise

All three designers give plausible explanations for the noise,of which D1 provides the most detailed. D2 and D3 provide explanations which are included in the D1 response.

47 Oven wall thickness

D1 and D3 gave detailed plausible answers, whilst D2 gave a limited single response. All three fall into the single Technological response classification.

TABLE T9

CLASSIFIED DESIGN RESPONSES

Note that M indicates a Manufacturing, O an Operational, S a Stylistic and T a Technological response.

X indicates a matched response where there is no disagreement amongst members of the design team.

Question	D1	D2	D3	Total Match
1 Function of red light	O		O	X
2 The colour red	T	OT	S	
3 The rectangular shape	S	S	S	X
4 Sizes of power/timer	M		O	
5 Metallic finish	M		MO	
6 Power scale, part circle	T	T	T	X
7 Orange/yellow circle	O	O	O	X
8 Timer above power switch			O	X
9 Timer scale, larger at zero	O		TO	
10 Timer, orange circle	S	S	S	X
11 30 minute timer limit	M		O	
12 Door release position	T	O	SM	
13 Shape of the door release		O	S	
14 Textured finish of release	O		S	
15 Function of the door mesh	O	O	O	X
16 Dark band on the door	S	S	S	X
17 Colour of control panel	S	MS		
18 Control panel, graphic line	S	S	S	X
19 Position of the controls	TM	T	TS	
20 Gap between panel and door	MS	S	T	
21				

Question	D1	D2	D3	Total Match
22 Off-white case colour	S	S		X
23 Textured case finish	M	S	OS	
24 Rounded corners on the case	M	M	MT	
25				
26 Exposed door hinge	M	M	M	X
27 Metal door trim	T	T	T	X
28 Internal grey strip	S	T	O	
29 Colour grey of strip	S	T	TM	
30 Black door trim	T		O	
31 Three door catches	O	O	O	X
32 Cavity colour white	MO	SO	S	
33 Size of cavity	TO		TO	X
34 Cavity ventilation panel	T		T	X
35 Rectangular cavity corners	MT	M	TSO	
36 Lack of shelving	T	T	T	X
37				
38 Power knob material	TM	T		
39 Door panel material	T	T	T	X
40 Outer case material	M	M	M	X
41 Cavity floor material	TO		T	
42 Cavity wall material	M		T	
43 Cavity roof material			T	X
44				
45 Weight of the product	T	T	T	X
46 Operating noise	T	T	T	X

Question	D1	D2	D3	Total Match
47 Cavity wall thickness	T	T	T	X
TOTAL NUMBER OF CLASSIFIED RESPONSES	47	33	50	22
Total number of nil responses	3	13	3	

5.4.2 The Table of Classified Design Responses

This table of results shows a list of classified responses for all three designers before the consensus results have been determined. It therefore contains a number of responses that have proved to be incorrect when compared with the information stated by a demonstrably more informed member of the team. It shows the degree of parity/disparity between the responses, both factual and mythical, of the team and also shows a lack of unanimity.

The column entitled 'Total Match' denotes all those questions to which a similar classification was obtained from all three designers, nil responses excepted. It shows a total of only 22 responses with identical classifications out of the total of 43 questions. It should be borne in mind that a classification itself does not denote a specific response but a 'type' of response. Thus even identical classifications do not necessarily denote identical responses.

There is a fundamental lack of unanimity about the function of no less than half of the product's perceivable characteristics. Error is inevitable in gathering such information from a number of possible sources, some of the reasons being: memory failure in recalling past decisions, the difficulty in recalling multipe functions for individual characteristics, the tendency to 'invent' functions for which a response cannot be recalled, and misunderstood questions. However, it is unlikely that such factors would account for the extremely low level of unanimity recorded.

To explain the disparity, it is necessary to examine briefly the roles of the three designers and to explain why there should be limits to the understanding of a product's design parameters. The implications of such limits on t i p design are then discussed.

5.4.3 The Microwave Oven Design Process - The Roles and Relative Involvement of the Designers

The design evolution of the Creda Microwave oven was complicated because it was effectively split between two different companies: Litton (USA) and T I Creda (UK). According to the interview with D3,[(1)] Litton had failed to penetrate the Japanese market because of the protected sales distribution in that country. It had subsequently decided to adopt a policy of working in partnership with a company already established in an appropriate field within future target countries. Creda was selected from amongst three other companies for the British project, with D3 operating as the co-ordinator of cooker design and development between Litton and Creda.

It is clear from the interview with D3 that the technological development of the product was carried out in the USA by Litton, well before the contact with Creda was developed. The Creda involvement is described in the following terms by D3:[(1)]

> "Creda took the basic product and their design team did a series of design drawings to show

> what they considered the product should look like for the British market. I then took the information back to the USA where Litton manufactured it and then exported it in a finished form to the UK."

