CONFERENCE

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# Computing in the construction industry

Europa Hotel, London W1. June 26th – 27th, 1973

Mgr. Inz WOJCIK
The Polish Ministry of Building

# PROGRAMME & SPEAKERS

| | | |
|---|---|---|
| **Profitable Construction Package** | | 26th June, 1973 |
| CHAIRMAN | | J. N. F. Turner<br>Managing Director,<br>E. Turner and Sons Limited |
| 9.30 | OPENING ADDRESS | R. E. Eyre<br>Parliamentary Under Secretary of State, (Housing and Construction) |
| 10.00 | THE COMPUTER AS A CONSTRUCTION TOOL | P. W. Maier, Manager,<br>Management Services,<br>Foster Wheeler Limited |
| 11.00 | Coffee | |
| 11.30 | A TOTAL SERVICE FOR THE CONSTRUCTION INDUSTRY | M. J. Sands<br>Managing Director, Wates Computer Services Limited |
| 12.30 | Lunch | |
| **Design for Construction** | | |
| CHAIRMAN | | Dr. D. B. Chandler<br>Managing Director,<br>Atkins Computing Services Ltd. |
| 14.00 | INTEGRATED SOFTWARE FOR DESIGNING AND DETAILING BUILDINGS | C. Diet<br>S.I.G.G.M.A., France |
| 15.00 | Tea | |
| 15.30 | COMPUTER-ASSISTED STEELWORK DESIGN | A. P. Dorman, Senior Engineer,<br>Constructional Steel Research and Development Organisation (CONSTRADO) |
| 16.30 | HOUSING DESIGN SOFTWARE: A WORKING SYSTEM | D. D. Smith<br>Consultant, SPL International<br><br>A. Bijl<br>Lecturer and Research Architect<br>Architecture Research Unit,<br>University of Edinburgh |

# PROGRAMME & SPEAKERS

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| **Planning and Control** | | 27th June, 1973 |
| CHAIRMAN | | C. B. Reynaud<br>Director, Hoskyns Systems Limited |
| 9.30 | THE USE OF THE PROKOR SYSTEM IN THE CONTROL OF LARGE INVESTMENT PROJECTS — Author: | Mgr. Inz. Wojcik |
| | To be presented by: | Mgr. Inz. Milewski<br>Centrum Etob, The Polish Ministry of Building |
| 10.30 | Coffee | |
| 10.45 | SITE PLANNING WITH NETWORK ANALYSIS | P. T. Rist<br>Planning Procedures Development, Production Technology Department, John Laing Construction Limited |
| 11.45 | THE RUNNING OF PERT FROM A REMOTE TERMINAL FOR LARGE CONSTRUCTION SITES | J. A. Black<br>Head of Computer Applications Merz and McLellan |
| 12.45 | Lunch | |
| **The Unexploited Potential** | | |
| CHAIRMAN | | D. Bishop<br>Director of Management Services, Department of the Environment |
| 14.00 | BASE RULES FOR BUILDING UP INFORMATION SYSTEMS IN THE NETHERLANDS CONSTRUCTION INDUSTRY | A. M. Bouman<br>Stichting Bouwcentrum Netherlands |
| 15.00 | Tea | |
| 15.15 | PROJECT INFORMATION STRUCTURING AND ITS EFFECT ON COMPUTER APPLICATIONS | P. F. Miller<br>Controller, Costs and Administrations, Architects' Department, J. Sainsbury Limited |
| 16.15 | PRACTICAL DEVELOPMENTS IN CONTRACT MANAGEMENT | Dr. N. M. L. Barnes<br>of Martin Barnes and Partners |
| 17.15 | Close of conference | |

# THE COMPUTER AS A CONSTRUCTION TOOL

P. W. Maier, Manager,
Management Services,
Foster Wheeler Limited

The substance of management's primary role, that of Organisation, Motivation and Control, is growing rapidly as the true strength of the computer is appreciated. More and more is the machine being used in its directive or strategy definition sense as its application to management problems is being forced into realistic practical uses.

The intent of this discussion, therefore, is to develop thoughts along these lines by the process of describing some fundamental Control requirements and applications, most of which are examples of Foster Wheeler operational techniques. It will not be the purpose to suggest that our own approach will equally solve everyone's difficulties: rather, the intent is to outline the basis of a proven successful system by broadly describing the essential procedures only whilst identifying the areas which lend themselves to computer applications.

To identify the environment from which our discussion emanates it is perhaps worth while to firstly describe ourselves. Foster Wheeler Limited is an international engineer/contractor organisation providing a complete service to process plants users, usually the petroleum and chemical companies of the world. Our business is the management of major projects. We are concerned with exercising our management skills within a highly competitive and fast moving industry where major design and construction projects of multi-million pound values are completed in very short period of time. A typical example would be a £30 M refinery designed and constructed complete in 30 months overall.

This environment is to some extent the ideal proving ground for computerised Management control techniques. We are compelled always to be mindful of the need to concentrate effort so as to reduce the number of interfaces necessary to the control function as the large project invariably creates difficult problems of communication and co-ordination.

The computer's role in planning and scheduling has been recognised for some years. These days, almost every large project utilises one of the many network analysis techniques, if not as a total plan for the project, then certainly as a means of defining the critical areas. We shall not discuss the various merits and demerits of the variety of network analysis packages available, we will simply define some of the advantages of computer utilisation in this area. At the same time, since we are considering the computer as a tool within a system, we will equally define some of the pitfalls which need to be eradicated in system design.

Secondly, we come to the Cost Engineering Phase and, needless to say, both time and cost factors are inextricably interfaced, the control of one must affect control of the other although good cost control is probably most of what management is all about.

Cost engineering, in our terms a derivative of value engineering, guides the entire engineering of the project to conform to the budget. It starts

at the process design stage where the process itself is frequently computer optimised in terms of equipment sizing, complex alloy pipe configuration, heater configuration, and the most economic types of heat exchanger train. Clearly there are many areas where design can be optimised and those referred to are simply indicative of our meaning in this respect.

The principles follow naturally through the engineering phases where the conceptual process design is translated into physical hardware. The procedure is that, today, more and more of the estimate itself is computer generated. Base material take-off data is a machine component, cost factors - unit or piece - can be assigned into the system, and the output is in the form of a completely calculated estimate. Sampling procedures are then initiated by the cost engineer to ensure that such objectives are being maintained.

Finally, the control system described would fail without the comprehensive back-up of computerised company accounts. The whole basis of a cost report is collation of data, already in the company system, for accountancy and financial control. Additionally, within the control system itself, trend analysis can be appreciably assisted through the many commercial curve fitting packages, which exist in most computer service bureaux. It is not infrequently the case, for instance, that before we accept forecast we may cross-check by extrapolating the actual curve through a regression analysis to determine its shape. This is particularly valuable when one is measuring a productivity trend. The future is still unbounded and is undoubtedly computer based. The very large proviso to this is that this powerful tool must be used with discretion.

Session 2

# A TOTAL SERVICE FOR THE CONSTRUCTION INDUSTRY

M. J. Sands,
Managing Director
Wates Computer Services Limited

Wates as a construction group has had a tremendously successful history as regards computing. The company started considering how computers could be of benefit almost ten years ago, and has been using computing in various ways over the last six years. Recently we had installed a £$\frac{1}{2}$ million computer which greatly enhanced the service that Wates Computer Services Limited (a separate and autonomous company within the group) offers to Group companies as well as outside clients.

One prime reason for Wates success is that they realised at a very early stage the importance of the computer staff understanding the Construction Industry. For this reason they selected construction men of varying disciplines within the Group and trained them to be Systems Analysts and Programmers. In this way all the systems that Wates operate have been designed and implemented by Construction men.

The Wates integrated system is a very good example of the sensible application of computers to an Industry. The system performs both an Accounting and Management Information function. Payroll is a good example of a straight forward Accounting function whereas the Forecasting System takes information and presents it in the form that senior management require in order to monitor activity.

The components of the integrated system are considerable subjects in themselves. This is merely a brief overview of each system and does not go into technical concepts of design or physical operation.

The first set of information to be fed to the system is generated during Week 1, and thereafter at regular intervals during the life of the project. Results produced by the computer not only facilitate management control by measuring delays but predict precisely how every task affected by these must be rescheduled and what extra resources, if any, will be needed to meet the target date.

