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Agenda item 9

DATA PROCESSING IN THE STEEL INDUSTRY:
THE STATE OF THE ART AND
TRENDS IN COMPUTER APPLICATIONS 1/

by

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S U M M A R Y

The major potential uses of computers in the steel industry have been well recognized for the last decade, and it is now largely accepted that the successful operation of the large modern integrated multi-product plant requires extensive computer assistance. This paper suggests that differences in business environment across the world have influenced the relative priority given to applications and the state of development. The paper discusses these inter-relationships between applications and reviews achievements to date.

INTRODUCTION

In reviewing progress to date, it is now apparent that Steel Industry management had recognised the majority of the important uses of computers in their industry by the early 1960s. Concepts were developed at that time for the control of one or two strip mills[1] which are still regarded as advanced ideas.

These concepts, for successful implementation, require real-time interactive communication techniques coupled with the rapid accessibility of large volumes of information. It is not surprising therefore that steal companies the world over are still striving towards the fulfilment of those original objectives, although notably Japanese companies and a few companies in Europe have made very substantial progress. These latter companies have quoted benefits which have been quantified to justify fully their considerable expenditure on computers. Their over-riding comment, however, is not so much that the systems saved $ X,000, but that the large integrated multi-product modern steelworks of today just cannot be successfully controlled without extensive computer facilities. It is their firm belief that every new works must be built not only with the most modern production facilities, but with most of these units under direct or supervisory process control, and with all management planning and control systems aided to the utmost extent by business computers.

This situation is seen most clearly in Japan, where their computer systems are still three years ahead of the rest of the world, with a few notable exceptions.

THE [illegible] ENVIRONMENT

Fig. 1 shows a general comparison between three major world areas for various environmental conditions over the latter half decade of the 1960s[2].

ENVIRONMENT UNTIL 1971

	USA	EUROPE	JAPAN
MARKET	Capacity > Demand	Balanced	Capacity < Demand
SERVICE	Important	Important	Less important
EQUIPMENT	Old	Mixed	New
INVESTMENT	Small/Base	Modest/Base	Large/Base
RETURN	Below Average	Fair	"High"
LABOUR	Very expensive Some Dedicated Experienced Available	Expensive Mostly Dedicated Experienced Short	Expensive Dedicated Inexperienced Short
TRADE UNIONS	Strong	Mixed	Co-operative
DISTRIBUTION	Centres	Mostly Direct	Direct
ORDER SIZE	Large	Small	Small
INFRA STRUCTURE	Developed	Developed	Under-Developed
GNP/CAPITA	High	Medium-high	Low
NATIONAL PLANNING	No	Partly Yes	Yes

The USSR and associated Eastern European steelmaking countries have not been included in the comparison but crude steel production of that group has exceeded all other groups since 1966.

It can be seen that the USA environment is dominated by the need for fast response to customer sales situations in a "buyers" market, minimise high-cost manpower, and reduce interprocess stock costs (see also figures 2 and 3).

Fig. 2

EFFECT OF ENVIRONMENT ON PRIORITIES

USA	EUROPE	JAPAN	1971+
1. Marketing Services	1. Marketing Services	Production Planning	Marketing Services
2. Financial Performance	2. Production Planning	Financial Performance	Production Planning
3. Production Planning	3. Financial Performance	Marketing Services	Financial Performance

Fig. 3

JUSTIFICATION CRITERIA FOR COMPUTER INSTALLATIONS

USA	EUROPE	JAPAN
Customer Service	Customer Service	Manpower
Manpower	Inventories	Complexity of Plant
Inventories	Yield	Throughput
Uniform Products	Economic Production	Customer Service.

Longer runs of identical ordered qualities and sizes reduced the requirements for complex production planning and control systems.[3]

The European environment demands customer service in terms of fast response to order enquiries, good delivery performance and good quality performance. The wider difference in manpower situations in Europe means varying interests in justification and only a few quote direct reduction of manpower as a priority. More emphasis for quantifiable savings is placed on minimising interprocess stock levels and improving yields. Despite considerable increases in production level, some companies who have installed successful production planning and control systems claim to have reduced interprocess stocks by between 20 and 50 % while one company even reported an 80 % reduction of slab stock.

Claims of yield improvements up to 3 % are common. Although it is difficult to isolate the effect on production volumes, it is generally agreed that a 1 % improvement can be expected.

The case of Japan was quite different until 1971. Virtually all plants were extremely modern and the coastal monster plants were commonplace, all using the most modern technical processes. Investment was being poured in to catch up with a larger demand than production situation ("sellers market") despite the grave shortage of labour skilled in operating steelworks. The means to control this complex plant with as few as possible operatives, whilst still achieving maximum production, therefore became the number one priority. Computer systems servicing the needs of production were designed and available in nearly all cases before the plants themselves were commissioned. There are many examples - Kimitsu and Yawata plants of Nippon Steel Corporation, and Kashima of Sumitomo Metal Industries are just a few where they have "adopted from the very start of the plant design where nothing could be done without computers[4]". "Designed as an integral part of the original Kimitsu project, this Production Control System has been able to use computerisation to the fullest possible extent. This system is thus only one step short of complete automation - a totally unmanned operation"[5]. The result of this approach was to improve further the already phenomenally high output per man statistics.

