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COMPUTER AIDED MANUFACTURE: SOME INTRODUCTORY REMARKS

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Computer Aided Manufacture: Some Introductory Remarks *

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I. A New Era

It is my contention that we are entering on a new era where a major portion of the corporate skills that determine the technological level of a nation, an industry or a company, can be transferred on reels of magnetic tape and in the equipment to process them.

At the time of the Industrial Revolution the predominant feature of merit was the personal skill of the engineers and craftsmen of the industry, based partly on a country's general educational level, partly on tradition accumulated over a number of generations. At this stage the mechanical engineering industry of a particular country could earn a reputation for the excellence of its products (e.g. Britain and Germany), but skilled itinerant artisans of other countries could also acquire their know-how, and brilliant engineers in the more backward countries could produce "islands of excellence" even amid relatively poor industrial environments. (The Hungarian Banki was able to invent the carburetor in 1893 and Hungarian automobiles made in 1905 were fully competitive with the products of contemporary foreign workshops). The difference lay in the numbers of these highly skilled people, the number of trades in which they were active, the receptiveness of the country's economic environment to their efforts.

During the course of the twentieth century the feature of merit became the scale of production, in particular the introduction of mass-production techniques into a country's engineering industry. The mechanised assembly-line, the conveyor belt, the practice of the new discipline of production engineering standardisation, and the division of labour were the main characteristics of advance in this period. Since these required substantial capital investments and large markets, they were no longer transferable to small enclaves of skill in the less advanced countries. With the concentration of productive resources also came a concentration of technological and organizational know-how which increasingly became proprietary secrets. It was no longer possible for

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journeymen and engineers to import the skill of more advanced nations as they had previously done. A seemingly unbridgeable technological gap developed.

In the second half of this century mass-production has become increasingly separable from the advanced technological and scientific specializations which it brought into being. In many parts of the world the assembly-line facilities which were formerly the pride of an industry have been relocated to economically backward areas and the advanced industrial nation has retained the skills of research, development, and the extremely lucrative, expanding market of highly specialized one-off and small-batch production in the production of the complex tools required for the mass-manufacturing industries. The new feature of merit is thus once again that of skill: skill in the scientific, technical and market research leading to new products, in the development of new manufacturing technologies, in the organization of production, in the production of the complex tools required for the manufacture of the new products. These skills are incorporated in a complete new "industry," with its own new technology, tools, and organization, comprising the computer, advanced laboratory resources, and the increasing automation of the phases of research, design, analysis, and planning. The technological gap is consequently widening still further.

How can this trend be reversed? How can the less advanced nations of the world escape the fate of permanent technical (and consequently economic) subservience to the bigger and more advanced ones? The only way this can be done is to accelerate the international transfer of technology. The latest achievements in the development of integrated manufacturing systems now indicate that this is a distinct possibility, which would benefit not only the receiving countries, but through the consequent elimination of a vast amount of duplicated effort, also (to at least the same extent) the "donors."

II. Integrated Systems for Processing Materials and Data

The new feature that distinguishes the integrated systems now emerging in the engineering industry is the automatic processing of materials into products (machining, assembly, etc.) interwoven with the automatic processing of the data (stocks, costs, scheduling, etc.) pertaining to them. The separately developing disciplines of:

- Computer-Aided Design,
- Computer-Controlled Production, and
- Management and Business Systems

are coalescing into single, computer-based manufacturing systems.

Computer-Aided Design has evolved in all four main areas of the design field:

1) conceptual design, where mass data storage, file handling, and retrieval techniques have been developed to aid the designer and market analysis and prediction programmes made available to him;

2) design analysis, where programmes have been evolved for a very large number of mechanical constructs, ranging from gear trains to linkages, from finite-element stress analysis techniques to full dynamic simulations;

3) detail design, where aids have been developed for automatic digitizing, drafting, lofting, plotting, and the mass storage, retrieval, handling, updating, and output of detail drawings; and

4) design communication, which has been helped by software and hardware aids to automatic documentation, parts listing, cable listing, etc.

The Computer-Aided Design (CAD) field has been greatly helped by the introduction of such highly flexible devices as the interactive graphic display terminal. The hitherto distinct phases of Concept, Analysis, Detailing, and Communication have been intrinsically interlinked in an increasing number of systems with the aim of having data transferred from one phase to the next through a common, structured data base.

Computer-Controlled Production has also developed from a number of separate antecedents:

a) Computer programming languages for numerically controlled (NC) machine tools have been written by the dozen (close to 100 are in industrial use) for various types of computers, control units, and machine tools;

b) Programmes to compute machining technology--some using large machineability data bases--have been evolved;

c) A large variety of control schemes for the direct computer control of groups of numerically controlled machine tools (DNC) has been developed;

d) Complete machining systems including the computer controlled transfer for workpieces and tools, the automatic measurement of dimensions are now available; and

e) An increasing number of flexible automatic assembly systems, some involving pattern recognition and robot techniques, are being built which can be operated under computer control.

The integration of NC programming, DNC, and complete machining systems (possibly also comprising assembly) has become a task whose realization is being attempted in an increasing number of countries.

Production control, scheduling, management information, stock control, order registration, purchasing, invoicing, and similar programmes and programme-packages have been introduced into industrial practice in large numbers. There is a notable tendency to amalgamate them into integrated management systems.

From even this very cursory listing the trend towards the development of large, self-consistent subsystems will be apparent and the portent of their eventual further integration into total manufacturing systems realized. In such a system, the CAD, NC programming, DNC, and management components will all be part of a single, homogeneous system, with internal communication between all system modules.

Early in the development of the idea of large, self-consistent subsystems, the integration of the separate subsystems was considered a trivial task. We can all recall the "artist's impression" type of drawings, ten years ago, in which the component parts were simply drawn beside each other on the shop floor and connected by thick cables. Next came the attempts at drawing up highly methodical, overall systems approaches. They helped a good deal towards clarifying ideas, but they were too grandiose to implement. Now these attempts have been succeeded by the piecemeal, pragmatic method where one autonomously viable and intrinsically useful subsystem after another is linked to a gradually evolving central hub. This strategy is bringing swift results. The integrated manufacturing system is here with us, and the transfer and updating of such a system is becoming the equivalent of transferring a large, permanent staff and library, the accumulated corporate skill of many tens of years.

III. Some Controversial Advice

I would like to seize the occasion of this opening address to offer some (unsolicited) advice:

1) Do not reinvent the wheel!

During the on-going world-wide surveys into various aspects of Integrated Industrial Systems, being conducted by the

International Institute for Applied Systems Analysis, one of the most striking of our experiences has been the amount of high-level effort going into the duplication of other people's results.

2) Develop stepwise!

It has been our universal finding that systems which were too grandiose in concept and could only stand or fall together, in fact fell. Economic, psychological, and technical factors all indicate the importance of linking industry-tried and tested modules one by one, instead of all at the same time.

3) Accept suboptimal solutions.

This is, of course, a corollary of 1) and 2). No piecemeal system, assembled from building stones created by other people for other conditions, will ever yield an optimal solution outside its original context. But it will yield a working solution within reasonable time and at reasonable costs.

In summary, our slogans should be:

- Standardize,
- Buy and sell know-how,
- Cooperate, and
- Down with the NIH* complex!

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*Not Invented Here.