CLASSIFICATION OF BUILDING DESIGN INFORMATION

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DECLARATION

The material in this thesis has not previously been published except in the instance of a few illustrations noted in the List of References.

INDEX TO DIAGRAMS AND TABLES

KEY TO ABBREVIATIONS

BRE	Building Research Estabishment (formerly Building Research Station)
BS	British Standard
BSI	British Standards Institution
BTN	Brussels Tariff Nomenclature
CACCI	Committee for the Application of Computers in the Construction Industry
CBC	Co-ordinated Building Classification
CI/SfB	The British Version of the SfB Classification
CIDB/CIB	International Council for Building Documentation
DC	Dewey Decimal Classification
FID	International Federation for Decumentation
IBCC	Classification Committee of the International Council for Building Documentation
IHVE	The Institution of Heating & Ventilating Engineers
NBA	National Building Agency
NBS	National Building Specification
RIBA	Royal Institute of British Architects
SfB	Samarbetskomitten for Byggnadsfragor (Swedish Classification System for Building)
SMM	Standard Method of Measurement
UDC	Universal Decimal Classification

SUMMARY

The more widely used classification/coding systems for building elements and components, such as CI /SfB and UDC, were developed to classify documents. A classification/coding system for use with computer aided design has to be able to convey detailed information about the features and properties of components.

Previous studies of the use of information in the construction industry, in particular the CACCI Reports, have examined the logical structure of design operations and how this influences the structure of a corresponding information system. This Thesis examines also the traditional roles of the participants in the design team and demonstrates that these roles modify the ideal structure.

A number of existing classification systems are analysed to provide, with an analysis of the theory of classification, the desirable features of a practical classification system.

The CACCI Report proposed the development of a national commodity file . In the Section on an outline of a possible classification system it is argued that the function of a national commodity file could be replaced by a three-level classification/code with responsibility for information being divided between manufacturer, trade sector organisation and the design team, responsibility for information rests with the participant-most-concerned.

Examples are provided of an individual participant's use of the proposed system and how the system would be used by several participants.

In the absence of a national system, it is suggested that the proposed system would allow teams of designers to proceed with the development of a data base for computer aided design.

SECTION ONE : INTRODUCTION

1.1 THE AREA OF STUDY

A major study of information flow in the construction industry was set up in 1966 by the British Minister of Public Building and Works. The study was supported by the major professional and contracting organisations and was divided into a number of detailed investigations. Fig 1.1 (1) shows the structure chart of CACCI, (the Committee for the Application of Computers in the Construction Industry) and the major Reports published by the main and sub-committees.

Based on a report by the Sub-Committee on Coding and Data Co-ordination, which was submitted in 1968, the Minister asked the National Consultative Council to form a Working Party on Data Co-ordination which commissioned a number of studies and issued a final report (1) in 1971. In the same year the Government withdrew its support from CACCI and the impetus and co-ordination of the study has been lost, although some work is continuing (2) (3). During their brief lives the various Working Parties made detailed studies of the communication of information within the design/construct team and published their findings in a number of reports. These reports, which form the main source material for the section on the survey of the use of information, have been noted on the structure chart.

The CACCI study was stopped before there was an opportunity to modify the proposals to incorporate comments from practitioners. There had been only a limited feed back on the Teams' analyses of the use of information.

Included in the CACCI Report was an illustration of a code structure for the construction industry. This part of the Report is reviewed, with other systems in Section 5.