An example may help to illustrate how the system works. Say plumbing is completed in only four units instead of six scheduled for Week 20. The Forecasting Program will first calculate how this delay (plus any others that may have occurred) affects tasks which cannot commence until plumbing has reached a given stage or has been completed. The computer now knows the number of units yet to be done for every task. Finally, it applies the individual algorithms to map out an amended schedule. For plumbing, it might forecast that five units must be completed next week, seven in each of the next four and two in the weeks succeeding these. For wall tiling, the pattern might well be different, since the use of extra labour or of overtime might make it possible to adhere to the original schedule.

Those familiar with PERT or CPA methods will appreciate that this Forecasting System is considerably more sophisticated than either of these.

1. ESTIMATING

CREST is a system that has been developed by Wates over a number of years.

Crest is a computer system designed to give control over the design and estimating processes in building. It entirely eliminates manual calculation at every stage, rationalises the recording of basic detail, greatly reduces clerical work, ensures accuracy, and provides the means immediately, fully and inexpensively to assess the cost effect of any proposed changes in specification.

2. BUDGETARY CONTROL

Estimate details (whether or not produced by the CREST system) are held in computer files where they represent a budget against every section of work - e.g. excavate foundations, concrete pile caps, plumbing stacks, etc. Each week, progress is recorded in a format that corresponds with that of the estimates. This detail, fed to the computer, is compared by it with estimates already held on file, thus enabling it to produce a print-out showing performance to date. The report is given for each section of work and analysed under Labour, Materials, Plant and Subcontractors.

3. THE FORECASTING SYSTEM

The forecasting system is a suite of highly sophisticated computer programs for the accurate monitoring and control of medium to large-size building projects.

4. PAYROLL SYSTEM

Designed specifically for use in the building industry, this system automates the calculation of pay and the production of individual documents and records. A weekly input of Ministry number, hours worked and other items such as subs, sick time and so on, is used to produce a payslip for each employee. Tax, National Insurance, holiday stamps, inclement weather, are all provided for, and a coin analysis is also produced. Chief benefits of computerising payroll are enhanced accuracy and considerable time-saving on site or in wages departments.

5. LABOUR COSTING AND CONTROL

This computerised system provides detailed management information on all labour and plant items each week for contract, site and section managers. Details of the estimated costs of each project are maintained in a computer file, and records of progress are fed back to the machine, which compares actual results with the tender and the target and calculates any bonuses payable.

6. SUBCONTRACTORS

Details of all orders are held in computer files. Information on weekly and monthly progress of subcontract work is fed to the computer, which then calculates the amounts payable. Items

such as discounts and retentions are taken into account, and the system produces a series of printouts which include sub-contractors' efficiency reports, accounting reports, remittance advices and cheques. Again, costs are automatically transferred to the budgetary control system.

7. PLANT

This system covers both management and accounting for a plant depot or hire company. Starting point is a computer file of detailed information on each piece of plant operated by the user, minor plant, however, such as drills probably being grouped together for convenience' sake.

Each time a piece of plant is used or maintenance is done, the computer is notified. At intervals determined by the user, it produces reports which inform management of utilisation and profitability, including costs and time of repairs, broken-down time, and idle time, comparing these statistics with budgets for similar items. Accounting information produced by the system includes revenue accounts, asset accounts and invoicing.

The whole system or any of its components is available for outright sale, 'over the counter' bureau, or RJE usage.

# INTEGRATED SOFTWARE FOR DESIGNING AND DETAILING BUILDINGS

by Christian Diet S.I.G.G.M.A. - Paris

## INTRODUCTION

The Graphic department of S.I.G.G.M.A. helped by its research and development department has developed some integrated software for use in the design of civil engineering buildings.

This software aims towards the automatization of most of the calculation and drawing found in the design departments of the building industry.

The computer output from the technical programs can be used as inputs for programs concerned with such problems as administration, price quotation, list of component etc.....

Most of the studies are carried out on our company computers i.e.

- one IBM 1130 16 K connected to a 360.75
- one IBM 1130 8 K
- one IBM 3/10 disk

## CONCEPT OF AN INTEGRATED CHAIN

A - The "cut to measure" idea instead of "package system".

We do not provide packages of software. Experience has taught us that standardized programs never meet with all clients requirements unless they are monsters that cannot be operated.

B - Computer input.

The only input which is needed is a summarized description of the architects sketches.

From this information alone the computer software will produce the following output:

a) Preliminary plans, quotations.

- general arrangement plan
- estimates
- specifications

b) Technical data.

- calculations

c) Fabrication drawings.

- general arrangement plans
- detailed drawings
- manufacturing drawings

d) Administrative output.

- price list, bill of quantities
- stock control
- purchase orders
- production planning
- data for accounting

## THE ADVANTAGES OF THE CHAIN APPROACH

The advantages of the chain approach may be summarized as follows:-

A - Financial advantage :

Fewer plans have to be executed by hand.
Many companies now working with our programs using an IBM 1130 connected to a plotter have reduced one month of a draughtsman's time to two days of filling data sheets and a few hours of computer work.

B - Cut in delays :

The original drawing time is generally reduced by a factor of ten and also the delays in answering and quoting are on much the same scale.

C - Coping with a fluctuating work load :

Nowadays it is hardly possible to find the qualified draughtsmen necessary during peak periods and just as hard to dismiss them during slack periods. With tremendous work power and related low cost the computer eliminates the problem.

D - Great possibilities in development :

One of the major advantages of the system is to enable a firm to answer all enquiries as the complete set of drawings and estimates are output by the computer readily and at a low cost.

E - Manual errors are avoided :

Manual method always produce a certain percentage of errors.
Once the programs have been tested and working the computer cannot be wrong.

## THE HARDWARE NECESSARY TO IMPLEMENT OUR SYSTEMS

Each of the chains consists of about 40,000 or 50,000 Fortran instructions and they have been made for small computers of the IBM range (i.e. IBM 1130, IBM 3/10 and IBM 3/6).

They can also use terminals such as RAX, CALL 360 and CRBE etc...

Of course larger size computers such as IBM 370's and quick terminals such as IBM 2780 can operate our software.

## TRADITIONAL OR INDUSTRIALISED STRUCTURAL STEELWORK BUILDINGS

These programs can deal with :
- factories, office blocks, agricultural buildings, etc...

A - Main input

Description of the architects sketches and the main technical specification.

B - Computer output

a) Preliminary project

- general arrangement plans
- quotations, estimates and specifications

b) Technical calculations (already operational in the industrialised field is being achieved in the traditional type of building).

- wind braces
- stress calculations and actual choice of steel sections
- connecting outputs so as to check calculations by IBM programs "Stress and Strudl".

c) Fabrication drawings

- general arrangement plans and elevations
- assembly drawings FIG. 1
- fabrication drawings for the workshops (as these plans are computed, a paper tape can also be produced by the computer to be used with numerical control machine-tools). FIG. 2 to 7.

d) Other data

- price list of all materials
- stock control
- minimisation of waste in bar cutting
- planning
- all the above computed information could be used as input for a management chains of programs.

## LARGE CONCRETE PREFABRICATED PANELS SYSTEM

(Building with prefabricated reinforced concrete panels.)
This technique which has spread all over the world allows for the rapid erection of office blocks, housing schemes, etc...

A - Main input

Data sheets are completed with information taken from the architect's plan showing positions of the panels and inserts.

The average time to fill a data sheets by a relatively unskilled employee can be approximately half-a-day for 5,000 square meters of floor.

B - Computer output

1) Calculations notes of :

- wind braces
- stresses
- steel in panels and foundations

2) Detailed plans of casting and reinforcing of all panels in the building for :

- facades
- partition walls FIG. 8
- slabs FIG. 9
- plans of the different moulds, optimisation of the filling of moulds FIG.10
- general location plan FIG. 11 - 12
- foundation plans

3) Bill of quantities

- casting surfaces and volume of concrete
- steel weight
- bill of quantities of all the building components
- scheduling of the fabrication of the panels
- output required by the cost accounting department.

## REINFORCED CONCRETE BUILDINGS

In this field where the techniques employed vary from one firm to another, we have given the civil engineer facilties for incorporating his own methods of calculation.

A - Main input

Description from the architects plan of :

- walls
- beams
- balconies
- columns
- openings
- loads

B - Computer outputs

a) for the preliminary plans at the quotation stage.

- casting plans
- rough estimate of the main walls, slabs and foundations of the building.

b) For the plans : at the time of order.

- casting plans
- reinforcing plans and calculations of :
  . beams
  . columns
  . slabs
  . floors
  . section through the building
  . concrete volume
  . steel weights and order material lists of all steel
  . some output for the cost accounting department.

