paper reprinted from

sheet steel in building

proceedings of a meeting organized by
The Iron and Steel Institute and The Royal
Institute of British Architects, 22–23 March 1972

THE IRON AND STEEL INSTITUTE
1 CARLTON HOUSE TERRACE
LONDON SW1Y 5DB

The applications gap in new product development of sheet-steel building components and systems

G. M. E. Cooke

The author is Research and Development Engineer with Pell, Frischmann and Partners, Consulting Engineers

669.14–415:
691.7

The paper describes some of the important considerations in new product development, and briefly reviews technical and other features of two large industrialized building projects utilizing sheet steel. It seeks to identify those factors which can, and often do, prevent the project from reaching the stage of full-scale production, and equally those factors essential for success.

Many products are successfully developed to the proven prototype stage, but few are commercially exploited. It is the failure to continue through to large-scale development and marketing which is becoming known as the 'applications gap'. For the purpose of this paper, the definition of 'applications gap' is broadened to cover any event or circumstance which prevents the project concept from reaching the stage of full-scale production and erection. Clearly, this can occur at any stage owing to inadequacies in initial market research, performance-specification writing, technical research and development, architectural and engineering design, physical testing, marketing and construction, etc.

It is, however, at the point where management has to decide whether or not to venture beyond the proven prototype stage into pilot-scale or full-scale production that a project is perhaps most likely to founder. This is understandable for, to state a commonplace, the purpose of being in business is to make a profit (a DCF return on capital invested of not less than 12%–15% being a rough criterion for industry), and it is not until a proven prototype exists that all the technico-economic data is available to enable a decision to be made. It may be that the acceptability of the product on the market can be tested by having it produced under contract in another manufacturer's works, in which case unit costs may be high, but no risk capital is involved, or, to take the other extreme, that large investment is required for a new factory on a greenfield site. In between, and a more likely choice, is the possibility of utilizing existing factory space and purchasing a minimum of capital plant. The choice will mainly depend first on the degree of accuracy with which production costs can be predicted, second, on the initial and potential size of the market, and third, on the availability of finance. The first two factors are related since production costs will vary with level of production which, in turn, is dictated by market requirements.

Reference is made to two sheet-steel building projects with which the author has been associated in various roles – as inventor and as supervisor of research and development. First is the IBIS industrialized housing system, initially designed for low-rise, medium-density, local authority housing schemes in this country, but now licensed for use abroad. The second is the IBIS internal-partition system designed to meet a detailed performance specification first compiled by the Department of Education and Science. This partition system is currently being used extensively in the South Eastern Architects' Collaboration (SEAC) schools program. Both projects are now within the Constructional Engineering Division of BSC. (It must be recorded that, following the presentation of this paper, and for reasons unconnected with it, the production of IBIS projects has now been terminated, and the whole range of IBIS components has now ceased.)

THE IBIS HOUSING SYSTEM

It is not the intention to describe in detail the design and development of the system, as this has been done elsewhere.[1,2] It suffices to say that IBIS is a modular building system based on the use of fabricated steel sheet for the main structural members, and external cladding and certain internal fitments, together with more conventional but lightweight materials where these are appropriate to provide the necessary sound insulation, fire resistance, and other performance requirements. The IBIS system is suitable for a range of building types although, as already mentioned, development has been confined to low-rise housing to local authority requirements. The development was initiated by the then Richard Thomas and Baldwins Ltd, with Alex Gordon and Partners as architectural consultants. In 1967 two prototype houses designed to MOHLG Welsh Office requirements were erected near Newport, to prove target erection times and other technical objectives, and also to enable the attitude of architects and local authority housing-committee personnel to be assessed. The prototypes are shown in Fig. 1.