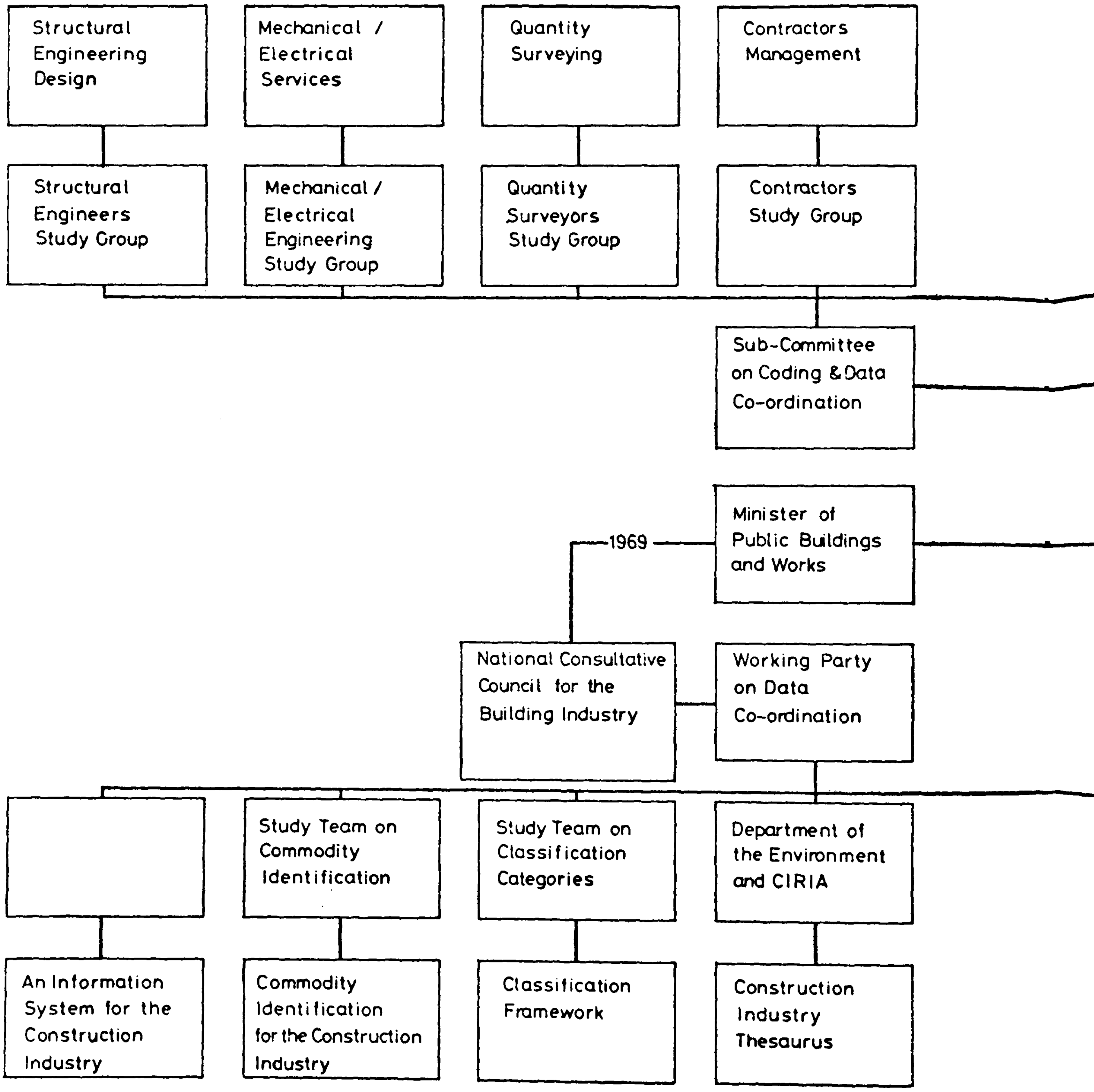
During the period of the study and preparation of the CACCI Report there had been a parallel study by the British Standards Institution of a national classification and coding system (4) (5) but the two studies had not been co-ordinated.