Thus the design development can be divided into three stages: firstly the technological development in the United States, secondly the product engineering/design in the United States and thirdly the industrial design carried out in the United Kingdom. With such a distinct boundary between the sets of activities, geographic, chronological and administrative, it is probable that the roles of the designers within each would be different. As the first two stages involve a wider participation in the total product design, it is equally probable that the designer(s) would have a more comprehensive knowledge of the rationale behind the design work. Nevertheless, both companies agreed to co-operate in the development of the product/user interface for the UK market. A common knowledge of the rationale behind the product's perceivable characteristics between the designers of both companies should therefore be expected.

The 'Classified Design Response' table shows that this is not the result. If the total number of responses (either correct or incorrect) is considered, it is apparent that D3, with a total of 50, is able to provide a greater number of responses than either D1, with 47, or D2, with 33. As D3 is the only member of the design team linked to the Litton company, it would appear that there is still a bias of knowledge in favour of the company of origin.

The interviewee with the lowest number of responses, D2, is the only member of the design team to describe his role as that of industrial designer in the interview records:(2)

"D1 Design manager at T I Creda, Cooker Division. Responsible for administration and getting the product and components developed technically and approved.

D2 Chief Industrial Designer, T I Creda, Cooker Division. Responsible for supervision of the brief and design work carried out by a subordinate.

D3 European General Manager for Litton. Responsible for aspects of marketing, technical development and sales, as well as design decision-making. Played a key role in selecting a partner in the UK with whom he was responsible for co-ordinating design and sales."

Further examination of the designer interview data revealed that none of the design team had had any professional design training, but also showed that, in the case of D2, there was considerable experience in industrial design work.

The total number of nil responses for each designer identifies even more clearly the lack of knowledge about the perceivable product characteristics displayed by D2, with a total of 13 compared with 3 for both D1 and D3. As both D1 and D3 have been involved in the more technologically-based development of the product, it is probable that such an understanding of the internal technology of the product provides a greater understanding of externalised forms of technology, ie those which affect the perceivable attributes of the product.

It is concluded that those members of the design team who were responsible for technological development work had a greater understanding of the product's perceivable characteristics than did the designer who was responsible for the industrial design work on the product.

It would be incorrect to draw general conclusions about the nature of t i p design from this single product evaluation. However, it does illustrate a potential weakness in the abilities of a t i p design team to produce a rational design solution. To further explain this, reference is made to a simplified view of product design, as being concerned with the styling of 'boxes' of enclosed technology developed by engineers. This view is misleading, not merely because the industrial design role encompasses more than the product surface, but also because the product technology of many t i p's extends into the perceived surface of the product. The microwave oven has been shown to be an example of such a product; of the 130 design response classifications obtained, 46 were technological. Thus, over one third of the design decisions concerning perceivable attributes were made on technological grounds.

Thus the microwave oven cannot be thought of as a core technology surrounded by a styled enclosure, through which it is operated. Instead, much of the core technology is dispersed and amalgamated into the operational surface and, in many instances, aesthetically treated along with that surface. This view is not compatible with a current view that technical innovation frees the industrial designer from the limitations of traditional technology, which tended to constrain scale, shape and presentation. If one third of the design criteria for perceivable characteristics are technologically-based, then there would be quite profound constraints on stylistic aspirations.

The results of the classified design responses demonstrate that the industrial designer in the team had a limited understanding of the exposed technology of the product. It is unlikely that with incomplete knowledge about the product/user interface, a successful rationalisation could occur. It could be argued that other members of the design team would compensate for this. However, the interviews with D1 and D3 provide role definitions which do not include a general responsibility for industrial design work.

5.4.4 Causes of the Disparity Between the Three Sets of Design Responses

The research method was not primarily designed to determine the causes of lack of unanimity within the design team, since this was not originally anticipated. Rather, it was designed to document mismatches between design intentions and user needs and preferences. The design disparities have implications for the quality of the final product design and it is necessary to include some discussion of their likely causes. Whilst the interview data provided a detailed background to the organisational aspects of the microwave oven development, they do not contain sufficiently detailed information about the decision-making process at the design stage. This could only be effectively covered by a research study which documented the decisions at the time they were made. It is assumed therefore that the causes of the disparities between the design responses have been identified by this investigation, but not their relative levels of importance.

The apparent success of companies like IBM, which develop different portions of the final product in a variety of geographical locations, employing different personnel and management teams, has demonstrated that the decentralisation of the design process should not be an automatic disadvantage (in the case of IBM, it is seen by that organisation as a positive advantage). It cannot then be assumed that, because two companies, Creda and Litton, co-operated on a single project, there should be a reduction in design standards. There will be special difficulties related to the co-ordination of activities between the two companies, which must be solved satisfactorily if design errors are to be minimised. In the case of the Litton/Creda partnership, it was the first time that the parties had worked together and therefore no existing co-operative management structure could be utilised. This structure had to be established before the partnership could make joint design decisions, and is a more difficult operation than, for example, co-ordinating links between different divisions within the same company or conglomerate. It is also less straightforward than establishing links between different companies, where the relationship is less balanced than a partnership, for example where a manufacturer subcontracts work out to another. In this case, the project management structure continues to be an extension of the organisational hierarchy of the prime mover.