Factors affecting the development process

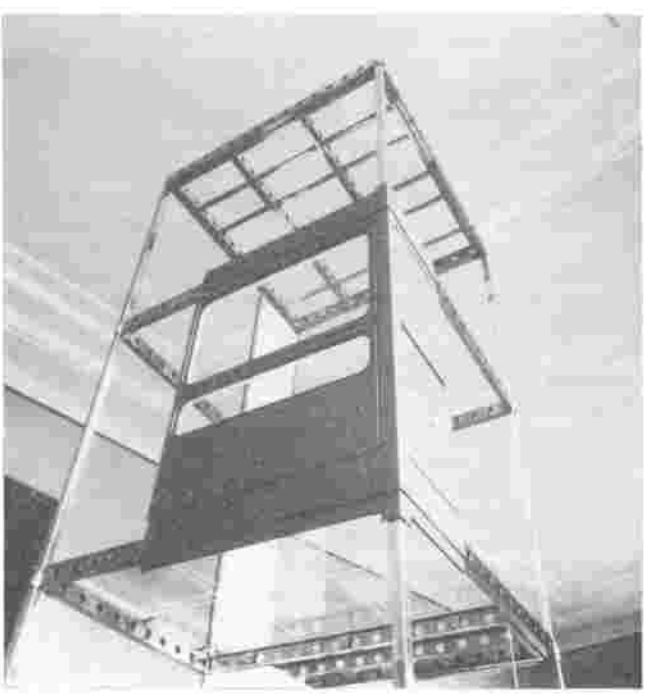
It is relevant to identify the factors which have resulted in a design and production approach radically different from the original objectives.

The original objective was the design of a vocabulary of modular-building elements for the flowline production of a minimum range of elements using matched-tool pressing techniques, thus making for economy through flowline production in quantity. The model shown in Fig. 2 illustrates the conceptual and aesthetic possibilities of this approach. In practice it was found that this approach had certain disadvantages which included higher costs, limited planning flexibility, and importantly, problems of stockpiling. Consequently, the original approach gave way to the

1 Two cluster-type IBIS prototype houses built to MOHLG Welsh Office requirements

'kit of parts' concept in which the elements (varying to meet different requirements and sizes) are assembled in the factory from a range of standardized parts produced using roll forming instead of pressing. In this way, the manufacture of larger elements was possible without cost penalty or limiting planning flexibility.

Again, where material costs represent a high proportion of the as-installed costs, it is essential to reduce wastage of sheet materials to a minimum. As a result, the dimensional basis of the system has been changed a number of times due mainly to uncertainties in the metrication program. The original design was based on an imperial tartan grid of 2 ft 8in and 3 ft with a 4in module. This grid enabled Parker Morris standards to be met within a ±5% margin of total floor areas. Then, following the announcement of metrication in the UK, a metric tartan grid of 90 cm and 100 cm with a 10 cm module was devised. Although at this time (1965), NBA and MOHLG favoured the 30 cm centre-line grid, this was discarded because the tartan grid was essential to limit the variety of components and accessories then dictated by pressing techniques. The subsequent change to roll-forming production allowed greater dimensional flexibility and ability to meet floor area requirements more precisely than the ±5% tolerance. Tramlines were, therefore, superimposed on the main tartan grid to provide an additional grid pattern of 15/25 cm, and it was this basis on which the prototype houses in Fig. 1 were designed, manufactured, and built. Basically, this provides 3 ft external planning flexibility and 1 ft internal planning flexibility. Finally, and following the publication of the BSI's recommended horizontal dimensions which indicated that 1m sheet width would be adopted, it was decided to abandon the tartan grid concept in order to avoid wastage of sheet materials. It was, therefore, decided to follow NBA and MOHLG's 30 cm grid. Yet another reason for abandoning pressing techniques was the realization that the Government target of 500 000 houses a year by 1970 would not be met. Hence, the MOHLG estimate that 100 000 houses (95% in the public sector) would be built in 1970 by industrialized means would not materialize, and the reduced market would not support production of houses in car-like manner.



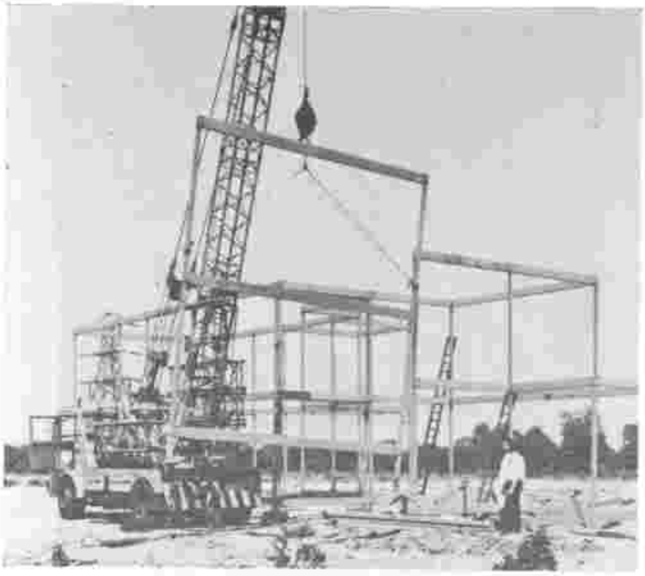
2 Model showing IBIS pressed panel form of construction

3 Adjustable column foot and precast foundation pad

Technical features of the IBIS houses

In the manufacture of IBIS houses, it is important to use the same equipment for as many applications as possible. In the prototypes, for example, one cold-rolled section was used for floors and roof decks, and another for internal partitions, party walls, and external cladding.