This software cannot handle all the particular cases that can arise but can deal with some 80% of all cases.

## PLANS AND ESTIMATES IN ARCHITECTURE

In the field of architecture, the computer can help the architect by producing detailed drawings and estimates leaving him free to concentrate on design.

A - Plans and estimates

a) Main input :

Description by the project manager from sketches and the type of materials employed.

b) Computer output :

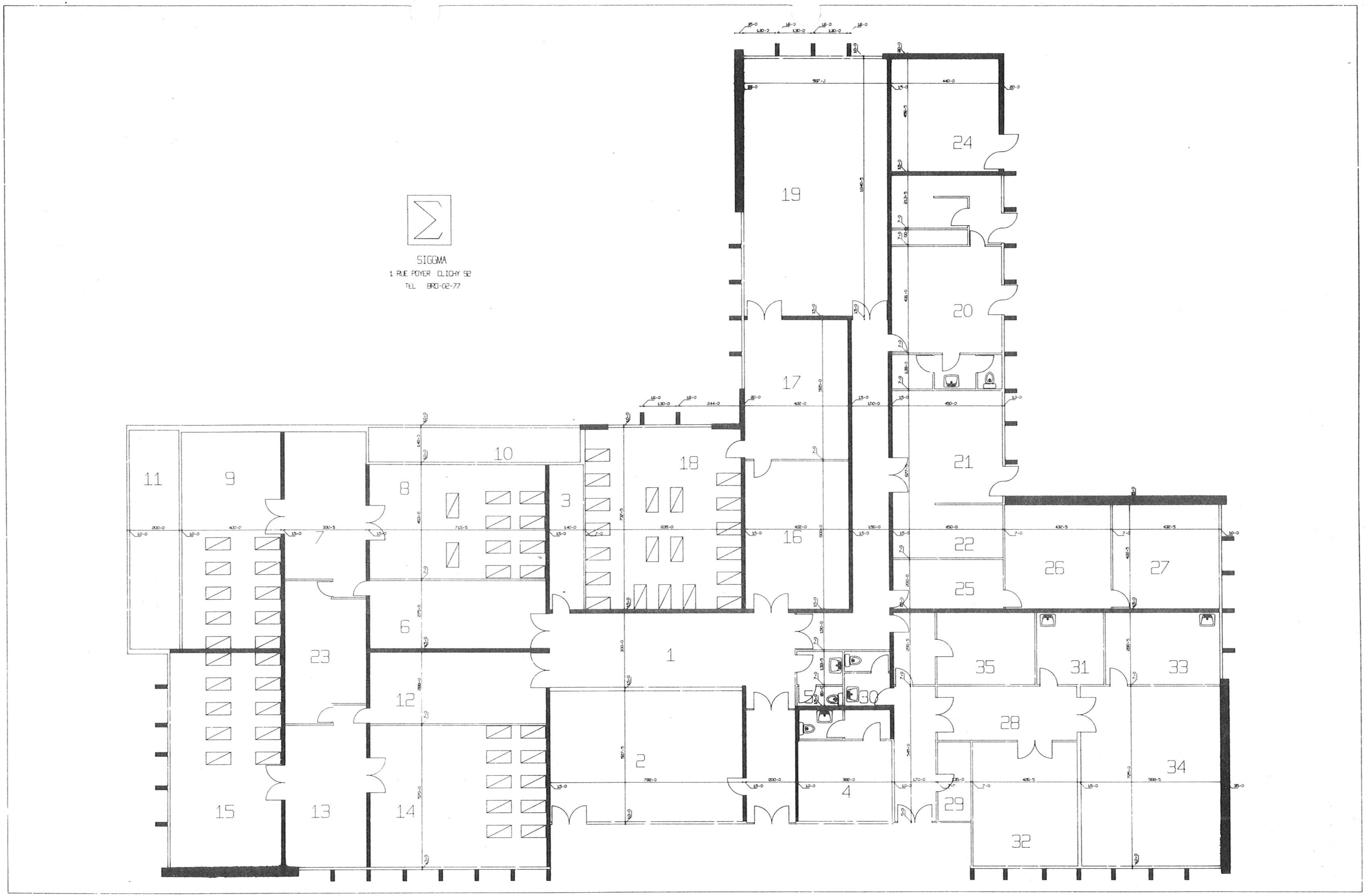
- architects plans
- estimates
- specifications
- elevations

B - Interactive design

The description of the sketch will enable the computer to achieve all the process described under A (b) above.
From this output the architect will be able to alter whatever he wishes (position of walls for instance) by describing the new position of these elements.

The modifications would automatically relocate all other walls or partitions that are related to it. All financial consequences of these alterations will be read on the printer (new value of surfaces for every room and so on) and according to the architect's wish a modified plan will be issued in a short time and at very low cost by the machine.

Each plan will have a scale according to its requirements. The interactive technique enables a dialogue to be carried on between the machine and the architect. This dialogue can be performed on a cathode ray tube in order to speed up all these processes.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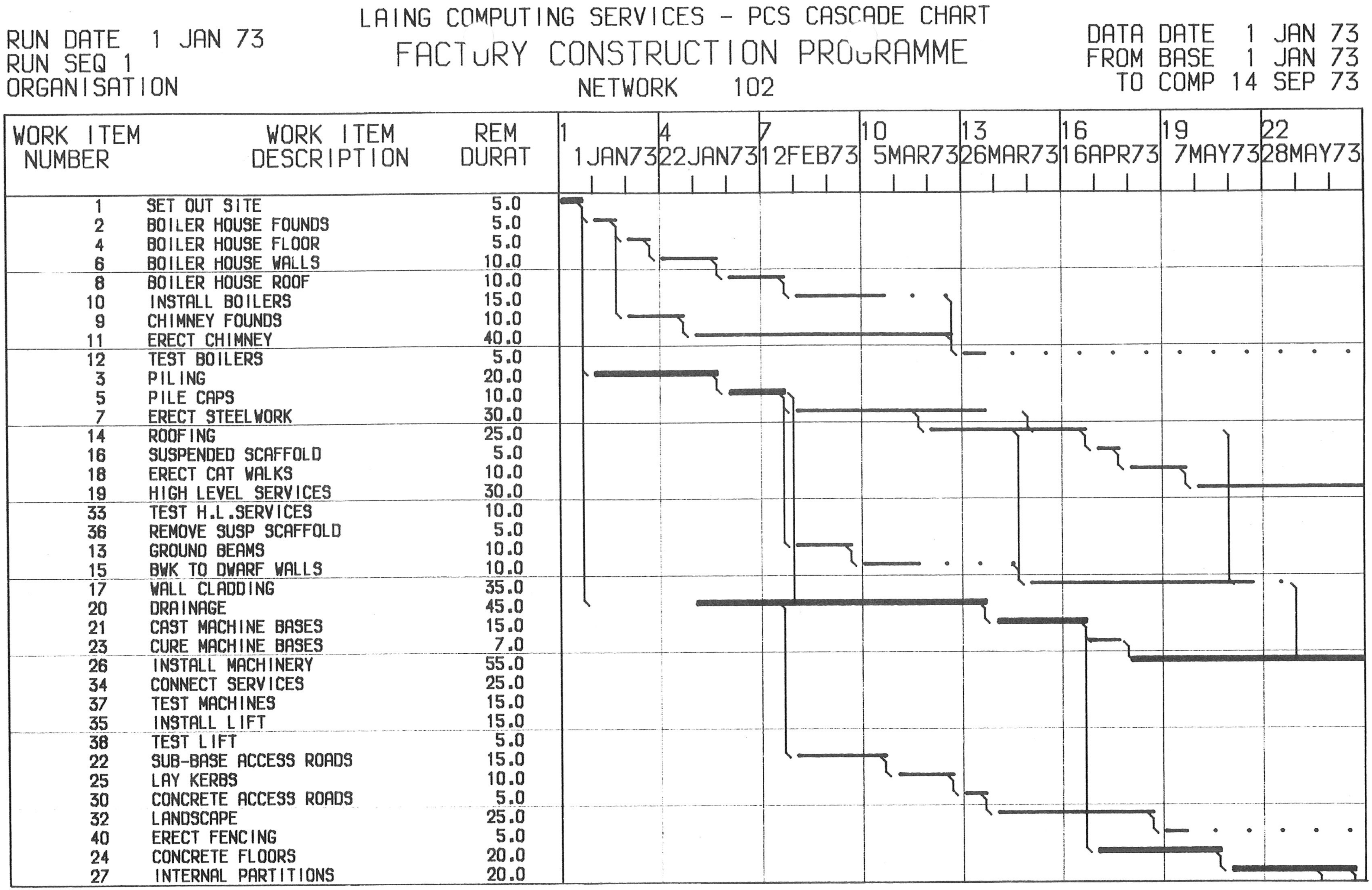


Fig. 1. Part of a Cascade Chart produced by graph plotter.