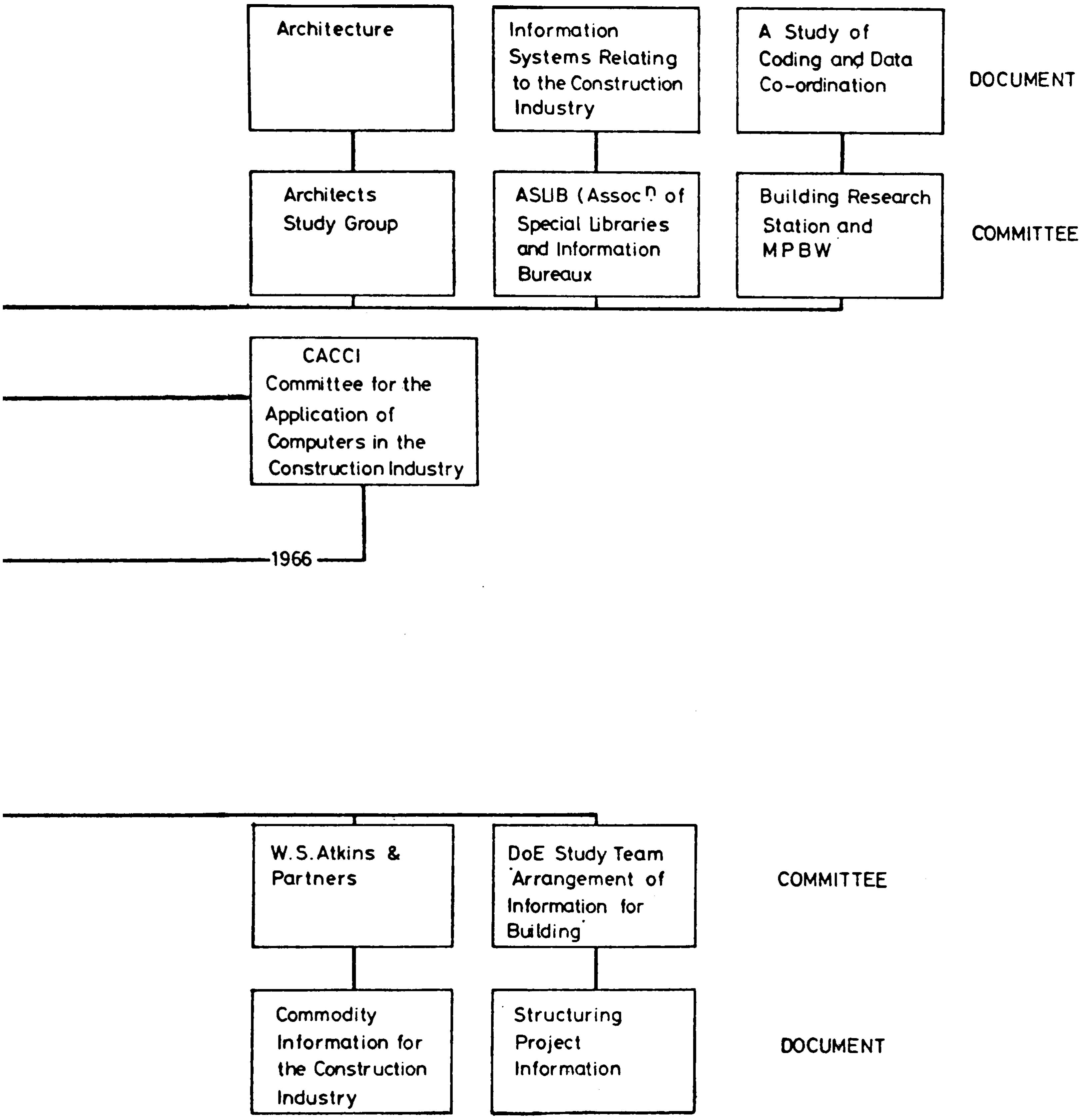
Comments received from the industry on the Draft BS Proposed Standard showed strong opposition to the Standard and led to a decision to withdraw the proposals and stop development.

Also during the same period as these studies, the Author was responsible, as a Partner in a firm of Consulting Engineers, for the development of computer aided design and documentation for environmental engineering systems. Programs were developed for heating and cooling load calculation, pipe and duct system sizing and material scheduling, costing and specification. The development of computer aided design for environmental engineering systems was defined and controlled by an overall flow diagram, 1. 1 (2). Early in the development it was realized that the logical link between programs for system design and documentation is a coded component identification, description and classification which is capable of presenting the particular information required by a routine in a specific program. The development of programs is now reaching the stage where operations can be carried out in sequence and the need for a classification system has become more obvious and urgent.