Since IBIS was designed for flat and sloping sites, it was important to develop a suspended ground-floor system, and a structural jig which could be lined and levelled with ease. Speed of erection was achieved by eliminating the wet



4 Erection of frame of IBIS prototype houses

6 Interior view of IBIS prototypes showing normal finishes

trades associated with traditional flooring in concrete. The development of the adjustable column foot shown in Fig. 3, together with a lightweight modular framing (Fig. 4), gave the system a great advantage over alternative housing, whether industrialized or traditional. Again, so as to reduce costs and increase speeds of erection, large external wall panels were designed for assembly from within, thus obviating the need for temporary scaffolding and working platforms. This is illustrated in Fig. 5.

A consistent objective throughout the development process was the need to provide a high degree of planning flexibility – an ingredient often missing from industrialized building systems – and a balanced, and not overbearing, use of sheet steel. The 4- and 6-person houses shown in Fig. 1 were designed to MOHLG standards, and it is considered that these precepts are met. It was equally important to ensure that appearance and comfort conditions within the houses were acceptable, and preferably above the accepted standards. Fig. 6 provides a typical view inside a kitchen.

5 Erection of large wall panel at first-floor level

DESIGN, PRODUCTION, AND MARKETING OF THE IBIS INTERNAL PARTITION

The design is based on the maxim that maximum sound insulation and fire resistance can only be obtained if two independent leaves are used. This approach also enables panels to be produced in any thickness with space between leaves to accommodate mechanical and electrical services and structural steelwork. Each leaf comprises PVC-coated steel sheet 24 BG thick, roll-formed in modular widths, and backed with ½in plasterboard adhered with PVA adhesive. The leaves are located at head and foot in channel sections. Figure 7 shows a typical installation in a SEAC school in Hertfordshire.

The production consists of two separate lines – one for steel, the other for plasterboard. It is particularly interesting that the existing factory utilized has been supplied with new plant comprising six roll-forming machines, a motorized conveyor system, an adhesive curtain coater, plasterboard cut-up line and ancillary equipment for about £50 000. This is a small outlay for a plant with a production capacity of 300 panels a day, and employing only 12 men per single shift day. The sequence of production commences with the cutting to length of the Colorcoat coil which is delivered from the steel mill in widths to order. This is shown in Fig. 8. The sheets (for panels) or strips (for cover strips and accessories) are then formed using several 6-station, 10 ft long, roll-forming machines (Fig. 9). In parallel, the plasterboard has its ends coated with shellac to prevent depletion during handling, and is then cut to width (Fig. 10) using a machine developed by the BSC Blackwall works' personnel for about £500 – a proprietary machine costs about £8 000. The plasterboard then travels on an inclined overhead conveyor system to the curtain-coater station. Here an 0·008in wet thickness of PVA is applied on the inside face of the roll-formed sheet (Fig. 11) and the plasterboard is then lowered on to the adhesive, and the panel edges crimped to retain the plasterboard. The crimp-

