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<th>Return To Craft Manufacture</th>
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Ever since the nineteenth century, when mechanization began to have a serious impact on the building industry, architects have been increasingly distanced from the systems of production by which buildings and their parts are made. The English Arts and Crafts Movement was a nostalgic reaction to this development, which was recognized by William Morris and others as symptomatic of the more general trend towards human alienation in an industrialized society. Walter Gropius later saw the problem differently, and tried for a more constructive approach in the Bauhaus School. Even Gropius’s approach though was based in part on expediency, having to reconcile the early craft orientation of Bauhaus teaching with the emphasis on industrial design which the School came later to represent. In a deft compromise aimed at bridging the gap, he described the continuing need for craft training as follows:

The teaching of a craft is meant to prepare for designing for mass production. Starting with the simplest tools and least complicated jobs, he gradually acquires ability to master more intricate problems and to work with machines, while at the same time he keeps in touch with the entire process of production from start to finish.

The implication is that both craft and industrialized production methods belong together on the same scale, ranging from simple to complex tools of production. The basic idea was correct for what it promised, but at the time the statement was made it glossed over some enormous differences, not just in the scale of production, but in the degree of human control the designer had over mass-production processes, and not least in the degree of individuality that could then be achieved in the end product.

BRIDGING THE GAP

It was many years before architects were to take up the challenge again and get to grips with manufacturing technologies. For a short time, the spirit of Gropius’s educational programme was revived at the Hochschule für Gestaltung at Ulm in southern Germany, where students were encouraged to develop working prototypes of product designs intended for large-scale production. Few designs reached the commercial market, however, and none of the housing prototypes, which
remained wedded to prewar concepts of standardization and mass production, were realized. The mass housing systems that eventually came to dominate the market involved relatively crude, heavyweight technologies and bore little relation to the sophisticated methods of industrialized manufacture that had motivated Gropius and other Modernist visionaries.

Not until the late Sixties, with the emergence of more flexible, computer-based production systems, did the possibility of any true reconciliation between craft and factory production become feasible. Now, the extraordinary thing about the new ‘cybernetic factory’ is that the incongruities previously inherent in Gropius’s vision disappear, and the scale from craft tools to automated tools reflects a true continuum. For now we can produce factory-made components that are also tailor-made – a previous contradiction in terms – according to specific designs for specific buildings. In other words, the potential is there for the designer to regain a level of control over the industrialized building process previously thought possible only with craft building techniques.

The potential is there, but it is far from clear that the architectural profession, and just as important, the architectural schools, are currently in any position to take advantage of the tremendous opportunities ahead. For all their efforts, Gropius and his followers had failed to deliver the promised ‘new kind of collaborator for industry and the crafts’.

to the production of system building, with rare exception, they failed to grasp the essentials of manufacturing. More generally, architects have since come to accept an increasingly circumscribed role as form makers, to the point where the selection of components from a catalogue is all that is left of most architects’ contact with the building industry. Where they do get involved at all in the making of new components, it is usually in the writing of performance specifications.

**DESIGN DEVELOPMENT**

A notable exception is the work of Foster Associates. In their early projects, the Foster team mostly confined themselves to making the most out of ready-made components, though put together with imaginative understanding of the industrialized materials at their disposal, and rare attention to detail. However, in the Hongkong and Shanghai Bank headquarters, Foster has produced a very different kind of building, requiring an entirely new approach to the design and construction process. Almost all the components used in the project were designed by the Foster team itself in close collaboration with manufacturers’ own
4.3.
design and shop-floor people, an exhaustive process which included the making and testing of full prototypes. But it was in the design and making of the special aluminium cladding for the steel structure that the Foster team achieved what is their most important breakthrough in industrialized building technology. The masts, trusses, suspension rods and cross-bracing of the bank’s unique suspension structure required layers of corrosion protection and fire-proofing materials, which in turn required some kind of maintenance-free cover. In order that the structure underneath should be still expressed as directly as possible, it was necessary that the finished aluminium cladding should closely follow the complex geometry of the structural members. Reductions in the size of the structure as the vertical loading diminished skywards magnified the problem, necessitating the design and production of thousands of separate pieces of cladding with almost as many variations in shape and size. The complexity of the geometry in some cases was difficult enough even to visualize, let alone manufacture.