The market condition in Japan changed during 1971 and the various companies became involved in violent competition for both quality and delivery (both short and accurate delivery). So the situation of the "Sellers" to "Buyers" market arose in Japan for the first time, just as it had in Europe in the early 1960s. The Japanese plants were well equipped with their extensive real-time computer systems to start realigning their priorities as shown in the final column of Fig. 2. The production planning control systems, which were geared to handling small orders as are the European systems, were used more to shorten delivery times and ensure delivery accuracy, as well as controlling the complex large plants, rather than aiming to balance the plant for the utmost production possible. Quality Control systems, too, were improved[6].

The justification for the Japanese approach in their environment is typified by quotes by these companies such as:

> "120 less staff required"
>
> "6 general roll changes fewer per month required on Hot Strip Mill"
>
> "10 % improved rolling efficiency"
>
> "$ 690,000 yield saving" [6]
>
> "400 less personnel required," "resulting net saving in cost, even with the cost of computers taken into account, amounts to more than $ 650,000 per year"
>
> "30 % reduction with local workers, planning and scheduling department and technical department"
>
> "10 % decrease in slab surplus"
>
> "20 % shortening of lead time"
>
> "30 % increase in weight of a slab (heavy plate application)".

Japan, in building a new Iron and Steel Industry over the past twenty years, have laid down clearly defined objectives (Fig. 4) which saw computers as an integral part of the total requirement of the whole plant.

Fig. 4

MANAGEMENT OBJECTIVES

USA	EUROPE	JAPAN
Limited Objectives	Limited Objectives	Clearly defined Objectives
No total solution	Total solution	Total solution Computer activities part of total plant.

Designers of the new large coastal plants being built in the rest of the world have realised that these comprehensive computer systems must not only commence operations with the plant (or the benefits will never be fully recovered) but all managements' planning, control and administrative thinking must be based on the fact that computer systems will be utilised to the utmost to help them make better decisions in all fields.

The effect of the environment through its effects on the priorities, justification criteria, and management objectives, directly influence a number of data-processing parameters (Fig. 5).

Fig. 5

EFFECT OF ENVIRONMENT ON COMPUTER SYSTEMS

	USA	EUROPE	JAPAN
SYSTEMS COMPLEXITY	Low	Mostly high	High
TOP MANAGEMENT INVOLVEMENT	Low	High	High
DP-MANPOWER	Limited	As high as possible	High
PERFORMANCE DP EQUIPMENT	Below Average	Average high	High

It can be seen that Japan's success in running complex systems has been backed by top-management involvement, the full involvement of user department skills, and the use of sufficient numbers of well qualified data-processing staff.

COMPUTER APPLICATIONS

Between 50 and 60 % of computer time in the UK is spent on production support systems. In Japan, this figure approaches 80 %. A typical spread of applications is shown in Fig. 6, which covers the four main areas of commercial, scientific, production planning and process control. Reviews of these areas have been published.[3, 7]