In the case of the Litton/Creda partnership, neither company carried ultimate responsibility for the success or failure of the resulting product, being by definition a joint venture. Thus the co-ordinating process is dependent on mutual co-operation rather than an imposed series of management directives.

The two companies, although equal in management status, are less than equal in terms of their contribution to the final product design. Litton had a long history of designing, producing and marketing microwave ovens in the United States, whilst Creda, conversely, had no experience in these areas. Instead, Creda offered a broad knowledge of the domestic cooker market in the UK, together with an ability to translate British consumer requirements into modifications of the existing Litton microwave oven. Thus, as the Creda designers stated, the design and production exercise was seen as an educative process for the company, with a view to the future manufacture of a totally Creda-designed and manufactured oven.

Although the partnership was founded on an equal basis, the design process was dominated by the Litton influence. This influence was characterised by a fully resolved technical specification for the oven and a partially resolved user/product interface, the latter being completed by the Creda team (ref Illustration I19). Thus the Creda designers were unable to design from first principles, because of lack of technical knowledge and also because of their relatively late arrival in the design process. This situation is not unlike the case of an external design consultant, in which the scope of design work undertaken is usually determined mainly by the employing company and not by the designer himself.

The effect of this isolated design role can be seen to relegate the Creda design input to an essentially minor adjustment of the stylistic characteristics of the product. The restrictions on their contributions were further compounded by the fact that Litton continued to manufacture the product and therefore continued to match many of the product's manufacturing characteristics to existing facilities.

In attempting to produce a microwave oven that was matched to the needs and preferences of the British consumer, the partnership can be regarded as disadvantageous for the resolution of product identity. The Creda team possessed the greater knowledge of what this identity should be relative to the British market, but were effectively denied the capacity to apply this at an early enough stage in the design process. Litton, on the other hand,

ILLUSTRATION I19

THE LITTON 7425 MICROWAVE OVEN

The original microwave oven that was produced and marketed in the United States by Litton, and on which the Creda microwave oven design was based.

were duty-bound to present an almost complete basic product to Creda, even though they were aware of their limited knowledge of the British market requirements. The perceived benefits for Litton of an almost completely resolved design lay in the ease with which it could be produced within their existing plant.

Product innovation often demands that manufacturers enter into working relationships with one another which may not fall into the traditional commercial pattern of total amalgamation. The current vogue for the joint production of a number of technologically demanding products (eg audio/video disc systems, cars, etc),in order to increase competitiveness and to establish a general system standard or product model in the market, illustrates this. In other areas, where technological innovation is becoming increasingly taxing on single company resources, agreements to manufacture a common product are becoming more common. It is therefore likely that the problems encountered by the Litton/Creda partnership will occur in other t i p areas.

NOTES

1 See 'Designer and User Interview Records'. (Ref D3)

2 See 'Designer and User Interview Records'. (Ref D2)

5.5 RESEARCH FINDINGS RELATED TO THE PRODUCT IDENTITY OF THE MICROWAVE OVEN

This research has been concerned with the general principles for the design of products which are currently considered to be technologically innovatory. On a practical level the limitation of time and resources has meant that the research has been restricted to a pilot and application for a single product. This places limits on the application of specific evidence from the study to the general view of t i p design. However, in the area of design concerned with the resolution of product identity, formal research is so relatively rare that some tentative extraction of general principles from this individual case is warranted. This section is devoted to a discussion of the microwave oven product identity with comment on its relationship to the identity of other t i p's. Throughout the section reference is made to the position of the microwave oven within the WORK/LEISURE SPECTRUM (1.7.2), with a view to establishing the product's relationship to general patterns of product use.

5.5.1 The Product as a Functional Tool

The role of the microwave oven, like many kitchen durables, is seen as being to ease and/or to facilitate patterns of (house)work. However, this definition, as has been shown in the section on the relationship between patterns of work/leisure and products (1.7.1), is not as simple as defining the role of the tool in professional work. The distinction between those products in the kitchen which are used to perform unpaid work and those which form part of active leisure patterns is blurred. At one extreme, it is unlikely that a washing machine is seen as anything other than a device to facilitate unpaid work - its entertainment value being strictly limited. On the other hand, a bone china tea service is directly connected with social and leisure activities in which the concept of work as an unenjoyable effort is replaced by participation in an enjoyable social ritual. Between these extremes lie the majority of kitchen durables, which display characteristics of both groups in varying proportions. The conventional cooker demonstrates this duality of identity. It is, on the one hand, a source of household drudgery and, on the other, the principal item in the cooking ritual enjoyed by many aspiring chefs. The extensive sales of cookery books, few of which are concerned with the basics of food preparation, tend to expand the activity into increasingly exotic and fashion-orientated cooking styles. It is evident that this duality is reflected in a conflicting series of design characteristics, which contribute to the traditional cooker's identity; the simple technical detailing of the exposed hob is found alongside the applied 'decorative' chromium trim, straightforward controls are augmented by the (seldom used) complexities of oven timing devices, and the simple oven is extended by the addition of the 'rotisserie', eye-level grill, etc.