SMART TOOLS

Problems such as these called for a major retooling by Cupples, the US firm selected for the job, which included the acquisition of computerized, variable presses, as well as a number of robot welders. The benefits accrued from this massive investment in new technology...
included months of labour saved in drawing board work and the rejigging that conventional presses would have required, as well as distortion-free welds in assembly. More than that, given the nature of the task and the constraints of the ‘fast track’ programme into which the whole operation fitted, it is doubtful that this unique job could have been completed satisfactorily at all without the help of these ‘smart’ tools.

The project involved the largest application to date of computerized production machinery to a single building. But it is in the special relation between the method of design used by Foster and his team and these special tools of production that the real significance of this case study lies. For here we have one of the first true examples of the unification of craft and industry which Gropius alluded to, but which is only now made possible by the new technology at our disposal. Note again all that this case study involves: architects working in close collaboration with industry to design, test, produce and assemble an enormously varied range of building components, for one building project only, using fully automated but flexible tools of production. What all this adds up to is craftsmanship on a grand scale, and it completely reverses those industrial developments which underpinned Modern Movement dogma, and which have led to architects’ alienation from the tools and products of the building industry upon which they rely.

Given the very high cost of the bank, it is right and proper to ask if technology of this sophistication does not carry a cost penalty. Leaving aside the issue of the very high standards stipulated for the project by the client, the general answer is no, despite the initial high capital cost of the special production machinery. It is here that popular beliefs concerning the nature and cost of automated production lines break down. The high cost of conventional, fixed-purpose automated machinery of the sort still used to make engine blocks, for example, can only be justified by producing tens or even hundreds of thousands of identical engine blocks. The computerized machinery Cupples acquired also involved a sizeable capital investment, but, because of its inherent
flexibility, it has almost unlimited capacity for use on other jobs requiring similar manufacturing operations. Initial purchase costs do not therefore have to be recouped by producing the maximum number of the same component, but can be amortized over a very wide range of different products.9

**CAD + CAM = CRAFTSMANSHIP**

Aside from questions of cost, the other question that arises is, given the amount of time and care that the Foster team were willing and able to give to these projects, is the design development process replicable by less committed architects, working for less committed clients and with less adventurous manufacturers? The answer here is less certain, and we may have to wait for further advances in computer-aided design, as well as in manufacturing technologies, before we see the model accepted as normal practice. Some portion, and possibly a large portion at that, of the unique expertise which the Foster team as well as the manufacturers brought to bear on the project, may have to be taken up by automated expert systems and other advances in artificial intelligence (AI),10 if the approach is to become more widely available.

It may be asked if this further degree of computerization represents a loss of human control, and thus a regression from the craft-orientated model of design and production just described, but this need not be so. It may be more useful to think of such aids in the same way that cyberneticians and AI researchers do, as intelligence amplification.11 Just as we recognize true craftsmanship when we see it, as the result of a combination of artistic intelligence and technical dexterity, then so is it also possible to represent both developments in computer-aided design (CAD) and computer-aided manufacture (CAM), as extensions of the same human faculties of control over the quality of the end product.