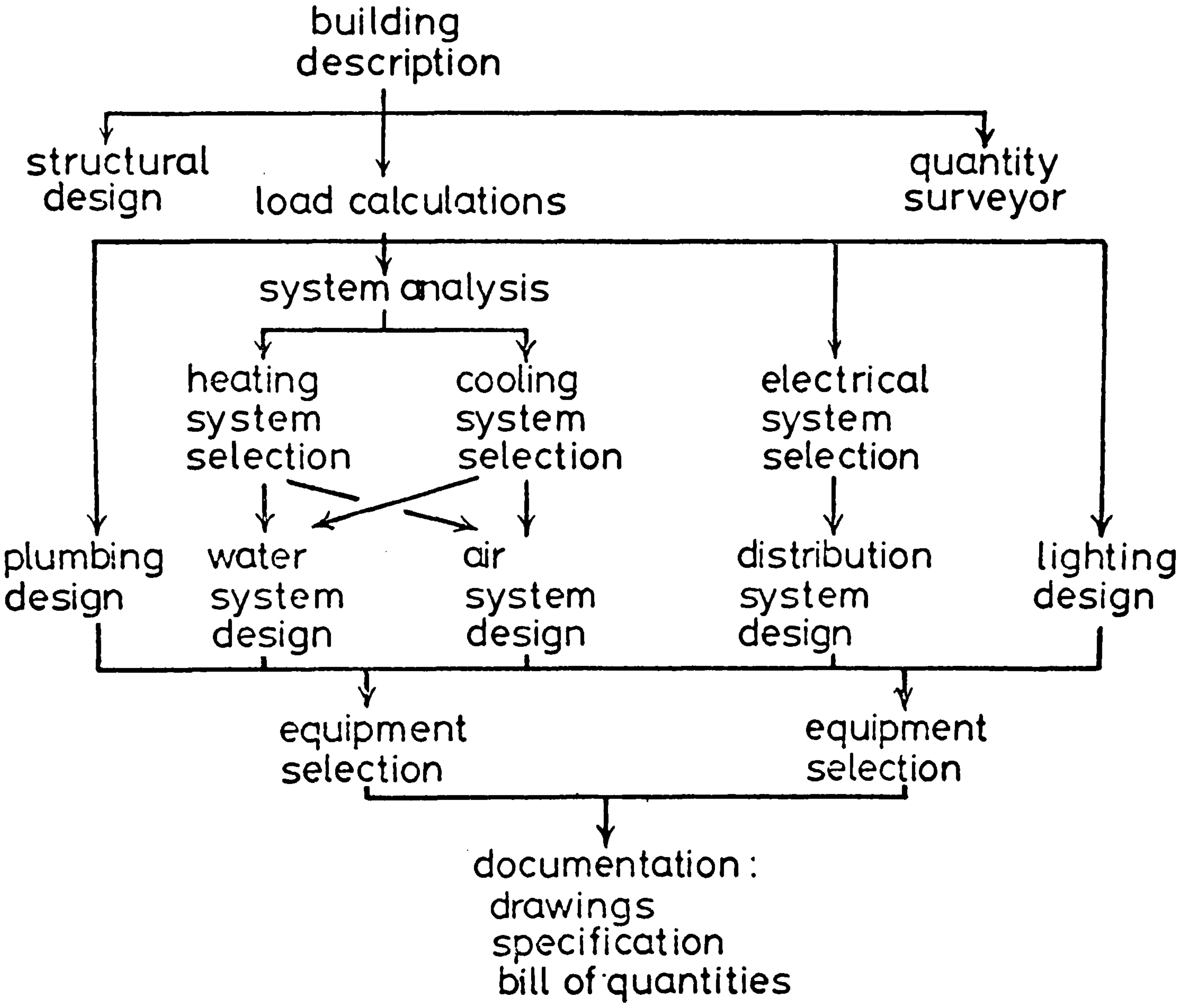
As part of the development of a suitable classification and coding system the Author has studied in particular the CACCI and BSI proposals to see if the principles of these general systems can be incorporated into a system designed around the needs of one participant, when that participant is not the originator of the basic information about the building form.