The Creda design team has a history of involvement in the production of stylistically overlaid kitchen cookers, so it is to be expected that some of the design criteria applied to conventional electric cookers would find their way into the more advanced microwave oven. It is also likely that the similarity between the basic function of the traditional and microwave ovens means that the latter must also share the dual associations of functional advantage and social ritual.

The results of Support Question 3 show that both designers and users believe the principal pre-purchase intention to be a combination of speed of food preparation and the convenience of this process. Little comment is made on the subject of better quality food, increased creative involvement in the cooking process or extension of the cooking menu. It is assumed therefore that, prior to purchase, the oven is closely identified with the activity of unpaid work. The results of Support Question 4 confirm this view, in that both designers and users identify the large internal cooker capacity and the variability of the power control as being the major pre-purchase attractions of the oven. This preference for such utilitarian characteristics, as distinct from aesthetic or socially directed characteristics, places the pre-purchase identity of the product in the unpaid work sector and not the active leisure sector.

In terms of the product's identity after a period of use, the Support Question 13, although primarily concerned with stylistic detail, shows a continuing identification of the product with utility, as a number of users (unlike the designers) associate the product with visual simplicity. This is emphasised in the responses to Support Question 14, in which the Creda is compared with two competing models. The majority of users express an unsolicited preference for the visual simplicity of the Creda oven. This is consistent with the differences between active leisure and unpaid work products in the table of 'Product Attributes and Characteristics Related to Patterns of Use' (Table T2). In the comparison of control interface design, the product controls designed for unpaid work are seen to be less complex than the controls of the professional equivalents.

When asked about the general level of product success, compared with pre-purchase expectations,[1] there is again no evidence that the basic expectation of a utilitarian product for unpaid work was changed to encompass active leisure patterns. The concern is still with the convenience of preparation for traditional dishes and not with innovation or quality improvements.

5.5.2 The Product Perceived as a Safety Hazard

The safety threat that the microwave oven presents to its users is a complex issue. There is no doubt that recent publicity has informed most of the public about the dangers, mythical or real. However, those interviewed must, in some way, have rationalised the threat with no direct recourse to a valid testing method.

It is not within the scope of this research to determine how safe or otherwise the product is, but rather to identify and document the effects of safety constraints on the identity of the product. In the case of both groups, there is a difference in attitude between an open rationale for designing/purchasing a potentially dangerous device and a suppressed suspicion of it.

Evidence of this duality can be found in a number of support question responses. Question 27 illustrates the uniform patterns obtained from both users and designers when probed directly on the subject of how safe the microwave oven is. All three designers and the majority of product users agree that it is safe. This is in contrast to the results of more subtle questioning, in Support Question 26, which forces the interviewee into a critical response of safety characteristics. It demonstrates that the majority of users believe the least safe aspect of the product is the microwave seal, as does the D1 Creda designer. Also the majority of other responses have a direct link with accidental exposure to microwaves. Support Question 28, which provides a choice option between a number of possible technical facilities, shows a clear preference for a microwave leakage detector over all the other aids to operation. Support Question 24, which is concerned with those characteristics that the interviewees believe will show wear and tear first, shows that the majority of users quote details related to the door - locks, panels, hinges and seals - considered the front line in microwave protection.

A number of the non-support questions also reveal a concern with suspected safety problems. Question 12, which asked why the door release was not mounted on the door itself, shows a number of users who link this to reduced damage to the door. Question 16 illustrates how a purely stylistic characteristic, the dark band around the door panel, can be identified by the majority of users as a microwave screen, in the absence of a more plausible explanation.

The results of Question 47, which are concerned with the perceived function of the oven wall thickness, show again that the user group will readily associate the function of certain characteristics with microwave protection if the correct function is not readily comprehensible.

Although these separate points are inconclusive, they demonstrate the users' preoccupation with oven safety and hence point the way towards increased design effort, primarily to render the operation of the oven safe, but also to broaden the perception of safety by the manipulation of the product's identity. The series of factors outlined indicate those characteristics which display either ambiguous functional meanings, where incorrect assumptions are made, or characteristics whose associations allow scope for imaginary hazards. It is clear from the design responses that the perceptions of users are unmatched and therefore existing design knowledge is not sufficient to identify them at the development stage.

Although the microwave oven is probably unique in presenting such powerful associations with safety factors as part of its product identity, the general inability to separate myth from reality, where a strong association is involved, is probably common to all products. The t i p is particularly vulnerable, since the most demonstrable form of testing, ie testing through use over a long post-sales period, is, by definition, non-existent. This research has identified a number of characteristics identified with a powerful association by systematically probing the meaning of the perceivable product characteristics. It would be possible to carry out a modified version of this research method, using early prototype models to identify negative associations and correct them prior to the marketing stage.