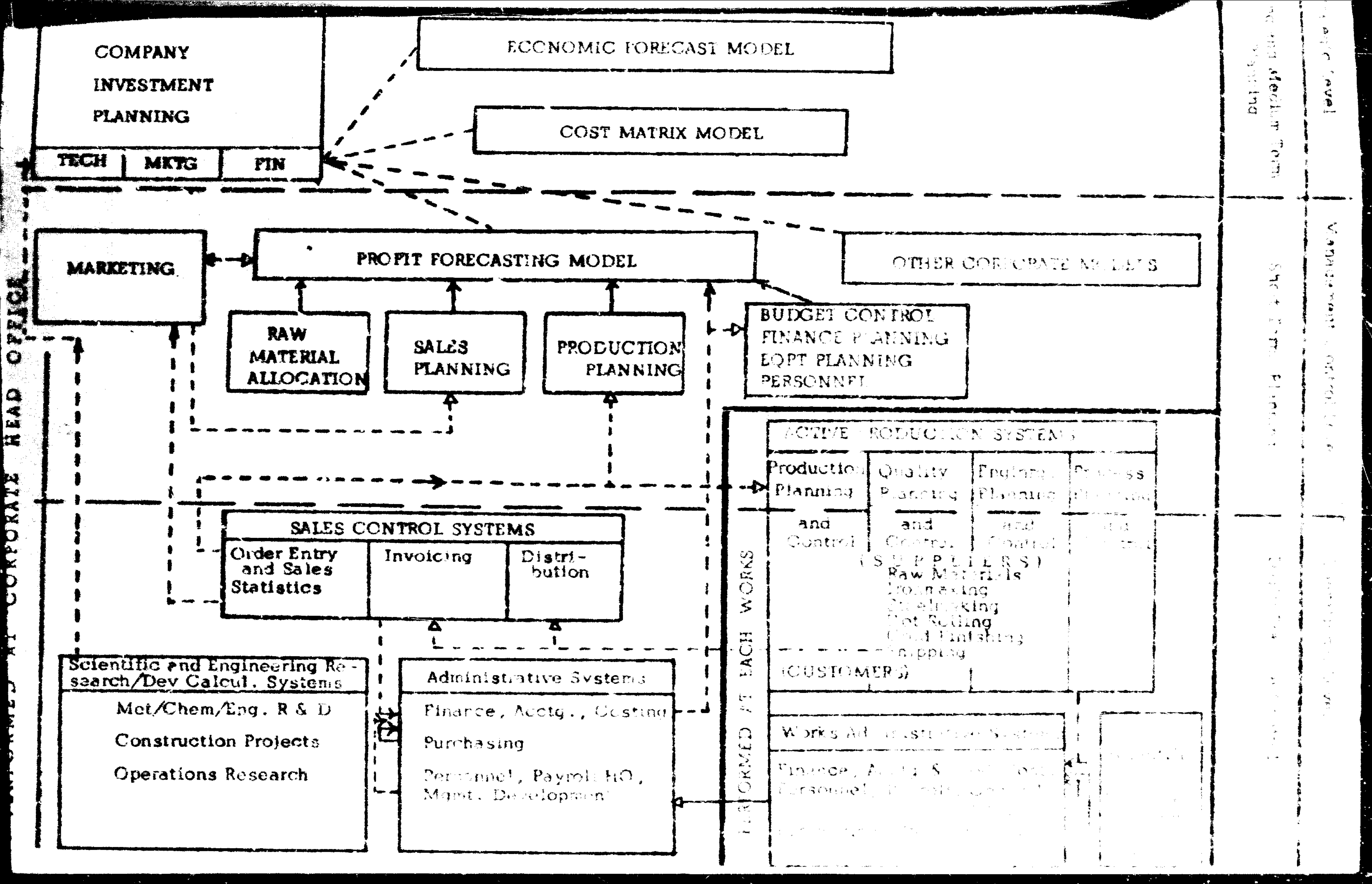
Fig. 6

APPLICATION SPREAD IN JAPANESE STEEL INDUSTRY

Company Function		Application
Sales	-	Order entry, Billing,
	-	Sales Statistics, Sales Forecasting, and Allocation
Production	-	Order Acceptance and Dressing,
	-	Production Planning, Scheduling,
	-	Control Work Instruction,
	-	Data Collection, Order Status,
	-	Shipping,
	-	Process Control
Quality	-	Quality Data Collection, Reporting,
	-	Statistical Analysis, and Quality Improvement
Personnel	-	Personnel Records, Payroll
Accounting	-	Cost Management, Financial Accounting
Material	-	Purchase, Delivery, Inventory Control
Equipment	-	Construction, Maintenance Scheduling,
	-	Inventory Control
Corporate	-	Raw Material Procurement Planning,
	-	Sales and Production Planning,
	-	Economic Forecast Model,
	-	Corporate Financial Model,
	-	Cost Accounting Model

Scientific	-	Design and Engineering Calculation
	-	General Scientific Calculation.

The integration of these individual applications into an overall company information system is shown in Fig. 7.



COMPANY INVESTMENT PLANNING
TECH
MKTG
FIN
ECONOMIC FORECAST MODEL
COST MATRIX MODEL
MARKETING
PROFIT FORECASTING MODEL
RAW MATERIAL ALLOCATION
SALES PLANNING
PRODUCTION PLANNING
BUDGET CONTROL
FINANCE PLANNING
EQPT PLANNING
PERSONNEL
SALES CONTROL SYSTEMS
Order Entry and Sales Statistics
Invoicing
Distribution
Scientific and Engineering Research/Dev Calcul. Systems
Met/Chem/Eng. R & D
Construction Projects
Operations Research
Administrative Systems
Finance, Acctg., Costing
Purchasing
Personnel, Payroll HO, Mgmt. Development
Production Planning and Control
(CUSTOMERS)
EACH WORKS
HEAD OFFICE
CORPORATE

It can be seen that there are three levels of operations performed either at Head Office or at each of the large works. These levels correspond to long-term planning, short-term planning, and every-day control. Some of the major interactions between the individual systems are indicated and, although the works are self-sufficient for managing short-term planning and everyday control activities, they feed the corporate systems, which not only monitor the over-all works performance, but maintain overall planning and objective setting for the company as a whole.

The production planning and control system is regarded by most Steel Companies as central to their operations. After receiving customer orders at Corporate level, entering them on-line at visual display units, and at the same time performing checking and validation commercial functions, the orders are allocated to works. The remaining order entry functions, including technical routing, figuring, and material providing functions, are performed before 10-day or weekly planning programmes can be developed.