The concentration of this study on the use of information in costing and design, both limits and extends the study. Previous studies have attempted


Structural Engineering Design
Mechanical / Electrical Services
Quantity Surveying
Contractors Management
Structural Engineers Study Group
Mechanical / Electrical Engineering Study Group
Quantity Surveyors Study Group
Contractors Study Group
Sub-Committee on Coding & Data Co-ordination
1969
Minister of Public Buildings and Works
National Consultative Council for the Building Industry
Working Party on Data Co-ordination
Study Team on Commodity Identification
Study Team on Classification Categories
Department of the Environment and CIRIA
An Information System for the Construction Industry
Commodity Identification for the Construction Industry
Classification Framework
Construction Industry Thesaurus

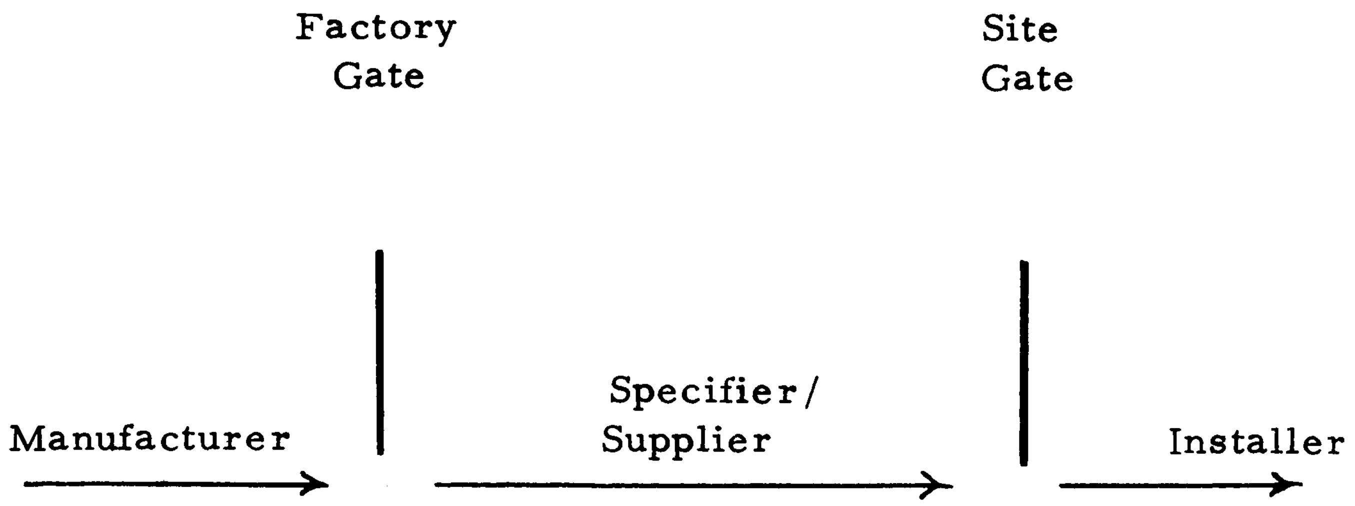


1. 1. (1) Structure Chart for the CACCI and NCC Studies



1.1. (2) Flow Diagram for Computer Sub-System Development.

to encompass manufacturing, retailing and construction as well as design and costing but have not studied in great detail the needs of any one information user. A useful division is provided by the 'factory gate'/'site gate' concept put forward by Karlen (6) and shown below.



The area of study is approached from two directions: the informal use of information as demonstrated by present practice, and the rigidly structured information framework derived from a logical classification system. A practical information system must achieve a combination of, or compromise between, these approaches.

Another practical consideration is the self-interest of the participants. If a system is to be used by more than one participant there will be almost certainly a conflict over the priority to be given to various features. An unacceptable compromise is reached when the efficiency of the system for any one participant is significantly less than that of an alternative system.

It will be shown that the best solution is to give the maximum control over the data required at each stage of design to the participant most involved in using it, even if this requires some duplication of data storage. A consequence of this decision is that the data files must be capable of division into small sections without impairing the operation of the system as a whole.