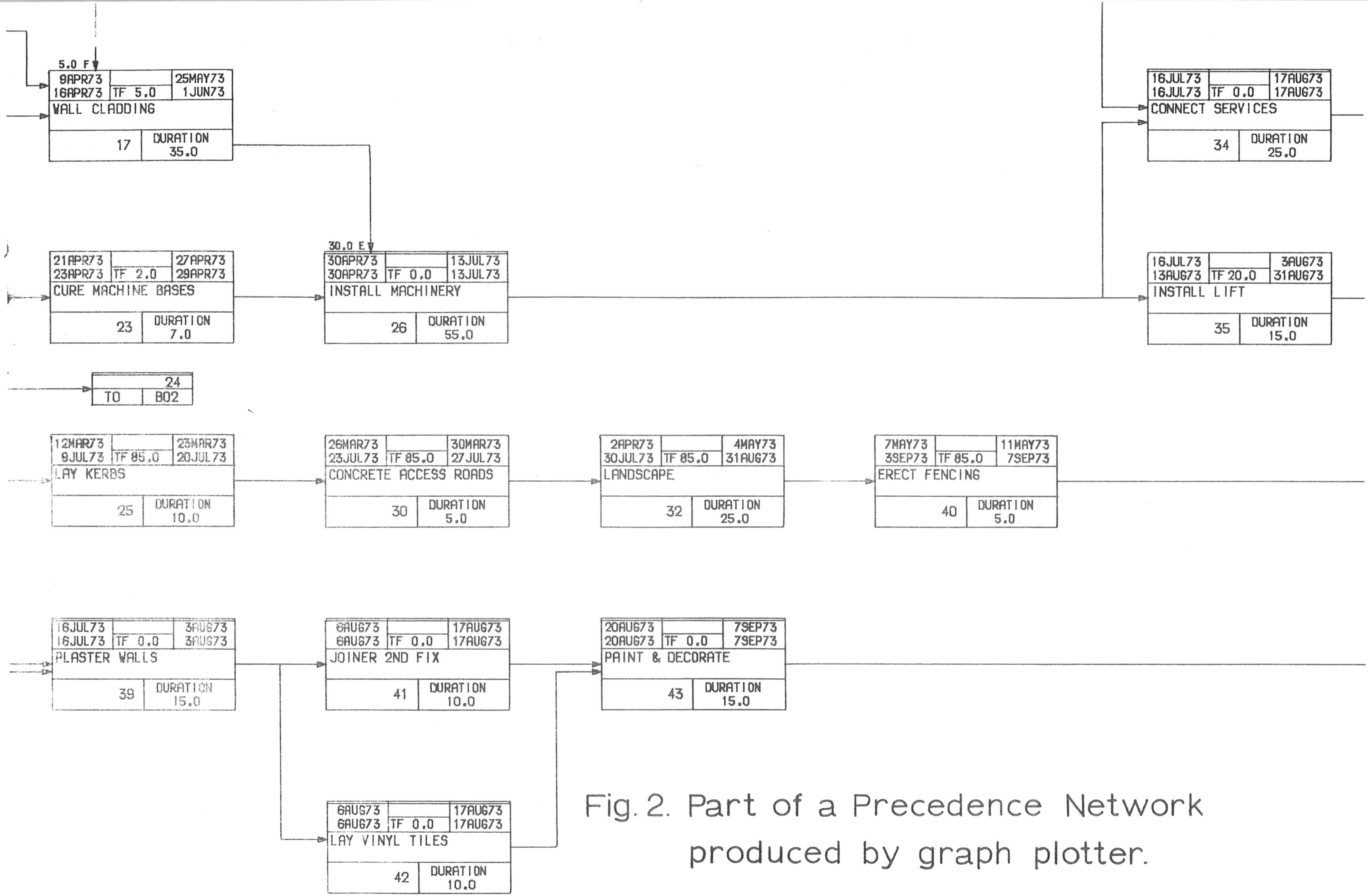


Fig. 2. Part of a Precedence Network produced by graph plotter.

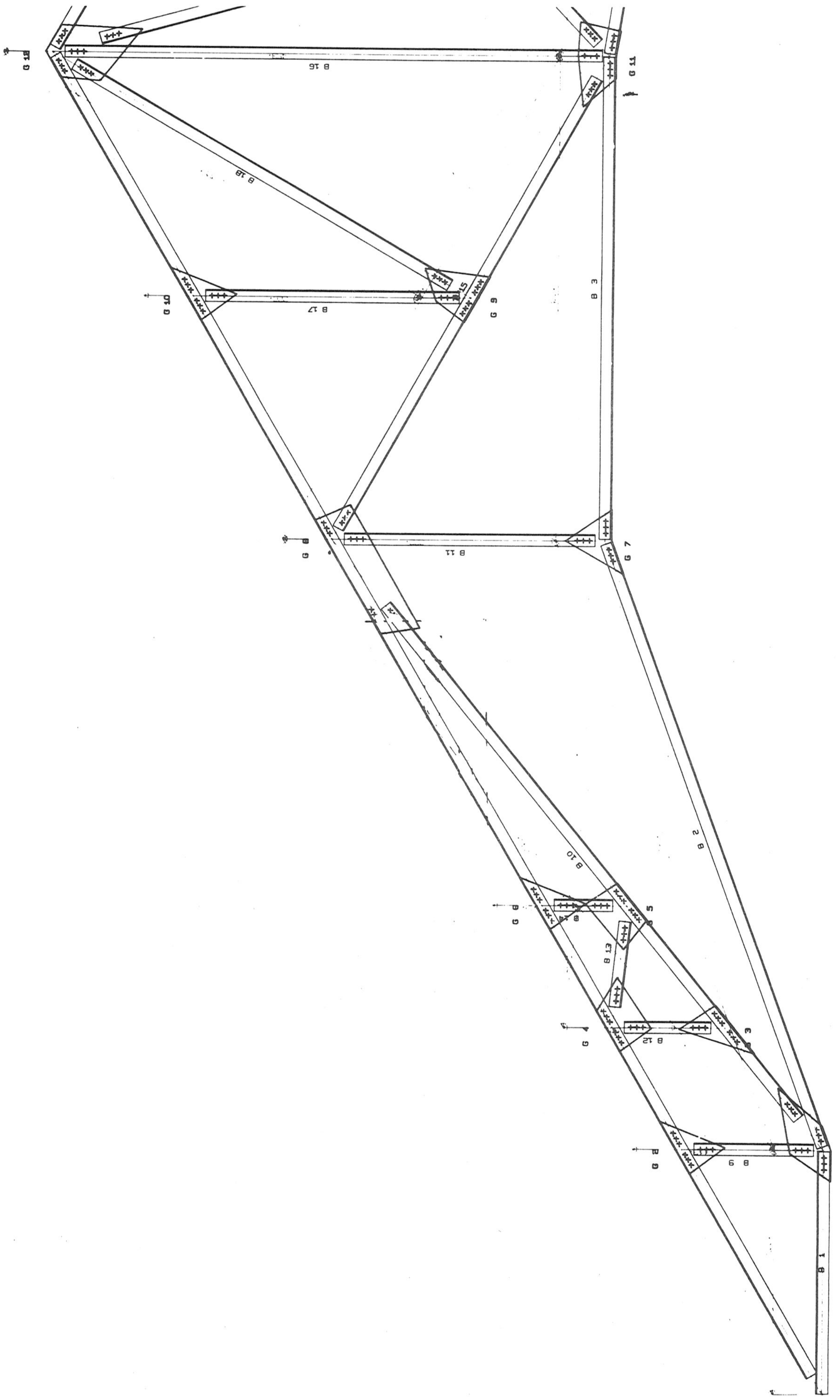


Fig 5.