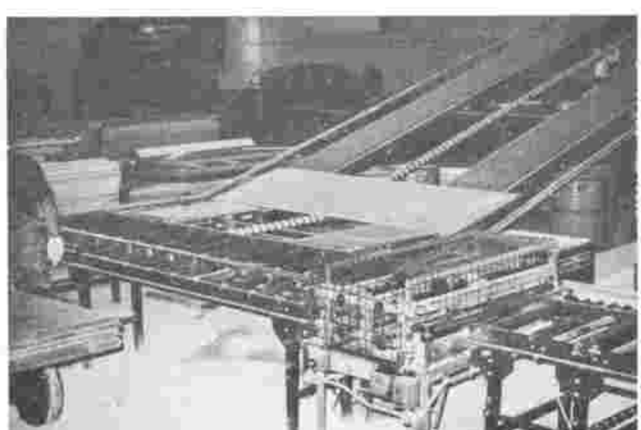
7 IBIS partitions used in SEAC school

9 A typical 6-station roll-forming machine

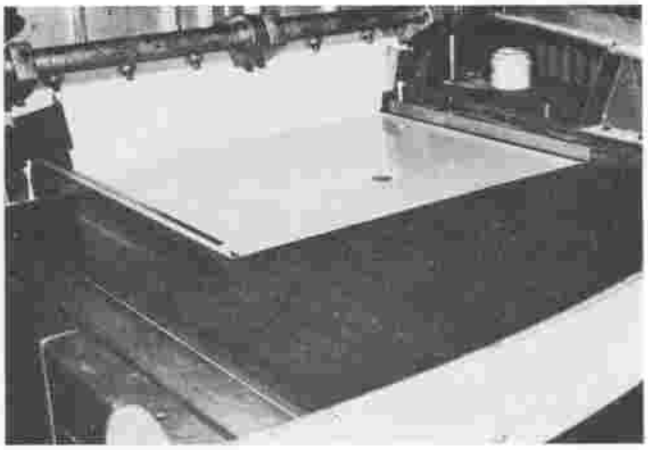
ing not only serves to support the plasterboard during the adhesive-curing stage and subsequent handling, but also contains the board in the event of fire. The completed leaves, with the PVC coating face down, are stacked on top of each other while adhesive curing takes place for 24 hours under a force of not less than 10 lb/ft^2. Protective layers of Kraft paper remain separating the leaves until they are ready for erection on site (Fig. 12). Here the bottom channel is shot-fired into the floor screed (Fig. 13), and the top track screwed to steelwork. Deviations in floor to ceiling height of $\pm\frac{1}{2}$in can be tolerated. The ease with which electrical services may be run before erection of the second leaf is illustrated in Fig. 14. With this system, any form of skirting may be used. Figure 15 shows the fixing of the IBIS skirting developed for use on the open market. This utilizes roll-formed Colorcoat with injection-moulded brackets and accessories.

Now that the partition system has been installed in some 50 schools, it can be said that it has proved itself in pilot-scale production. But this has not been achieved easily. The original objective of filling the roll-formed panels with an inexpensive plaster, sand, and water mix using a continuous dispensing machine was abandoned as a result of the cut-back in the government school building program. Even with the use of plasterboard, which permits a minimum expenditure on plant, it had been necessary to achieve economy not only in the use of materials (offcuts are rarely wasted since they can be used for cover strips and other accessories), but also in the labour force. The importance of these two points can be appreciated in the knowledge

8 Colorcoat cut-up line (note plasterboard stacking area in background)



10 Machine developed to cut plasterboard to width. The inclined conveyor for sized plasterboard is seen in the background



11 Curtain coater applying continuous film of PVA adhesive to Colorcoat

that roughly 50% of the 'as-installed' cost lies in the unfabricated Colorcoat steel. Clearly other costs must be kept to a minimum.

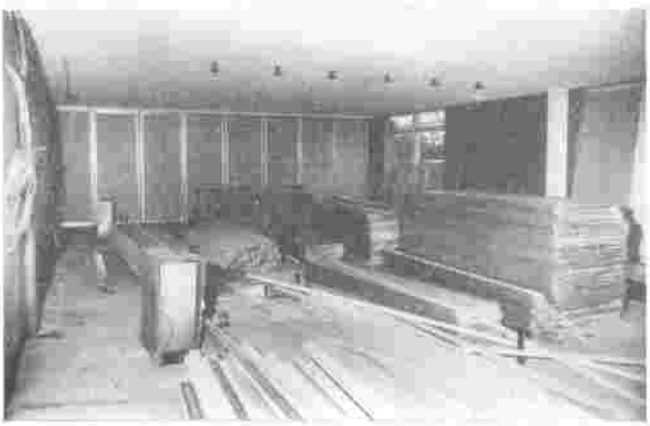
BISRA EXPERIMENTAL BUILDING

In retrospect, it could be said that one of the biggest application gaps occurred when it was decided to stop further development of the load-bearing panel system initiated at the Swansea laboratories of BISRA some 10 years ago. Figure 16 illustrates the simplicity of erection of the experimental building exhibited in the open days of 1963. While the writer was responsible for the design, fabrication, and erection of the building, Mr W. H. Jenkins, then head of laboratories, was the continuing source of inspiration and encouragement. The object was to show that sheet steel, unlike applications in curtain walling, could and should be used fully in a structural capacity, thereby negating the use of a frame. Figure 17 shows the finished building in the grounds of Sketty Hall. The concept was developed further as a result of contact with fabricators and architects etc.[3]

It is especially interesting to observe that during this ten-year period the most recent IBIS housing development has evolved towards the load-bearing panel concept.