Planning is an interactive process between the planner and typically batch-type complex computer planning programs which are building up loading tables for the various facilities. Visual display units are the ideal media for this man-machine contact, and enables far more alternative plans to be evaluated. Decision making remains firmly the responsibility of the planner.

The planning of steelmaking to produce ingots or continuously cast slabs of size within quality specification enables a firm start-production-date to be estimated and confirmation to be given to the customer on the delivery date for his order.

Actual steelmaking triggers off the order production functions which include extensive real-time capture of production and some quality data on operator terminals or directly from instruments situated at all key production/stocking facilities throughout the plant. Besides the monitoring of stock location, order status monitoring, plant status monitoring, unit or facility scheduling, plant balancing, and plan monitoring are functions also to be performed. Reporting of all types is a natural output of this kind of system.

A large number of works now have real-time systems in operation. The degree of automatic scheduling of units by computer varies. Most plants leave the difficult selection and sequencing problems to the scheduler while the computer feeds him with lists in priority and sequence order. Both scheduling and progressing functions are now being performed from visual display units located at both hot and cold mill offices and have direct access to the stock and order files in order to make decisions on excess or remake situations on orders.

The other key systems being implemented at the management control/ operational levels are quality control, engineering maintenance, and process control at most units. Process control applications have been reviewed quite adequately at international conferences.[8]

APPROACHES AND RESULTS

Computer Applications Hierarchies

Spencer Works, then of Richard Thomas and Baldwins Ltd, now British Steel Corporation, Llanwern Group, was one of the first new integrated plants to put forward advanced concepts for a total production planning and control system in the early 1960s. These concepts involved hierarchical principles on four levels:

Level 3	Management Information System
Level 2	Order Entry and Planning/Scheduling
Level 1	Data Communication in real-time
Level 0	Terminals and Process Control Computers.

The ideas for separating the total system into four levels were very similar to those used today. The attempt ran into problems involving the need for advanced hardware and software which was ahead of the state of development existing at that time of any computer manufacturer, and the cost of laying down excessive distances of expensive multicore cabling. Despite those difficulties, however, a real-time ingot tracking system was developed.

The second attempt commenced between 1963 and 1965 with about ten companies in Europe. Some of these companies installed successful systems but others ran into troubles with software, especially to support communications lines; high teleprocessing costs for cables, adaptors and terminals, project management limitations and inexperience in handling complex large projects, and high maintenance of the systems and programs. The latter effect was so pronounced that a number of the complex systems came to a standstill even during implementation (Fig. 8).

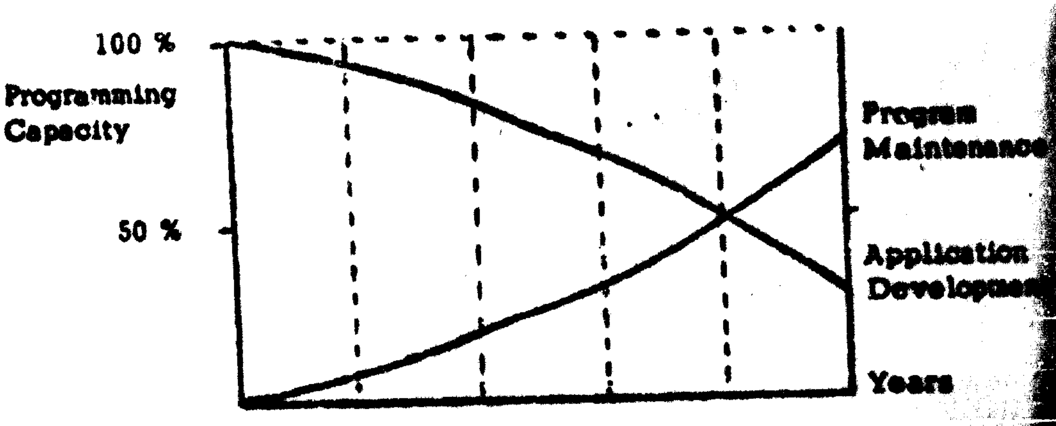


Fig. 8

Why was the second attempt largely unsuccessful?

The widespread feeling is that an inflexible monster system had been created and its inflexibility led to the impossibility of managing the project any longer. No standards had been laid down to control interfaces between sub-systems and the system had not been designed in a modular fashion. It was, therefore, almost impossible to alter any part of the system without incurring enormous program alterations in other parts.

The third attempt was made by several companies between 1965 and 1970, e.g. Yawata Steel 1967/69, Sidmar 1965/69, Salzgitter 1965/69, Lysaghts (Australia) 1966/70. These attempts represented a "point of departure" which used the original "Spencer Works Concept" but developed:

man-machine interactive approach, using

- on-line or real-time techniques with much improved hardware and software compared with that available for the first and second attempts,

- Systems design to give flexibility - <u>Modular</u> in both plant functions and production facility. This technique enabled management to control realistically sized individual modules, and for the design team to establish and standardise the interface relationships between modules.