After identifying the essential features of an information system, the study examines a number of existing systems against these criteria before proposing an improved structure. This proposal is illustrated by practical examples.

1.2 THE GENERAL BACKGROUND

The ability to rationalise classification and coding is unique to mankind and is highly developed from an early age. It is expressed in language, in which a name is a code. A child first names its parents and then, with developing knowledge, is able to classify them as belonging to its family. The ability of other animals to classify and code objects which they can identify is limited.

Because it is such a commonplace and necessary activity most people fail to realise that they have come to terms with the world of real existence and abstract concept by a continual process of classification and coding. That classification and coding are intimately linked is evidenced by the confusion in communication caused when two persons speak different languages, even though each is capable of accurately identifying and defining an object. In the activity of building man has long known the necessity for clear communication by an agreed coding of classified objects. The Biblical story of the building of the Tower of Babel records the realisation of the confusion caused by a breakdown in the system of coding.

There were few problems in building even the great expressions of mans spirit such as the medieval cathedrals. Despite their size and beauty these buildings were constructed of relatively few materials which were shaped on site and over a long period of time. It was possible for one Master-builder to control both the design of the whole and the detail of the parts.

The dramatic change in building technique occurred during the second half of the nineteenth Century with the progressive introduction of structural, mechanical and electrical systems and the growth of specialist, off-site, manufacturers of building components. With this dispersion of the centres of manufacturing there was an inevitable diffusion of information about the building and its components, from the Master Builder on site to the design offices of the Architects, Engineers and manufacturers.

In a recent British study (1) of the possible use of national commodity files it was estimated that:

> "The number of manufacturers supplying the construction industry is between 10,000 and 14,000 and information on 360,000 products would need to be held on the files."

Not only has there been this increase in the number of components used in building but there has been also a corresponding increase in the information required about the components. The change, from a slowly evolving building design in which the performance of a component was known by experience, to a rapid evolution in design has meant that the performance of the assembled components in the finished building has to be predicted now by calculation based on the experimentally established properties of the components.

The growth in knowledge about the building process has outstripped the ability of individual designers to command it, with the result that aspects of building design and construction have become the specialised knowledge of members of a design team.

No longer can one individual expect to understand the whole process of building, and the command of the Master Builder has had to be replaced by communication within a team. Consequently there arises the possibility of confusion unless the team establishes, or adopts, a common language for communicating information about the parts and processes of building. That buildings are being designed by teams using plain language shows that this ancient communication system can still be effective. But the increase in interest in alternative systems to convey information indicates the awareness of a need for a faster and more accurate system.

1.3 THE INTERNATIONAL BACKGROUND

The task of rebuilding the cities of Europe during the late 1940's and the next decade, emphasised the need for an international system for the exchange of information about building design methods and components. National building documentation committees had been formed in most of the 'western' European countries: the United Kingdom, France, Italy, the Netherlands, Belgium, Portugal, Norway, Denmark and Sweden. In 1950 an International Council for Building Documentation (CIDB, now CIB) was established. A Classification Committee (IBCC) was set up in 1952, jointly with the International Federation for Documentation (FID), which studied the currently available classification systems (7). The Committee included experts from non-European countries but the influence of IBCC has not extended correspondingly.

Atfirst the proposal for building component classification was based on the use of UDC by the British Ministry of Works as amended to allow for continual practice. This was soon supplemented by and eventually supplanted by the Scandinavian SfB System (8) which was the product of the Swedish Samarbetskommittén för Byggnadsfrågor (Co-ordinating Committee for the Building Industry).

The Scandinavian countries continued to develop standard documentation, such as the Swedish National Standard Specification for Building Works and the Danish CBC system which was arranged to allow computer processing of building documentation (9). These advances were easily communicated to other European countries through CIB/IBCC and use of SfB spread rapidly. This system is described in detail in a later Section.