5.5.3 Product Identity Conditioned by Incorrectly Interpreted Perceivable Characteristics

It would be incorrect to assume that all perceivable characteristics should be designed to indicate their precise function; this would be almost impossible to achieve but, more importantly, it is frequently advantageous to both manufacturers and users that some meanings are obscured or deliberately falsified. This is demonstrated by the relationship between the four characteristic classifications: manufacturing, operational, stylistic and technological. It is important that an operational characteristic has an unmistakable and unambiguous meaning. It is debatable whether the same principle applies to manufacturing characteristics, where a correctly interpreted function may mean that the user associates the characteristic with cheapness, cost-cutting or just mere shoddiness. Similarly, a purely stylistic characteristic in a broadly utilitarian product may be unwelcomed by the user, if it is recognised as such. If however it is seen as an aesthetically pleasing appendage to another, more 'useful' attribute, then it may well be approved of.

A more contentious issue is the meaning ascribed to technological characteristics, where there are two basic approaches: firstly, where the meaning is unclear and, secondly, where it is explicit. Again it would be wrong to promote either as the correct solution, since they both have advantages and disadvantages according to the particular characteristic concerned. An unclear or disguised meaning may possess more aesthetic attraction and it may simplify control of the product. On the other hand, it may well restrict or prevent an understanding of the product technology, which may or may not place limits on the use of, or extension of, the product (for example, an automatic automotive gearbox). Conversely, an explicit technological characteristic may complicate product control but extend the underlying principles involved in product use (for example, a manual automotive gearbox).

With the complexity of these issues in mind, there follows a brief examination of the research results, which demonstrate the effects on product identity of incorrectly interpreted perceivable characteristics. These characteristics have been selected by referring to the Product Characteristic Spectrum (page 296) and examining those which lie at the unmatched end of the spectrum with an Ma/Un value which is less than 3.00 (a value chosen because it stands at the halfway point in the spectrum).

The significant group of characteristics in the bottom half of the spectrum are those which are identified incorrectly by users as contributing to the prevention of microwave leakage. Of these, Questions 47 (concerned with the thickness of the cavity wall) and 16 (the dark band on the door panel) are the most obvious examples. As discussed earlier, in Section 5.5.2 (page 324), there is a strong association of the product with the potential danger of leakage and, in the case of these two characteristics, a meaning which diminishes this is imposed. Thus where the true meaning of a characteristic is obscure, a degree of wish-fulfilment operates in determining its perceived meaning.

Another group of important characteristics are those where an operational advantage is assumed incorrectly to be their purpose - Questions 24 (the rounded corners on the external case), 3 (the rectangular shape of the red light), 19 (the relative position of the controls), 10 (the orange circle around the timer), 18 (the graphic line on the control panel) and 6 (the part circle of the power scale). It would be wrong to assume that the user, in describing an extra operational capability, is promoting an unintended form of misuse of the product. The classifications listed demonstrate another form of the users' ability to substitute an advantageous function for those characteristics for which the purpose is unclear.

Reference to the table of 'Product Attributes and Characteristics Related to Patterns of Use' (Table T2). offers some explanation of the reason why characteristics should have an ambiguous function. In the table, products which are identified with 'Unpaid Work' often display a 'Style which is often related to attempts to disguise the frequent functional similarity with professional equivalents'. Thus the product designed for unpaid work, whilst possessing the functional identity of an efficient tool, must paradoxically avoid a close identification with professional equipment. Thus an exaggerated stylistic content may disguise the functional meaning of some of the characteristics.

The implications of this for the design of t i p's involve a critical appraisal of design characteristics to determine the value of an explicit meaning - what advantages and disadvantages might result. The mode of communicating the pre-determined meaning must then be matched to the position of the product in the Passive/Active Leisure - Unpaid/Professional Work spectrum. Thus the microwave oven which, at the beginning of consumer adoption has been identified with patterns of unpaid work, would possess, where necessary, explicit functional meanings (eg a readily comprehended sealing system), yet also possess carefully styled perceivable characteristics which sever the links with professional work.

5.5.4 Product Identity Related to Perceptions of Durability

Support Question 24 is a key exploratory tool for determining weak elements in the product's identity. In asking the interviewees to speculate on those characteristics which are likely to exhibit signs of wear and tear first, the intention is not to identify physically weak points. Instead the purpose is to glean information about the perceived weak points of the product.

The evidence was considerable that the door, its fittings and controls were associated with quality inadequacies. The design perceptions closely matched the users', so that design decisions to improve the product by upgrading these characteristics could easily have been made. However, as an approach to general t i p design, the questionnaire method could be applied during the design stage, in order to minimise weak perceivable characteristics.

For this to be done, the position of the particular product in the Leisure/Work Spectrum must be reliably identified or predicted. This is critical for those products which, like microwave ovens, are used in both unpaid and professional work activities (although not usually in the same form). As the table demonstrates, physical durability is less critical in non-professional work than in professional. However, cost reduction in the former group may well result in reductions in both real and apparent durability. In the microwave oven, this itself becomes critical because of the associations with safety hazard.