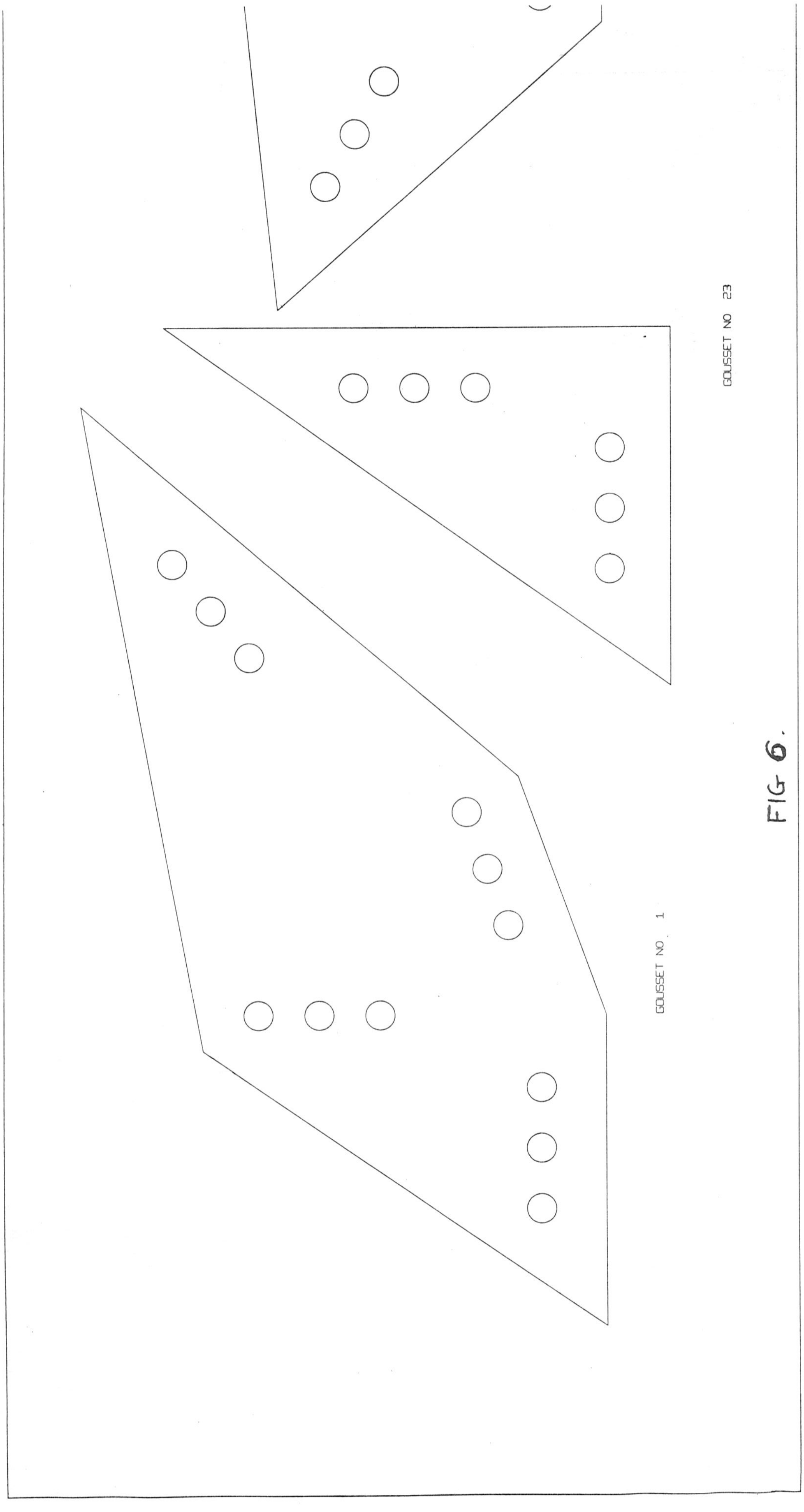


FIG 6.

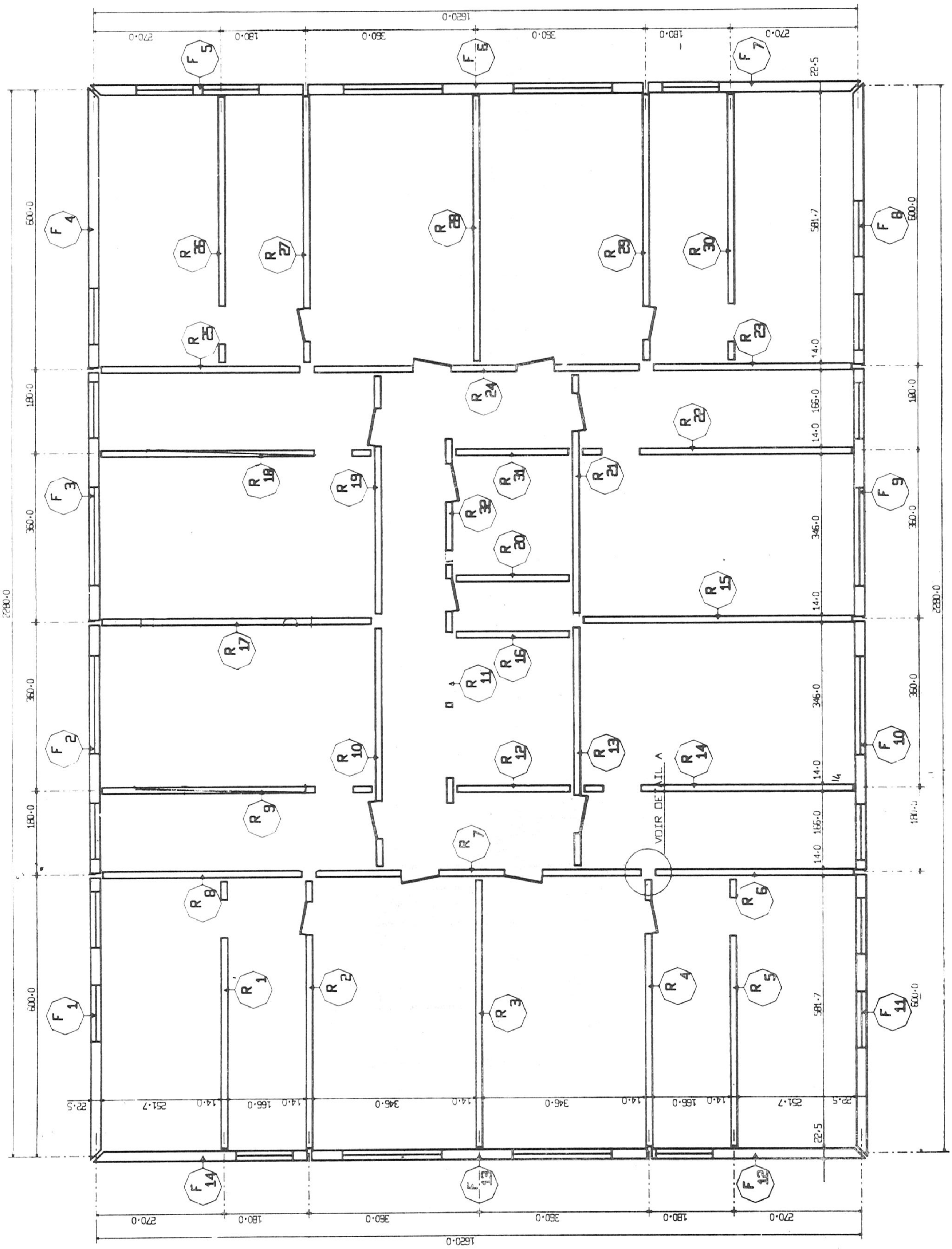


FIG 9.