Whilst the construction industry in Europe was collaborating through CIB/IBCC to produce an international standard system, there was a corresponding collaborative development between the USA and Canada to produce in 1970 the Uniform Construction Index (10), see Section 5.3. Isolated trade (11) and academic (12) (13) organisations also studied practical or theoretical aspects of the use of information.

The American Engineers Joint Council, in association with others have produced the Thesaurus of Engineering and Scientific Terms (14), which is a co-ordinate indexing system, but the subject matter is at the periphery of interest to the construction industry.

A major development, backed by Government funding of nearly $2m was started in 1973 by the Canadian Construction Information Corporation with the intention of producing a financially self-sustaining information system for the construction industry within two years. A study of the needs of the industry was made and published in two parts (15) (16). It demonstrated a potential financial saving resulting from a reduction in search time for commodity information. The study team under estimated, however, the task of processing manufacturers' data into a standard format and little progress was made. After an expenditure of a budget of nearly $2m, and with few users for the undeveloped system, Government funding and the development ceased in mid 1975.

1.4 THE NATIONAL BACKGROUND

As the source of the Industrial Revolution, Great Britain led the advance into new building techniques and management structures. Most of the present disciplines of design; Architecture, Civil and Structural Engineering, Heating and Air Conditioning, were established by the founding of their professional institutions during the early nineteenth Century. These divisions of the design team, however useful in assisting the transfer of information within each profession, have created barriers to the transfer of information between professions.

The separated education and training and the grouping into single-profession design offices form and continue an inward-looking attitude. Equally the suppliers of components, who look to one profession for orders, tend to be unaware of the needs for information of the other professions.

Early attempts to rationalise the flow of information were made by organisations which served only part of the design team, in particular architecture. Their usefulness to other members of the design team was in consequence limited.

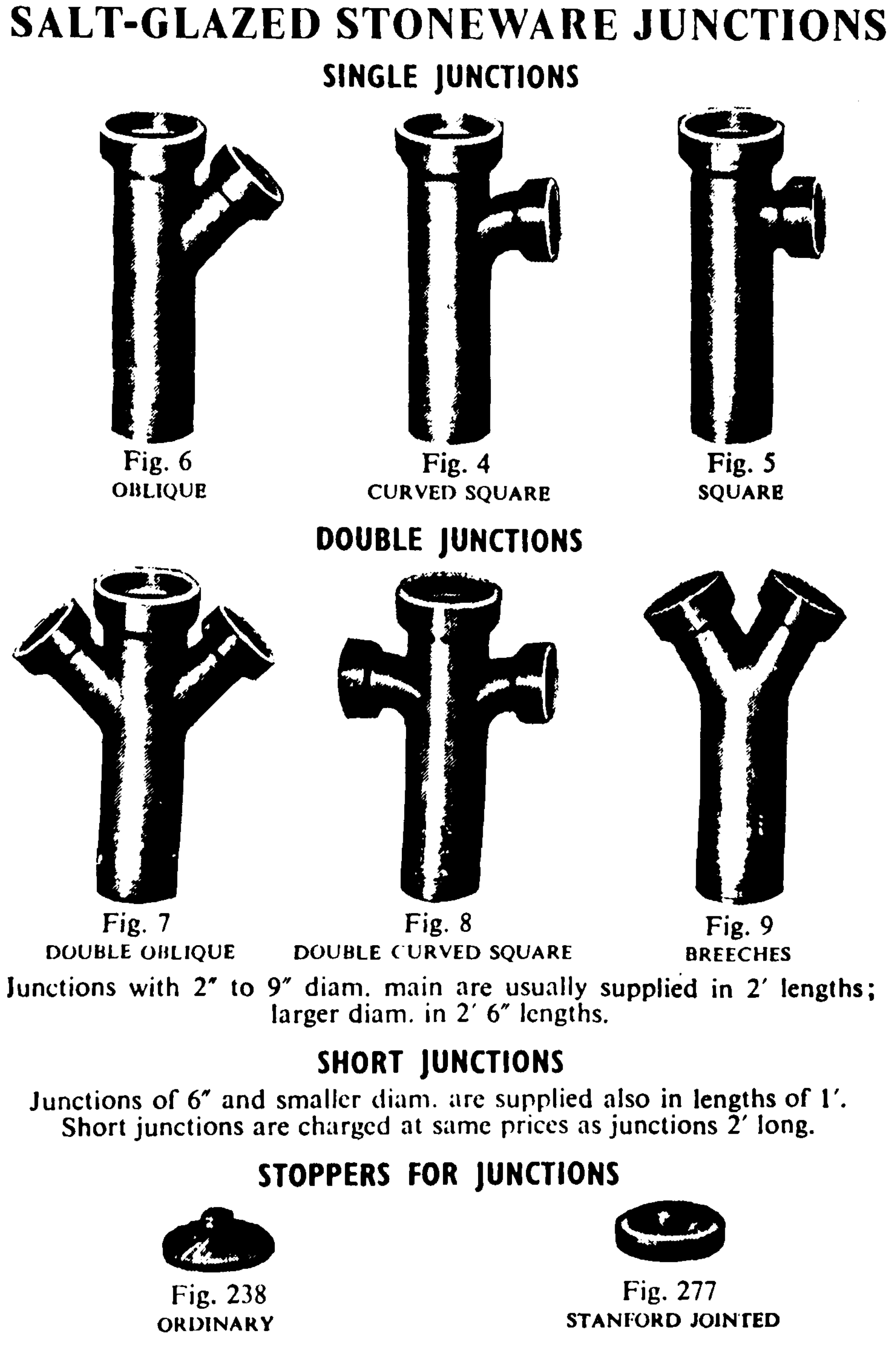
The British Government, through central and local government, is the largest employer of professional design staff and in 1966 the, then, Ministry of Public Building and Works set up the CACCI study which was outlined in Section 1. 1 and whose work is described in more detail in later sections. During the same period consortia of local authorities were formed to develop systems-building for schools and similar low-rise buildings. As part of the development of standard solutions components were classified and coded for use in design and contract documentation. SEAC (South Eastern Architects Collaboration) was a combination of a number of local authorities and the Ministry. In collaboration with manufacturers SEAC produced a computer program for scheduling components at the design stage in such a way that the information could be used directly by the manufacturer in producing the components, as described in a paper by Hale (17).