More typically, the majority of t i p's do not pose this problem. However, accurate information about how durable characteristics need to be is not easily obtained by most users. Thus association plays a large part in determining levels of durability. For example, the microwave oven construction will be compared to its closest perceived relative, the conventional gas or electric cooker. Even though the control requirements of each are quite different, there will be expectations of the t i p which demand parity with the traditional product - in this case a more apparently durable door construction.

A significant part of t i p design should be the identification of closely related traditional product associations, where they exist. Where a close relationship can be shown to exist, the expectations of the prospective t i p user, based on the traditional product but appertaining to the t i p, can be evaluated - and, where desirable, incorporated into the t i p.

In the interview with D3,(2) the Litton designer, there is evidence that this strategy is already being adopted by the company:

> "Overall company policy regarding the product:
> In the future the company is concentrating its

efforts on getting the microwave oven to emulate many of the properties of traditional cookers, whilst retaining the speed and convenience."

5.5.5 Product Identity Related to Technological Complexity

In discussing the relationship between the technological complexity of the t i p and its effects on product identity, a distinction has to be made between internalised and externalised functional complexity. As the former is predominantly the responsibility of the engineer, this passage concentrates on the design aspects of the latter.

The research results demonstrate that the product is perceived as being relatively simple in form. Support Question 13 contains a number of references to visual simplicity and Question 14 contains a number of references to the simplicity of the Creda compared with competing models. An examination of the product tends to confirm that, by current standards of control technology, the product with two control knobs and a door release is relatively uncomplicated.

In contrast, the thesis introduction has discussed at length the prevalence of over-elaborate product control systems associated with the stylistic use of novel control and display technologies. Whilst a number of microwave ovens exhibit highly complex configurations, the Creda remains a rather traditional form. (Although there are one or two competing models which are even simpler, with no power variation, these do not constitute an important volume of the market.)

As only one product has been studied, it is not possible to compare the performance in use of complex and simple product variation. However, some conclusions can be drawn on designer and user attitudes to externalised technology. To begin with, there are differences in attitude. Support Question 12, in which designers were questioned on product modifications to ease the learning process, shows a preoccupation with additional product technology (meat probe, digital timer, touch controls, improved browning). In contrast, the users concentrated on non-technological improvements (improved instructions, visible cooking guides). It is likely that this results from a combination of limited understanding of technological possibilities and an inherent preference for an uncluttered product. The difference in attitude between the two groups points to a potential design conflict in pacing the introduction of new, externalised technologies in one particular t i p. The advantages of relating the product to traditional products may be difficult to reconcile with the current developments in externalised technology - whether it be new control systems or new surface treatments. It is unlikely that there is a simple solution to this problem, but the example of the Creda microwave oven suggests that the level of acceptance of a major technological innovation (microwave cooking) may not be accompanied by a similar acceptance of other, applied surface technologies. In fact the reverse preference for more traditional control identities may occur.

The results of Support Question 28, in which users and designers were asked to choose from a group of technical product additions, is revealing on this point. The Table of Preference Order (page 261) shows that designer and users are in close agreement on the forms of desired and undesired technology. Technologies which have nothing directly to do with product automation take priority (leakage indicator, liquid stirrer, thermometer), whilst technologies which detect, over-ride and otherwise simplify control (spillage detector, non-operation when empty, turn-table, non-operation with metal objects, automated power cycle) are low on the list. It can only be assumed that there is some resistance to a kitchen appliance which removes too much physical involvement. This is consistent with the discussion of meaninglessness (Section 1.4), in which the views of Blauner on alienation are quoted. There is a preference for those technologies which expand the control options of the product and a questioning of those technologies which reduce user involvement with the product.

5.5.6 Product Identity at the Pre-purchase Stage

The questionnaire was put to microwave oven users after a minimum of one year's ownership and therefore, although questions were put which concerned attitudes at the pre-purchase stage, it must be borne in mind that some error and vagueness must result from the fact that all the responses are recalled.

The findings of Support Questions 3 and 4, on the pre-purchase identity of the oven, demonstrate a narrow, fairly stereotyped expectation of the product on the part of the user group. Put simply, it represents a device for speeding up the cooking process and making it more efficient and its principal attractions are the variable power control and the perceived large internal volume.

Although these are matched by similar design responses, there are a number of design responses which are not matched - nutritional value of cooked food; user safety advantages, especially for children; improved food taste and energy saving. This suggests that the prospective user only had a vague understanding of the innovative characteristics of the oven, consistent with the quoted description of pre-purchase awareness by Rogers in the Appendix (ref Appendix page 137).

> "The individual is exposed to the innovation but lacks complete information."