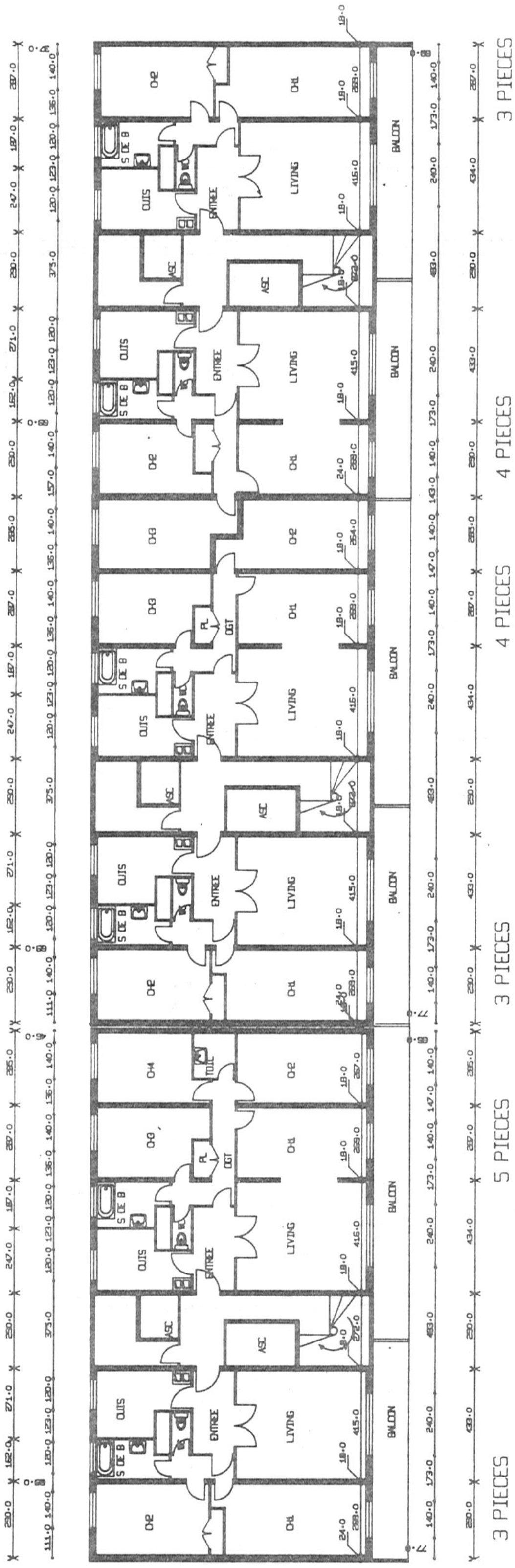
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FIG 10.

Session 4

# COMPUTER ASSISTED STEELWORK DESIGN

by A.P. Dorman MA, DIC, CEng, MICE (CONSTRADO)

The object of this paper is to review various recent developments in computer-aided design (CAD) techniques for the structural steelwork and to examine these in the light of the needs of the particular user's requirements.

The main objective in using CAD techniques is to increase profitability by reducing design and production costs. These cost reductions are brought about in the following ways:

(a) better quality designs will be achieved by the engineer, who will be relieved from much routine work and be able to devote more of his time to conceptual design;

(b) computer based techniques for the analysis and design of structures enable the engineer to consider a wider range of solutions and so, hopefully, produce more economical structures;

(c) a reduction in design time which enables full detailed drawings and costs to be prepared quickly.

The actual design process for a steel structure, which may be defined in broad terms as the complete procedure from the receipt of some sort of brief, to the actual erection of the structure, may be broken down into various stages, each of which may be regarded as a cyclic operation in information handling.

Information is received from a previous stage (for example, the structural engineer receives details of the proposed building configuration) and acquired from other sources (he obtains details of structural safety requirements from various codes and standards).

This information is processed and new information is produced.

Finally, the total information is transmitted onwards to subsequent stages in the design process.

The situation is complicated by the need for interchange of information between parties to the design process each of whom has a different economic viewpoint. The paper describes these various parties in some detail and attempts to relate the computing needs of each to the production of a final building. This apparent conflict of interests can be overcome only by means of a standard convention procedure for the transmission of information between stages of the design process. The requirements of such a convention are discussed, and the part to be played by CONSTRADO in its development is described.

The requirements of the potential user-consulting engineer or fabricator- are examined, and the types of program which can most nearly meet these requirements are discussed in some detail.

The second part of the paper comprises an examination of several examples of computer assisted design in practice. The techniques described are, with one exception, employed by firms engaged in the production of fabricated steelwork, or intended for their use. The one exception is an example from Canada, where a series of programs has been developed by an organisation engaged in the promotion of steel in construction, for use by consulting engineers.

The third, and final, part of the paper discusses the future plans of CONSTRADO, also a promotional organisation, for the development of CAD techniques for structural steelwork.

Session 5

# HOUSING DESIGN SOFTWARE: A WORKING SYSTEM

by

A. Bijl, University of Edinburgh and D.D. Smith,
SPL International

The purpose of this paper is to describe the computer aided House Design system; what it is and what it does. This system has been developed by Edinburgh University CAAD Studies, under the joint sponsorship of the SSHA and DOE, and the resulting software is being made available under license from the NRDC.

This is a computer aided architectural design system, i.e. the computer is used to aid the designer in obtaining and manipulating information which he may consider to be relevant. Interactive computer graphics has been employed as the means by which the designer communicates with the computer data structures.

The system is based on the use of highly structured data structures, which are built up within the computer as the designer builds up or modifies his description of a design proposal on a graphic display. This allows the designer to call for computer evaluations while the design description is being developed. The ability to carry out a variety of evaluations on the same design description characterises the system as an integrated design aid, supporting the generation of both building design and production information. The current range of evaluations cover room area calculations, materials quantities and cost, construction, structure, and daylight; and these evaluations are performed at a level of detail normally associated with practical building projects.

Initially, this system has been developed for use by the SSHA, to be applied to its operations in the field of housing. The system has been designed to cope with single and two storey houses with level floor plans, constructed of no-fines concrete or brick work. Its primary function is to introduce detail modifications to existing common range house types, to suit particular building requirements of any new site, local regulations or standards, or of local construction practices. The consequences of such modifications are automatically evaluated. Output from the system is in the form of drawings on paper, and the House Design system is interfaced with an SSHA program called SLID to produce bills of quantities.

A feature of this system is that it operates at a level of detail which does not require the use of standard house plans or building components. Instead it is based on the use of standard details of junctions between components. Even at this level it is not essential that the information contained in such details remains standard, as the system is based on the relationship which exists between separate items of information, i.e. the organisational structure and the permissible manipulations which may be performed on the information.

The initial benefits of this system to the user may be summarised as follows:

a) Rapid access to cost information, as a consequence of design modifications.

b) Improved ability to take advantage of variable market conditions in the construction industry.

The paper also discuss the degree to which these ideas can be applied more widely. It is possible to make out a case that a computer aided building system dedicated to simple 2-storey housing can be applied to a number of different users without substantial redevelopment of the programs.

A market survey has been carried out under the auspices of the NRDC which has canvassed the reaction of a representative sample of possible users. The response has shown that many architects in large house building organisations are sympathetic to the ideas of using computers in design and production documentation. They do not however have the financial and technical resources to develop such systems from scratch; but the existence of a system of this kind which provides solutions to the fundamental thinking and planning can be seen to be a major advantage in making the use of CAB techniques more widely accepted.

The paper will discuss the size of the potential market in the UK, the demands of the system on the user and the degree to which the present house building authorities are already prepared. Some of the problems of making the system useful in practice will be discussed and an outline of the planned approach to marketing the system can be stated.

Session 6

# SYSTEM PROKOR

Mgr. Inz. J. Wojcik,
Centrum Etob

The PROKOR system/Programme for Control of Realisation/provides for the dynamic management of complex projects. The project itself is described in the form of network activities but, compared to classic PERT, system PROKOR allows for greater variety of time limits and tolerances.

The basic difference between PROKOR and other planning systems is that PROKOR system treats the project as a sequence of activities whose duration times are random variables with different density of probability. Therefore it is useless to improve an algorithm to calculate exact results because any unequivocal results are unrealistice ones. Thus the efforts to prepare an ideal plan are fruitless and time-consuming. The problem lies not in planning but in permanent control and steering of the project. All main decisions must be undertaken by coordinating team. A computer is only a tool for storing, analysing and selecting input data and for proper drawing of schedules and printing of plans. On the other hand the coordinating team has to have special ultra-operational reserves of time to provide a smooth progress of work.

The input and output data of the system are adjusted to the specific habits of customers.

The basic concepts of system PROKOR were developed between 1967 and 1969.

Since then PROKOR has already been applied to the control of some 300 projects. These have ranged in size from a coca-cola factory costing approximately 30 million Zloty (approximately £500,000) to the Petrochemical complex at Plock (2,000 million Zloty - £35,000,000). Most projects controlled by PROKOR have been industrial construction complexes but the system has also been applied in the areas of civil engineering, design offices etc. At present about 100 projects are using the system.

Last year the Government Commission of Experts accepted PROKOR as a leading system in the field of steering and control of construction projects in Poland.

This means that the future requirements for using PROKOR are very large. In fact at present the limiting factor is the availability of computer time.

The principle benefit of applying PROKOR has been in the shortening of the project implementation cycle. This has been reduced by between 20-50%. The Coca-Cola factory mentioned above, for example, was completed in 4½ months against a planned time of one year. In this case the large saving was due to over-cautious planning as well as to PROKOR. However, the use of PROKOR enabled this to be discovered at an early stage.