To these innovations we can now add the more recent encroachment of computerized automation onto the building site itself.12 Already,

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4.6.
Hongkong & Shanghai Bank. CAD technology was used for design of complex cladding. Architect and photo: Foster Associates.
several types of robots have been developed to deal with different construction tasks. They range from assembly robots which help to put building structures together, reinforcement and concrete laying robots, interior finishing robots, including robots for concrete slab finishing and

4.7. The Japanese construction firm Takenaka have developed a variety of robots for use at all stages of the construction process. Applications shown include: concrete distributing crane (top left); automated cranes (top); automated material transportation systems (centre); concrete floor screeing robots (centre); automated coating delamination robot (bottom left); and self-climbing wall inspector (bottom right). Courtesy of Takenaka.

spraying fire-proofing materials, and exterior finishing robots, as well as drilling and cutting robots used for heavy excavation and engineering works.

The movement of robots from the relatively safe and predictable environment of the factory shop floor to the more rigorous and constantly changing environment of a construction site represents a considerable increase in demands on robot technology, especially on sensory capacity and durability, over that needed by their industrial cousins. The reasons cited to justify their use in these more strenuous conditions include savings in human accidents and improvements in working conditions, increases in productivity and improvements in the quality of the work carried out. Shortages of skilled manual labour in Japan and other parts of the industrialized world are also a main incentive in those affected regions. Preliminary studies suggest that widespread use of construction robots in most areas of the construction sequence is not only technically feasible, but economically desirable.13

There is little question that the prospect of a fully integrated, computerized design, manufacturing and construction process summons up a challenging vision, in which, at its ultimate, on-site robots complete the reinforcement of human intelligence and craft skills described earlier. At the same time, the use of robots throughout the manufacturing and construction process raises the same vexing questions regarding the redistribution of labour as have been raised in other industries which have already been fully automated.14 We should be careful to distinguish, for example, between cases where there is a genuine shortage of skilled labour, or the work involves levels of danger or some other conditions which are humanly unacceptable, from those where the social costs of automation outweigh the economic gains. Clearly, this is a Pandora's Box, but better it should be opened now, while there is still time to contemplate what we find there, than later, when it might be too late to influence events.

RESPONSIVE ARCHITECTURE

All of this points towards a very different kind of Modern architecture from that which we normally associate with factory production methods. As a so-called ‘High-Tech’ architect, Foster is widely assumed to be still clinging to those Modernist preferences for universal solutions that Postmodernists now eschew. But the observation is only true of his early work, and it would be a mistake to view the Hongkong and Shanghai Bank and his later work in the same terms. The bank’s Second Machine Age technology may be global, but the structural expressionism and spatial qualities are distinctly Pacific, if not precisely local: lightweight floating floors and delicate transparent screens against a massive, aggressive supporting structure: Madam Butterfly meets Godzilla.15

Works of this quality suggest a convincing resolution of what are usually considered to be opposing architectural tendencies, and are the outcome of a more general shift from the use of ready-made components towards a craft-orientated approach more suited to a responsive architecture. Like that other master of the modern tools of industry,
Renzo Piano, Foster repeatedly emphasizes the importance of process in the art and craft of making architecture, as much as any end product. This shift can in turn be interpreted, at a higher level, as part of a new, more balanced Modernist philosophy, which allows the architect to pay due respect to what is particular to a place and regional environment, as well as making the most of the technological culture all industrialized countries now share. And while variable production technology does not in itself guarantee high quality design or even respect for cultural and place identities, it will certainly facilitate those architects capable of responding to those issues.

**BATTLE FOR THE REAL MODERN MOVEMENT**

These then, briefly, are some of the more significant implications and opportunities which the current technological revolution presents us
with. The changes involved cannot be overestimated. It is going to take
an equivalent revolution in architectural and educational practices for
architects to come to grips with the post-industrial age these techno-
logical advances represent. Should it happen, we may have to re-
evaluate that earlier revolution trumpeted by the Heroes of the Modern
Movement for the very misleading event it was. For all the rational and
scientific trimmings that went with it, the ideal of mechanization at the
heart of orthodox Modernism has turned out to be defunct, at best a
staging post on the way to a very different Machine Age. The crucial
battle for the real Modern Movement – the one in which architects and
humankind in general finally master their machines and bend them to
humane use – has only just begun.