There are, of course, a large number of modules. Typically, for a large works one might expect a matrix of 70 x 70 application modules, i.e. nearly 5000 modules (Fig. 9).

Fig. 9

MODULARITY IN FUNCTIONS AND FACILITY

(THE APPLICATION MATRIX)

Management Control Systems (levels A–B)

Operational Systems (levels C–D)

→ PRODUCTION → FLOW →				
LEVEL	SLAB STOCK	HOT STRIP MILL	COILERS	COIL STOCK
A	ORDER LOADING MATERIAL REQUIREMENT (yield) PLAN (DECADES) QUALITY CONTROL - REPORTS			
B	SHIFT & DAILY PLANS FACILITY SEQUENCING INVENTORY CONTROL PRODUCTION REPORTING			
C	OPERATOR INSTRUCTION DATA COLLECTION MESSAGE CHECKING			
D	PROCESS CONTROL BY UNIT			

Success with this approach was achieved because these modules are easily modified without affecting other modules.

The functions are shown in more detail for the production planning and control system in Fig. 10.

Fig. 10

FUNCTIONS

A - Technical Order Entry
Order Modification
Material Request
10-Day Production Planning Programme
Production Completion
Shipping
Order Status
Work Instructions and Mill Data Reporting
(also Administrative, Cost, Quality, and Raw Material Systems)

B - Collection of Mill Data (daily by shift)
Work Schedules (daily by shift)
Test Results
Allocation of Products

C - Operator Instruction
Actual Data Collection
Reporting

D - Unit Process Control.

Computer Hardware Hierarchies

The functional application level structure determined the hardware total design strategy for the Kimitsu project in the late 1960s. The original hierarchy of eight main-frame data processing computers and four process control computers is shown in Fig. 11.