PROKOR has already been developed on 3 types of computer - Zam 21, Minsk 32, and Odra 1304 (Compatible with ICL 1900). Total development of both the prototype and current versions of the system on all 3 computer systems has taken nearly 40 man years of effort.

ETOBSYSTEM (The Department for Designing Information Systems and Managerial Advice in the Building Industry) is the directing organisation in the application of the PROKOR system.

The cost of applying the system falls between 0.5 to 1.0 per mille of the total value of the project.

Session 7

# SITE PLANNING WITH NETWORK ANALYSIS

P. T. Rist,
Production Technology Department,
John Laing Construction Limited

## A B S T R A C T

### Network Preparation

On most contracts, a master programme of about 200 activities is drawn. On small sites short term programmes covering three to six months at a time are prepared, based on the master programme. On larger projects section programmes, each covering a major section of the work are drawn. Each is linked to the master programme. From the section programmes short term programmes are prepared together with special ones for sub-contractors etc.

The Company stopped using arrow diagram networks some years ago in favour of precedence networks. In precedence networks each activity is represented by a box instead of by an arrow. Arrows are used to show the sequence of work and are called relationships. Many of the shortcomings of the arrow technique have been overcome by such facilities as lags in relationships which permit overlapping activities, and the elimination of dummy activities which helps to reduce network size.

### Network Processing

Many smaller networks are processed by hand. This is a slow process and it is easy to make errors. The finished result - a network with early and late times all over it - is not very suitable for issue to site users. For this reason the Company developed a method of manually processing networks which at the same time produces a linked bar chart called a Cascade Chart.

Each path in the network is numbered sequentially in turn and the activities are listed in numerical order on a programme sheet. The network is then re-constructed as a bar chart using the durations of the activities and the logic of the network to determine the timing of each activity. Relationships are drawn as thin vertical lines linking the bars. The critical paths and free float are clearly shown. In this way the time calculations, normally done as a forward and backward pass, and preparation of the finished output are carried out in one operation.

Larger networks are processed by a modified version of the IBM 360/PCS program run on an in-house 360/50 computer. The program produces Cascade Charts in two versions. One is printed in vertical strips on specially printed grid paper. The strips are then taped together and the relationships drawn in by hand. This version is a poor imitation of what can be done manually, and the second version is produced by a C.I.L. graph plotter running off line. Up to 200 activities can be plotted in sections and taped together. All relationships are plotted automatically and the standard of presentation is very high. (See fig. 1)

Another frequently used report is a schedule of activities specially written to give full details of each activity and its relationships with other activities. This supercedes three of the standard P.C.S. outputs and gives the description, duration, early and late dates, float and scheduled dates for each activity. Beneath each activity are listed its predecessors on the left and successors on the right.

Factors governing use of the computer

In general, computer processing is used for networks of 100 activities and more. Large contracts make the most use of network analysis. These contracts range in size from £1.5 million to £35 million. Nevertheless, networks have been processed by computer for contracts valued as low as £70,000 and programmes as small as 50 activities. It is economical to process very small networks if they are to be updated frequently since the planner is saved the time needed to re-draw the Cascade Charts and, if additional facilities such as resources, costs, or restricted outputs are required only a computer can do this quickly and accurately.

Operating Procedures

The program is operated by a small planning section which acts like a bureau in providing a service to the construction site users.

The precedence networks are prepared by the planners on the sites who also complete the input forms. In most cases the forms are sent by Securicor or first class mail to our Head Office in London. The planning section is responsible for organising punching, processing and despatch of outputs. Outputs are returned by Securicor. Data for all minor alterations is handled by telephone. On one site where paper tape punching facilities are available data is transmitted by Datel link.

With contracts scattered all over the British Isles communications are the main cause of difficulty in maintaining a short turn round time. At present it takes between 18 and 40 hours from the time the input forms leave the site until receipt of the computer output back at site.

Additional Facilities

One of the advantages of a central planning section is that it can act as a clearing house for new ideas and suggestions for improvements. Nearly all the program enhancements to date are a result of suggestions from sites. An example of this is the development of a program for drawing precedence networks using a graph plotter (See fig. 2). Some clients require a copy of the network and the program replaces the process of getting the rough draft of the network re-drawn by a draughtsman, then checked by a planner.

Choosing a Computer Program

At first the Company used computer bureaux to process networks, but after our own machine was installed it was decided to process 'in-house'.

There were three alternatives:-

(a) Write our own program.

(b) Have a program specially written.

(c) Buy a package program.

The first option was rejected because programing resources were not available, it was expensive and it would have taken a long time. The second alternative was also rejected because it was expensive and would have taken a long time. Only two suitable programs were available under alternative (c). One had to be purchased; the other was free so we used it. This meant of course that a working program was available immediately.

<u>Disadvantages of a Package Program</u>

It is impossible to write a general program which will satisfy all users. However many of the problems experienced could have been avoided if more care had been taken by the originators of the program in researching users' needs and in attention to detail.

Examples include:-

(a) When it was first used there were no input forms for the program.

(b) The program is designed primarily for use in the construction industry. Most construction programmes are in weeks but PCS outputs are available in days only.

(c) None of the standard reports give the user a comprehensive schedule of information about all activities in a programme. A report had to be specially written for this purpose and it replaces three standard outputs.

(d) The standard P.C.S. bar chart output chops the chart into single page sections. An early attempt to use this output resulted in 96 pages, most of which had to be trimmed on all four sides before being taped together. The chart was only available with a horizontal scale of one print character per day. This resulted in a bar chart for a $5\frac{1}{2}$ year project 17 feet 6 inches wide. Such absurdities to the computer industry a great disservice among ordinary users and sadly such things still occur.

A lot of money has been spent developing and improving the P.C.S. program. Although it is impossible to put a price on the other alternatives, it is likely that the choice of a package program was the cheapest. Users' requirements have changed over the years and a specification for a specially written program prepared five years ago would be out of date by now. Therefore the Company would have suffered the double expense of paying for a new program and paying for developments and improvements to that program.

## Future Requirements

It will probably not be economic to make any more major improvements to the P.C.S. program. Our experience to date shows that we now need a large package program with comprehensive time processing facilities including many user options. Additional Resource and Cost modules are required plus a powerful report generator. The report generator should use a high level language so that outputs can be quickly and cheaply designed for any purpose. Unfortunately, at the time of writing, no package satisfies all our requrements.

Session 8

# THE RUNNING OF PERT FROM A REMOTE TERMINAL

J. A. Black, Merz and McLellan

The terminal is an ICL 7020 situated at our Head Office at Newcastle, and is linked to an ICL 1904A at Bracknell.

By using a terminal, only a limited number of staff are required, however, it is important that close liaison is maintained with all user departments.

The link between the Computer Department and the Planning Department is the Pert co-ordinator. His responsibility is to advise on the use of Pert, organise the setting up of new networks for the computer, and arrange for them to be run. The Computer Department are responsible for running the Pert programs, and advising the Pert co-ordinator of techniques that can be used to either speed up or cheapen the running of Pert.

The creating of a new network on Pert, or updating an existing one, is carried out in two distinct phases. The first phase is to create or initially update a network, then identify and correct any errors. The second phase is to obtain and distribute all the necessary reports.

In creating a new Pert network the following steps are generally followed for the first phase.

The arrow network is drawn up by the Planning Department and the coding of the activity nodes formalised. The information for the network is then transferred to standard coding sheets, and the run directions prepared.

When all the data has been punched onto paper tape it is input to the computer and a filestore file set up, then listed back onto the line printer.

This is sent to the Planning Department and the information checked by them for errors. Any alterations required are marked on the listing and returned to the Computer Department. To modify the filestore data file the George 3 Editor is used. This is very fast and saves any re-punching. With the editor we can add or delete items of data, also change individual characters within a line. While the edit is being done Input/Output control prepares the job instruction for the PERT run.

The job instruction is typed direct into the terminal console typewriter, and the initial run is done.

Any errors are detected and reported on, also any outputs requested will be produced. After this the Planning Department check the results, prepare amendments to logic etc and pass the information to the Computer Department. The cycle is repeated, and continually repeated until the network logic is correct.

The second phase is much shorter and consists of a PERT 'Select' run. With this all necessary reports are produced. Normally the reports are listed off at Newcastle Office, on the 7020, however if these reports are excessive ie in excess of 300 pages the lists can be taken off at Bracknell on the high speed line printers, and either sent to Newcastle Office or to site direct.