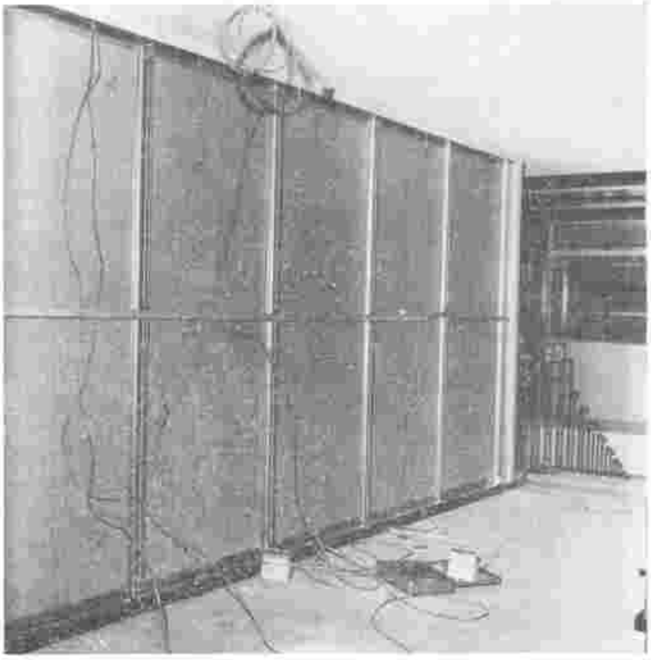
SOME WAYS TO AVOID THE APPLICATION GAP

However perfect the technical design and development of a component or system, the objective of being in profitable business will not be attained, except by chance, unless market research is conducted in considerable depth. This is essentially a two-stage process in the case of a large project involving extended time scales. The market research conducted at the outset of the feasibility study will be aimed at providing an approximate assessment of consumer reaction, the size of the market, and the extent of competition, etc. The second study must, and can only be made in far greater depth when the proven prototype stage is reached. The cost of such a second study undertaken by unbiased experts may appear to be high compared with the development budget. But even if it advises against full-scale production it will