Fig. 1

APPLICATION FUNCTION LEVEL

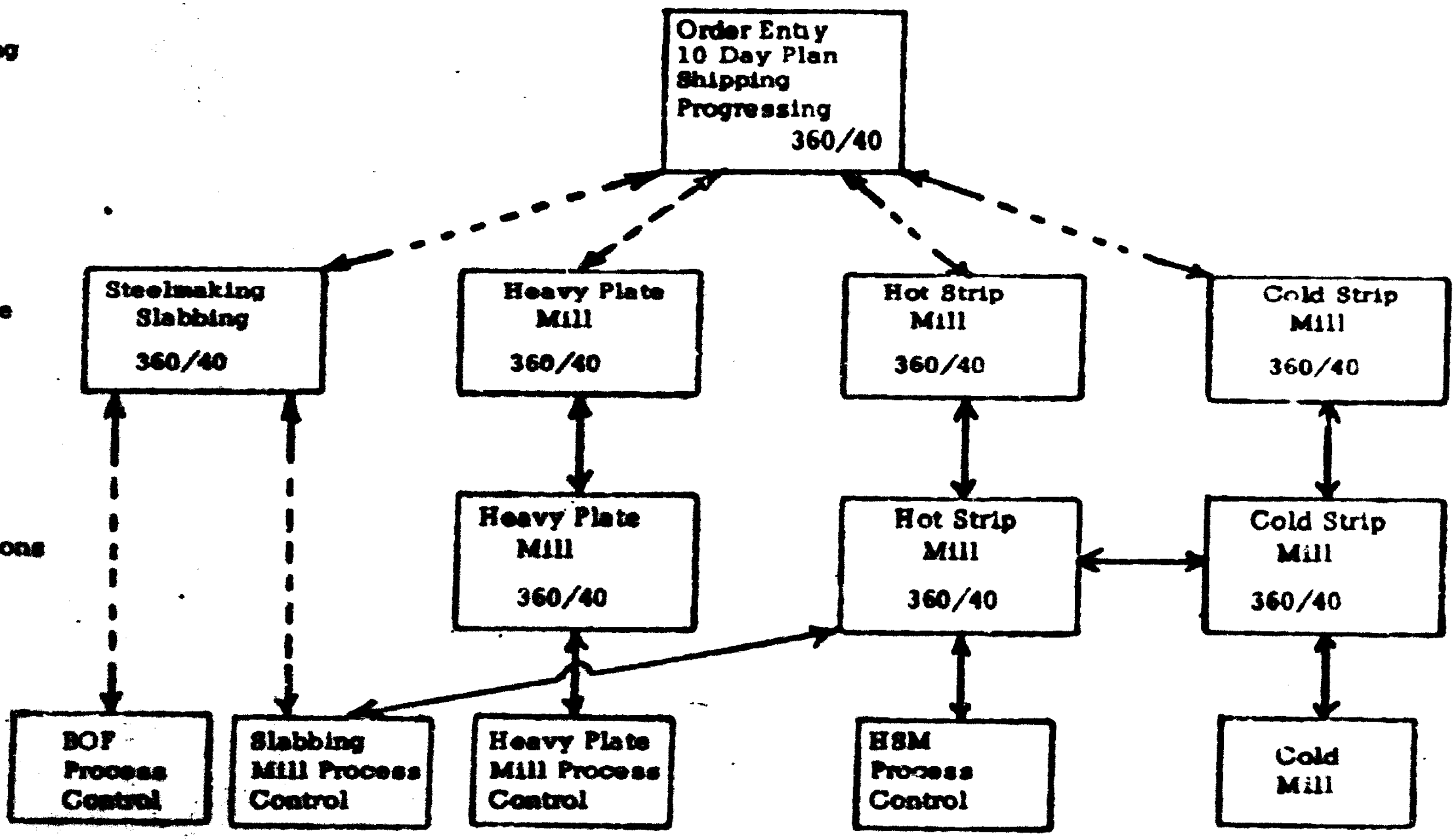
KIMITSU WORKS OF NIPPON STEEL COMPANY - ORIGINAL COMPUTER HIERARCHY STRUCTURE

A. (integrated)
- Production Planning
- Cost, Quality,
- Administrative
- Raw Materials

B. (daily)
- Scheduling
- Works Data Storage
- Allocation
- Quality Control

C. (real-time)
- Operation Instructions
- Online Scheduling
- Data Collecting

D. (real-time)
- Process Control
- Terminal/ instrument input



18 PROCESS COMPUTERS IN TOTAL (excluding Minis)

200 + OPERATOR TERMINALS IN REAL-TIME CONTROL OF LEVEL C COMPUTERS

The idea of simplification so that one functional level equals one business computer per major plant area (below level A) helped to keep clear lines of responsibility. Information is passed from level to level or horizontally in the case of the hot strip and cold strip mill computers either by direct links, paper tape, or punched cards, or transference of sharing or disk packs/tapes in the main computer room.

Results

This complex system was implemented in time for plant commissioning in two years with 91 people. As mentioned previously, net savings are estimated at $ 650,000 per year.

The principle approach to modularity is summarised in Fig. 12, which shows also the general characteristics of system implementation in the three world areas studied earlier.

Fig. 12

PRINCIPLE APPROACH

USA	EUROPE	JAPAN
Mostly non-existing	At least modular	Modular
	Mostly	&
	Hierarchical too	Hierarchical

IMPLEMENTATION

USA	EUROPE	JAPAN
Generally slow	Reasonably fast	Fast
User involvement weak	User participating strongly	Strong user involvement and responsibility
	Mostly not responsible	
Projects slip	Projects slip	Strong Project Control

The successful approach to achieve fast implementation of complex production projects and to meet the objectives of satisfactory justification is therefore based on:

1. The environmental driving force
2. Clearly defined top management objectives with a total solution strategy
3. Strong user involvement <u>and</u> responsibility
4. Good project managers
5. Modular and hierarchical systems design.

The results of the various approaches taken are summarised in Fig.13.

<u>Fig. 13</u>

<u>RESULTS</u>

<u>USA</u>	<u>EUROPE</u>	<u>JAPAN</u>
Many Plants without good production planning control system	All major Plants have production control system	No major Plant without integrated production planning & control system
Most companies with good order entry and order inquiry system	Very few have on-line order entry systems, but all have off-line systems	On-line order entry systems are under design or implementation

<u>DP PROBLEMS</u>

Productivity Flexibility	Productivity Flexibility	Productivity Flexibility.

Despite the development of good on-line order entry and stock control systems in the USA, good real-time production control systems in Europe, and very good production systems in Japan, there are still problems unsolved - systems productivity and further flexibility. The flexibility problem involves common data base accessing from more than one computer in an environment which is essentially 24 hours per day, 7 days per week, and where response time to the real-time systems must be maintained at 3/5 seconds.

CURRENT TRENDS

Advanced users of the complex real-time production control systems are now addressing the problems of improving flexibility and productivity. Most are examining software development coupled with new hardware available within the past few years.

Increased performance of hardware and the availability of virtual storage techniques have made possible greater programmer productivity by releasing the shackles of limited main memory problems. They have also greatly enhanced the feasibility of using data base / data communications packages which tackle the flexibility problem. The latter involves generalised file access methods, generalised terminal access methods, generalised terminals access methods, complex chained data base organisation and language interfaces.

The use of DB/DC packages have been proved to decrease drastically maintenance costs. This releases programmers for productive systems development (Fig. 14).