In order to keep costs down as much as possible Pert is run at night. Usually time does not allow listing the reports at night so they are held in filestore. Next morning, using a very simple command all reports are listed. Likewise selected reports can be saved indefinitely for re-listing at a later date.

The normal time scale from output of error list in phase 1 to output of reports from phase 2 is, check during morning, amend data file during afternoon, usually for running late that night. Reports being ready that evening or at the latest first thing the next morning. Normally most PERT jobs can be turned round within 48 hours, large networks may take 72 hours ie two validation runs before correct output run.

Session 9

# BASE RULES FOR BUILDING UP INFORMATION SYSTEMS IN THE NETHERLANDS CONSTRUCTION INDUSTRY

Arnout M. Bouman
Stichting Bouwcentrum, Netherlands

Within the next few months the foundation of the Netherlands Association for the Co-ordination of Information handling in the Construction Industry is to be expected. Amongst the founding members will be the principal organisations in the Netherlands Construction Industry, such as the Ministries of Housing and Planning and of Transport and Waterworks, Associations of Architects and Contractors and the Municipalities of Amsterdam and Rotterdam.

The aim of the Association will be to develop a set of Uniform Base Rules according to which various Standards for various purposes may be developed by others, in their turn facilitating the production of Project Documents and ensuring the relation between these, and of these with General Information Documents, such as regulations, commodity information and production data.

In pursuing this aim the Association will implement the recommendations of an industrywide Study Team of the Building Research Foundation, which has investigated the feasibility of introducing one or more of the existing classifications designed for use in the construction process uniformly throughout the Netherlands construction industry.

The Study Team has found that none of the classifications investigated satisfied the criteria for uniform application, developed during the study, because they were lacking in:

- clear directives for the construction of classifications
- a balanced framework of categories (also called facets)
- a range of terms, adequate for all parties
- operational formulations of objectives of application of the classification tables.

It concluded that uniformity in information handling should be pursued for the improvement of communication, and that it can only be achieved through the application of "Uniform Base Rules".

These Base Rules, parts of which have been developed in the course of the study, will consist of:

- Directives for the Formation of Information
- a Framework of Core Concepts
- a Thesaurus
- Models of the construction industry for the formulation of objectives in mutual relation
- criteria for the evaluation of information systems.

The Study Team, in reaching these conclusions, has made considerable use of the developments of the Working Party on Data Co-ordination of the Department of the Environment of the United Kingdom. Furthermore it gratefully acknowledges the help of many sponsors of the classifications investigated in providing documentation on these and filling in the inevitable and lengthy questionnaire. The Working Party has proposed that the international exchange of knowledge and experience in this field will continue and be broadened.

Session 10

# PROJECT INFORMATION STRUCTING AND ITS EFFECT ON COMPUTER APPLICATIONS

Peter F. Miller MIOB., MFB

J. Sainsbury Ltd.

Project information is the whole set of data and information necessary to the design and construction of a building, its contents and site environs in a state of control.

The manner in which the data is processed by the specialist concerned is the procedures and modes of calculations. The data which is the product of one procedure is usually a part of the input to the next. The data is usually transferred by use of documents, e.g. drawings, bills of quantities, construction programmes, etc.

The classification of data has facilitated the identification of data types, e.g. locational data, timing data, quantitative date, etc.

The work on structuring has so far been devoted to the collection of sets of data types transferred between procedures. These sets have been based on the premise that project information is to be considered as a whole and not as currently sub-divided by the present day 'important' documents or the rates of the specialists.

The idea of creating a structure and then fitting the data into it was rejected in favour of listing the types of data encountered together with the procedures used and then scheduling sets of data for each transfer. Each of these sets is a project information sub-set, each was arranged or 'structured in a convenient order, if necessary in several patterns for differing levels of details in the preceding and succeeding procedures, producing and using it respectively.

The initial work related these sub-sets of structured data to the principal procedures of the construction. This was subsequently re-ordered so that it could be seen from the point of view of the principal documents which would be prepared by the design team. In this case the origin of the data 'design team' or 'contractor' was a basic division, the others related to the procedures of 'Invitation/Acceptance', 'Estimating and Planning', 'Procurement of Resources', 'Legal', 'Payment and Finance' and 'Construction' for each of which a document could be prepared.

The whole of the work has been based on the needs of the information user's being met by the information producers; concepts unrelated to the practicalities of the design realisation and construction stages have been noted but ignored.

The results of the studies are currently being tested and these tests will be discussed.

The talk will relate the work on structuring to earlier work on coding and data co-ordination, to future work on the development of bills of quantities and specifications and then correlate the practice and theory of the structuring to computer applications of design control, cost control and production control.

INVITATION - SELECTION OF PROJECTS (RIBA Plan of Work Stage H)

| | | | | |
|---|---|---|---|---|
| T E N D E R | ESTIMATING | Planning strategic (general) resources | type<br>quantity<br>timing | ( " Stage J) |
| | | Pricing | resource costs<br>site working costs<br>contingencies | |
| | MARKETING | Mark up<br>Company resources | | |
| PRODUCTION | PLANNING | Strategic (general) resources | type<br>quantity<br>timing | ( " Stage K) |
| | | Tactical (specific) resources | identity<br>number<br>date | |
| | PROCUREMENT | Data | internal<br>external | |
| | | Recruiting | to planned levels<br>to replace wastage | |
| | | Hiring plant<br>Placing sub contracts | | |
| | | Buying materials | basic materials<br>items<br>components sub components<br>piece parts | |
| | | Working capital | | |
| | PROGRESSING | Design data | by consultants<br>by specialists | ( " Stage L) |
| | | Off-site manufacture and delivery<br>On-site manufacture<br>On-site distribution<br>On-site construction | | |
| | CONTROLLING | Costs | historical<br>forecast | |
| | | Progress | procurement: data<br>recruiting labour<br>hiring plant<br>placing sub contracts<br>buying materials<br>expediting: design data<br>off-site manufacture and delivery<br>on-site manufacture<br>on-site distribution<br>on-site construction | |
| | | Quality | materials<br>workmanship off site<br>finished work in place | |
| | PAYMENT | To main contractor<br>By main contractors | | ( " Stage M) |

Session 11

# THE POTENTIAL FOR PROFITABLE COMPUTING IN CONTRACTUAL ADMINISTRATION

N. M. L. Barnes, Ph.D., B.Sc.(Eng.), M.I.C.E., C.Eng.
of Martin Barnes and Partners

1. Until recently computers have not been effectively applied in the contractual area of construction activity. Profitable applications have been confined to the internal tasks of designers, quantity surveyors or contractors.

   The changes proposed for building and civil engineering methods of measurement will make computer applications crossing the contractual boundary an economic proposition. This paper examines how such applications will work and the prospects for their wider development.

2. BILLS OF QUANTITIES

   Bills of quantities are compiled by computer, contractor's estimates are compiled by computer. Bills have to be "decomputerised" into conventional documents before being sent out to tender, and the contractor's estimates have to be "decomputerised" into conventional priced documents before they can be returned as tenders. Procedural difficulties and non-standard bill item coding prevent these processes being by-passed. Both problems can be surmounted. The new I.C.E. Standard Method of Measurement, for example, provides for a coded classification of bill items which can mesh directly with the rational costing structure used by a contractor. Proposals being implemented for modernising building bills follow the same lines.

3. RATIONAL PRICING

   Rational pricing means using prices in a construction contract which match the cost synthesis used by contractors for their estimating and cost control. It means a shift away from the "shopping list" approach to valuation of work. Rational pricing, when adopted in construction contracts, will widen the scope for computer applications in contractual control. Computer aided design cost estimating, cash flow forecasting, estimating, valuation, cost control and planning can all be based upon a realistic common subdivision of the work in a project. The goal of "integration" of the contractor's control tasks comes within reach.

4. PROJECT SIMULATION

   With rational pricing it is possible to integrate and computerise construction control tasks on a much firmer base than has been possible up to now. Instead of integration being merely the linking of manual-origin tasks by computer data exchange, it becomes the assembly, maintenance, and observation of a single computer-based model of the project. Estimating and

planning are the assembly of the model, cost and progress control, valuation, and feedback are the principal observations of the model. The use of computer-based cost models for these purposes has begun and can be expected to become the basic financial control tool of the construction industries.

These three developments, standardised classification, rational pricing, and integral control by simulation, introduce the next era of computing in construction management. It has every prospect of being an era of really effective computing. A number of traditional manual procedures will be eliminated or simplified, and the quality of construction management decisions significantly raised.