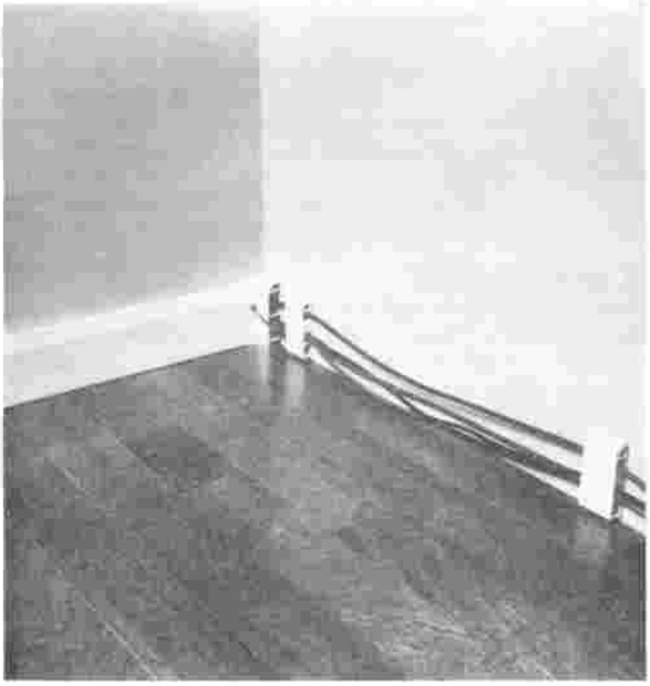


12 IBIS partitions stacked on site before erection

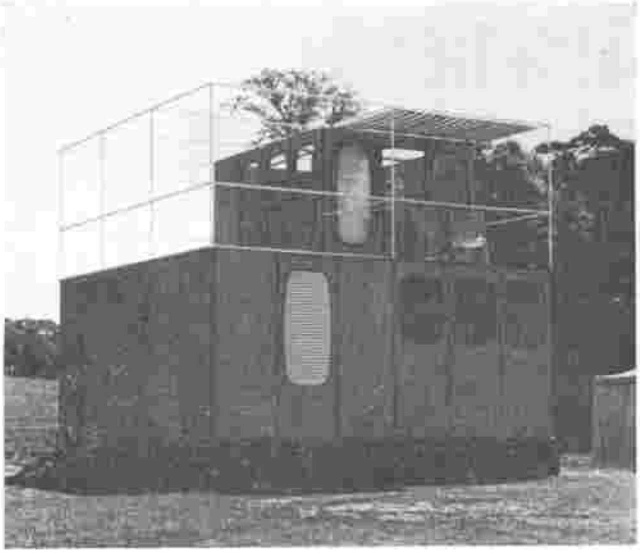
13 Partition track being shot-fired on to the floor screed



14 Installation of electrical services before erection of second leaf of partition



15 Assembly of IBIS skirting showing moulded plastic clips and Colorcoat section



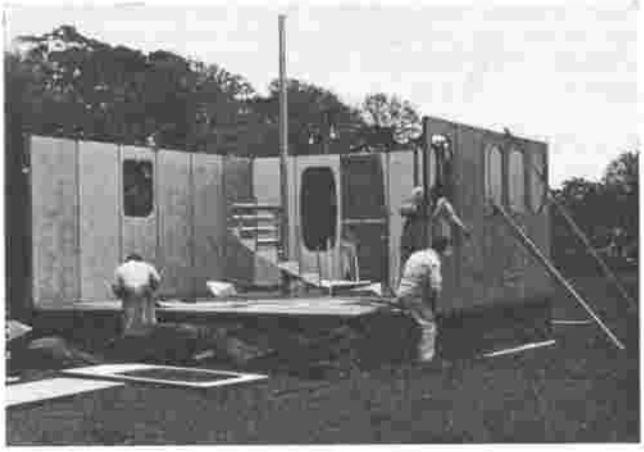
17 The completed BISRA experimental building

have been very worthwhile in so far as it will have prevented the project from reaching the stage where it makes a very considerable loss.

Not so critical, but nevertheless very important, is the need to have a complete performance specification for each component. With the publication of the CIB master list of properties for building materials and products,[4] and more recent publications by the then Building Research Station,[5,6] and the Ministry of Public Building and Works,[7] the task of writing performance specifications is made somewhat easier. Particular care should be taken, however, in interpreting the fire regulations especially where double-skin constructions are envisaged.

Production costs – which may be broken down into those associated with material, equipment, amortization, labour, factory, and storage and handling – will vary with level of production. Even where the material/labour cost ratio is high, as with most sheet-steel building components, levels of production will dramatically affect the profit loss margin. It is, therefore, essential that the correct balance be achieved between, on the one hand, high flexibility and low throughput, and on the other, low flexibility, high throughput, and perhaps related problems of storage. This problem may be resolved through careful factory planning,[8] and close liaison with production personnel during the product design stages.

Finally, the innovator who wishes to gain an overall view of the new product development process will obtain a good introduction to the subject from the proceedings of a conference[9] which remain relevant despite a time lapse of several years.



16 Erection of BISRA experimental building, 1963

REFERENCES

1 A. M. U. CALDWELL AND G. M. E. COOKE: 'Thin-walled structures', 477–506; 1971, London, Crosby Lockwood
2 A. M. U. CALDWELL AND G. M. E. COOKE: *ibid.*, 507–527
3 G. M. E. COOKE: 'Some aspects of sheet steel used structurally in low-rise, high-density dwelling units', 1964, BISRA, Report no. MW/INT/4/64
4 'A master list of properties for building materials and products', CIB report no 3, 1964, International Council for Building Research, Studies and Documentation, Rotterdam
5 H. W. HARRISON: 'Performance specifications for building components', 1969, current paper 37/69, Building Research Station
6 R. J. MAINSTONE *et al.*: 'Performance parameters and performance specification in architectural design', 1969, Current Paper 23/69, Building Research Station
7 'Performance specification writing for building components', 1969, HMSO
8 J. G. NORRIS AND B. W. SMALL: 'Planning a new factory', *Chartered Mechanical Engineer*, May 1967
9 'New product development', conf. proc., March 1966, Department of Industrial Administration, University of Strathclyde