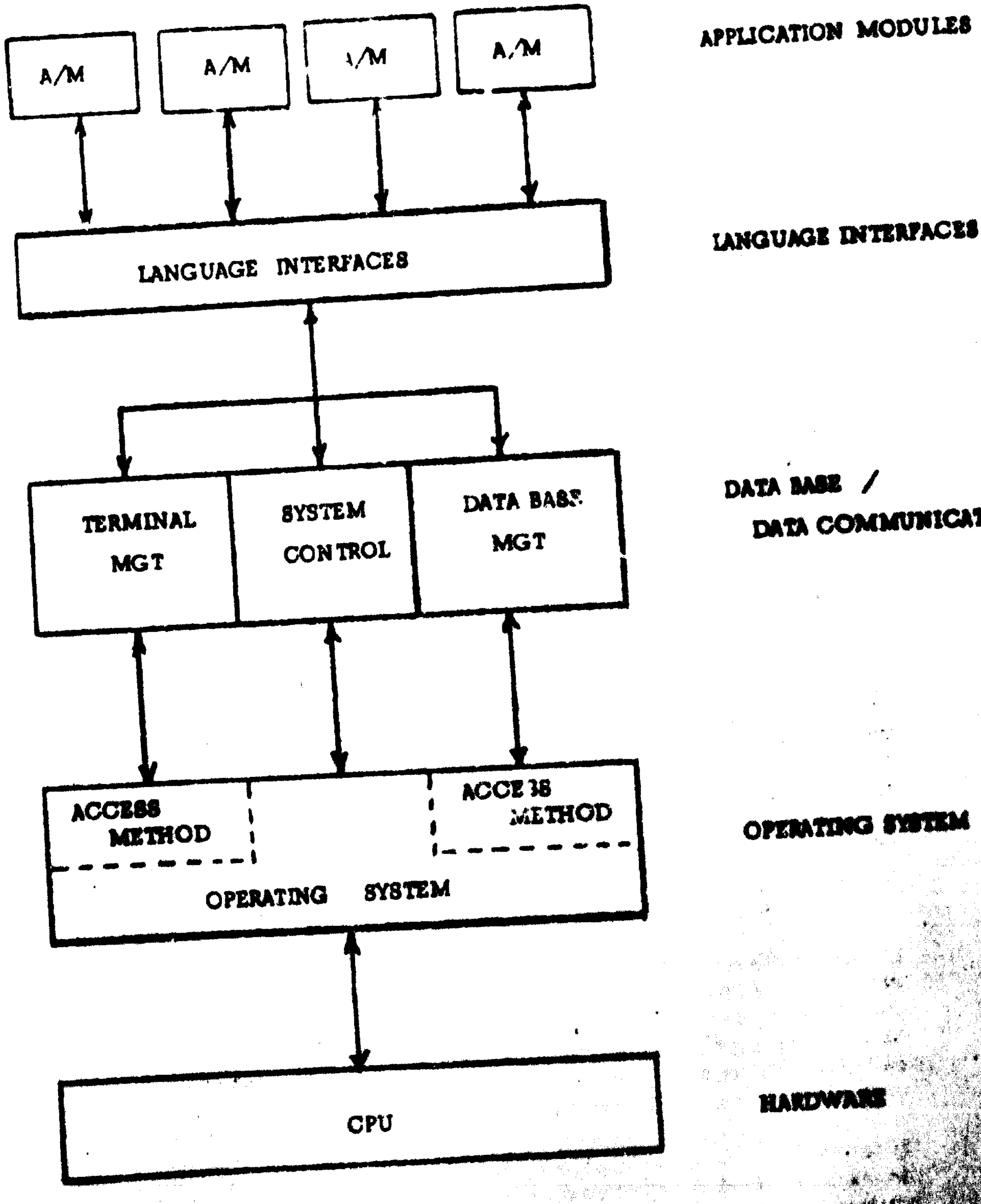
The greatly improved computer power has raised the question: "Is it not better to minimise the hardware hierarchy by combining two or more functional activity levels into one hardware level?" A number of steelworks are now moving in that direction and the established multi-computer 4-level hierarchies are now being replaced by a 2-level approach. Fig. 15 shows this change in configuration from several medium sized systems to two large and a number of small remote computers. The new configuration is called a distributed system.

Several steel companies in the USA, Sweden, and Germany are using data base packages for their batch systems. Several more are planning the possible move to include the real-time systems also. There is no doubt that this is a major trend that is occurring and it will become easier to affect the change as further developments in software DB/DC packages occur.

In terms of trends in applications, there will undoubtedly be a dramatic increase in effort devoted to corporate and scientific systems.