If the sources of information are studied, in the responses to Support Question 6, it is apparent that most of the users stated that verbal rather than non-verbal sources were most influential. Thus sales demonstrations and enquiries at retail outlets constituted the major sources of product information, rather than books, periodicals or sales literature. As the general product identity is unclear, it is assumed that these verbal sources have had little effect on broadening the perceived capabilities of the product. As the verbal sources represent a branch of the manufacturing/sales sector, rather than the consumer sector, it is curious that the widest possible range of product attributes is not communicated to the potential purchaser. There are, however, two possible reasons for this. Firstly that the sales outlets consulted were not sufficiently informed themselves to widen the scope of information available (although this is unlikely to be the case at sales demonstrations); secondly, there is no intention on the part of the sales force to propagate a wide spectrum of product advantages.

This latter explanation may well be typical of a number of t i p's in the early stages of adoption. If the four main patterns of product use are considered - passive/active leisure, unpaid/professional work - the majority of product innovations begin by exploiting a single pattern. This is because the new product has, initially, few competitors and a limited production capacity if successful. Thus a single retail segment usually provides sufficient market potential for limited outlay. Also, with many new products, the requirements for different product attributes appropriate to the different patterns of use (ref table of 'Product Attributes and Characteristics Related to Patterns of Use') mean that a great deal of separate design, production and marketing effort has to be devoted to the development of variations in the spectrum of advantages of the innovative product. As competition grows in the innovative product market, the breadth of product attributes is widened (either by adding new capabilities to the product or demonstrating new capabilities in the existing product - or both). This is demonstrated in the case of the Creda microwave oven by the change in emphasis of the advertising campaign as the market became more saturated. Initially the stress was on simple speed and efficiency, whilst after two years nutrition and taste advantages began to be deliberately emphasised.

It is argued that the response of the users reflects accurately the narrow identity of a t i p at an early stage in the life-cycle of the product and that this narrowness is as much a result of the users' lack of information on the product as a restricted projection of identity on the part of the manufacturer. As public awareness of the new product increases, the breadth and complexity of its identity increases. Consequently, where there are a number of products to choose from, the decision to purchase may become more, and not less, difficult to make.

This partially explains the responses to Support Question 8, in which the ease of pre-purchase choice was compared with the choice of other consumer durables. In contrast to the unanimous design consensus that the choice would be more difficult, the user response indicates that the choice was very similar to the selection of other consumer durables. This may be because, if the pre-purchase identity of the oven is narrow, both in terms of potential capabilities and product characteristics, then it can be easily assimilated by the potential user.

Whilst this phenomenon might be misleading for the minority of informed consumers, who are seeking information about a desired t i p, it offers definite benefits for the unwary, relatively uninformed buyer. The ranges of similar t i p groups can present a confusing spectacle to the uninitiated buyer, especially if a stylistic approach to surface technology is adopted to attract the buyer. In order to simplify matters, the designer may assume that the product should be simplified, so that only immediately essential characteristics are retained.

However, this may unnecessarily hamper the future development of wide product application, once the basic patterns of use have been learned and mastered. One solution which current developments in control interface technology are rendering feasible is to develop a two-tier user interface. The product is designed to present a simplified identity to the potential consumer/first time user, which could then be altered to present a more complex interface which provides finer control over the object and/or a wider range of capabilities, once basic control has been mastered.

This is accomplished in a variety of ways, from simple product instruction overlays to reprogrammable interface characteristics. The flexibility of the technology available would mean that the interfaces could exist simultaneously in the t i p and thus be open to examination by both the initiated and uninitiated buyer.

In the case of the microwave oven, this would effectively change the identity of the machine from an initially simple device which speeds up the existing cooking process to an identity compatible with the activities performed as both active leisure and unpaid work. The product would become increasingly informative about cooking technique and facilities, with over-ride facilities for the initially high levels of product automation.

NOTES

1 Reference - Research Interview Records - Creda Design Team - Responses to self-image question.

2 Reference - Research Interview Records with D3.

5.6 IMPROVEMENTS TO THE T I P DESIGN PROCESS

The research findings have demonstrated that it is possible for a t i p which is designed for the untrained user to exhibit design characteristics incompatible with the user's lack of familiarity with the new product. It is clear, however, that the innovatory nature of the product makes the accurate prediction of user needs, preferences and behavioural patterns difficult and that the design of any product will entail a prescriptive, as well as a predictive, element. Thus the designer may attempt to create new patterns of product use without direct reference to existing user aspirations and effectively change the pattern of future developments and design a product which will match the predicted operational parameters. In practice, the balance of these two approaches may vary considerably, according to the type of product (and the particular design methods employed).

In the case of the microwave oven, there is little evidence of a concerted attempt to predict user responses to the product as part of the design process.(1) The general design approach was characterised by a prescriptive design method. A general comparison(2) of the design methods employed for goods that are intended for trained use and those that are designed for untrained use has shown that predictive design devices tend to be more highly developed in the former than the latter. This would appear to be consistent with the design of the Creda microwave oven.