Fig. 14

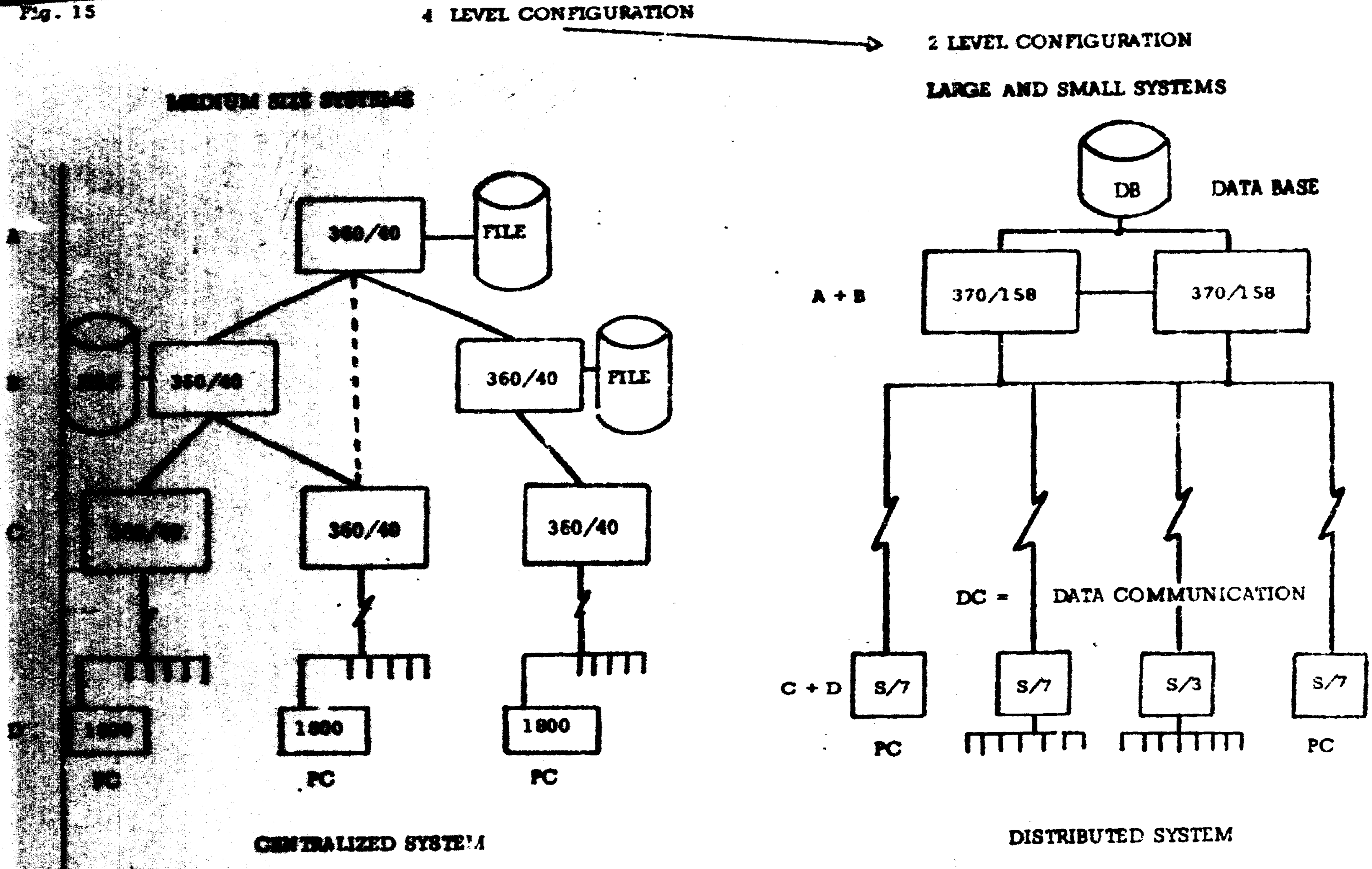
SYSTEMS ARCHITECTURE



THE BUILDING BLOCKS

Fig. 15

CHANGE IN CONFIGURATION



CONCLUSIONS

There is an abundance of evidence available to show that the complex real-time systems which have been found necessary to control the large, integrated, multi-product steelworks of today are fully justified on a cost basis. These complex systems are regarded by advanced computer users as essential for successful and efficient control of such large plants.

The main computer application interests have been centred around the production supporting systems from the receipt of the customer order to its despatch. Computer systems such as production planning and control, engineering control, quality control, process control, and very recently energy control, have, therefore, been given priority. Environment determines which of these systems, or parts of them, should be given priority.

Project Managers of the third generation of real-time systems overcame many of the problems of installing such complex applications, and there are many excellent examples in Japan, Belgium, Germany, and Sweden.

Flexibility and systems productivity are still two of the major problem areas, and data processing departments are studying the hardware, software and systems design necessary to minimise these difficulties. New computer systems have been made available over the past few years which give greatly improved price/performance ratios, and software features such as virtual storage. Handling of the vast data base, and communication with it, is at the heart of the flexibility/productivity problem Data base - data communication program packages which are available and constantly being improved are regarded as a key factor. These packages are far more feasible in conjunction with the new hardware/software, and several steel companies have decided to implement a standard DB/DC package.

Moves to rationalise hardware hierarchies have occurred at the same time and some companies have decided to simplify the hierarchy from four levels of medium-sized computers to two levels of large central machines and numerous small remote processors in the plant.

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