This research, although limited at this stage to a single product, has exposed a number of areas in which the lack of predictive design work has resulted in adverse product characteristics represented by design/ user response mismatch. It is the purpose of this final section of the thesis to examine methods in which the design process might be improved and to speculate on the general relevance of such improvements to t i p design as a whole. There are several ways in which this might be achieved:

5.6.1 Analysis of User Responses to Prototypes and Their Modification

Market research techniques which employ prototype models to gauge user responses have been applied to a wide range of consumer durables since their introduction in the motor industry, originally limited to tests on non-functioning models and concerned with visual and ergonomic characteristics only. Whilst an exhaustive investigation of such methods is beyond the scope of this research, interviews with a number of market research organisations[3] which specialise in these 'clinic' techniques have revealed little evidence of investigation into the perceived meaning of design characteristics. This research method has, however, demonstrated that it is possible and desirable to examine the implied meaning of perceivable characteristics, in order to minimise the misue of the product.

The simplicity of the non-support questions, which ask users about the function of various perceivable characteristics, means that the technique can be readily modified to investigate any product. Similar questions can be applied to potential users, using prototype models, although care must be taken to brief the interviewee on the general capabilities of the product, without explaining the specific connection between individual product characteristics and the more general capabilities. In this way, the designer would be able to gather information on the degree of self-explanation or otherwise of the developing product, as well as characteristics which are not consciously perceived.

In those products like the microwave oven, in which there is an important series of decisions to be made to determine what information should be product-based and what information should reside in the accompanying literature, an extended version of the method can be applied. In this case, an interview group can be exposed to the prototype with a minimum level of information about how to operate it beyond a basic statement about what the object is and what it does. (For example: "This is a microwave oven; it cooks food more quickly than other methods and has a variable power and timing control.") The form of the investigation depends on the degree of simulation achieved in the prototype. If it is a non-functioning model, the interviewees can be asked to describe how they would operate the product. Alternatively, their behaviour can be recorded after they have been encouraged to 'operate' a non-working prototype, provided some attempt has been made to simulate the projected functional characteristics of the product.[4] For example, the model microwave oven could simulate the sound, lighting and motion of the cooking process.

This method of model testing can also be employed to analyse the perceived identity of the product, in exactly the same way as the research questionnaire technique. An interview group is exposed to the prototype and given limited information about its function. The interviewee is then asked direct questions about why the product's external appearance was designed in the particular form presented. The responses can then be analysed using the M O S T classification system and cross-checked with the design M O S T responses. Significant mismatches are then identified and, where necessary, the perceivable product characteristics can be modified accordingly.

Under ideal circumstances a fully functioning prototype should be used for the testing, although it is recognized that the complexity and forward planning required for technical innovation may make this impossible. However, the research method could be employed whenever an existing t i p requires re-evaluation for a proposed new model.

5.6.2 Analysis of Design Responses to Prototypes

The research has demonstrated that there are differing responses to questions concerning product identity amongst members of a design team. In some cases this can be attributed to a lack of communication between members of the team involved in isolated aspects of the product's design. Where this occurs, there is a possibility that design work has been unco-ordinated and therefore results in unco-ordinated product characteristics. It is desirable to cross-link all design decision-making, in order to avoid a confused product identity, and the research questionnaire may be used as a means of achieving this.

For this method, the design team would be supplied with a completed set of design development details and/or a completed prototype. Each member would then be required to complete a Perceivable Characteristic questionnaire, in which the purpose of each characteristic is stated. The results of the questionnaire can then be discussed formally amongst the group and any serious mismatches identified. A unified appraisal of each characteristic can then be achieved, after design specialists within the group have shared their explanations. In this way, the possible detrimental effects of unco-ordinated decision-making can be monitored and, as with the user questionnaire, appropriate modifications to the perceivable characteristics made where required.

5.6.3 Value of Retrospective Application of the Research Method

If the combined user/design questionnaire method is used as a complete technique, it can be of value to design teams involved in continuous product or model innovation. Thus all new t i p's can be examined at the post-marketing stage and the degree of design/user mismatch assessed. The resulting information may then be used as a basis for modifications to new models of the basic product. In the long term, the data can be used to monitor the effectiveness of the design teams and to adjust their composition and organisation accordingly.

It is anticipated that further applications of the research method in the academic field will gradually yield information from which the parameters for successfully designed product identity can be identified. This knowledge can then be applied in the previously described manufacturing contexts (i to iii) as a comparison model.

NOTES

1 Reference - Research Interview Records, with E C Westermark, Marketing Manager, T I Creda. (Ref RM1)

2 Reference - Research Interview Records, with S Moody, Department of Three-Dimensional Design, Birmingham Polytechnic. (Ref RM9)

3 Reference - Research Interview Records; Richard Dossett of Marplan, A E Davies and G W Flude of Marketing and Retail Analysis Ltd, N Spackman of Research Surveys of Great Britain Ltd. (Ref RM8, RM10 and RM11)

4 As in the case of the prototype Hewlett-Packard pocket calculator. Reference - Research Interview Records, Hewlett-Packard. (Ref RM13)