The SCOLA (Second Consortium of Local Authorities) system was developed further by West Sussex County Council and is described in Section 5. 7. The CLASP (Consortium of Local Authorities Special Programme) system (17) (18) was also based on a facetted classification structure.

Until recent years the use by manufacturers of bound volumes to illustrate their products demonstrates the relative stability of an industry in which a design might have a market-life of two or three decades, 1.4 (1). It was natural for the manufacturer to reference a product as "Figure Number...." as would be a diagram in a technical book.

With the rapid increase in the number of products and the decrease in their market-life, volumes of illustrations were replaced by single sheets which needed non-sequential references to maintain their order in a file. It was to meet this need that UDC was developed and then relegated to a secondary role to SfB.

The receiver and user of trade literature also needed a structure for filing documents so that information about like items could be gathered together. Later sections describe how these document classification systems have been developed to handle information at various stages in the design/construct process.



SALT-GLAZED STONEWARE JUNCTIONS

SINGLE JUNCTIONS

Fig. 6
OBLIQUE

Fig. 4
CURVED SQUARE

Fig. 5
SQUARE

DOUBLE JUNCTIONS

Fig. 7
DOUBLE OBLIQUE

Fig. 8
DOUBLE CURVED SQUARE

Fig. 9
BREECHES

Junctions with 2" to 9" diam. main are usually supplied in 2' lengths; larger diam. in 2' 6" lengths.

SHORT JUNCTIONS

Junctions of 6" and smaller diam. are supplied also in lengths of 1'. Short junctions are charged at same prices as junctions 2' long.

STOPPERS FOR JUNCTIONS

Fig. 238
ORDINARY

Fig. 277
STANFORD JOINTED

1.4 (1) Traditional Trade literature
Component Referencing System

SECTION TWO: THE USE OF INFORMATION BY THE DESIGN / CONSTRUCT TEAM

2.1 GENERAL

There are two approaches to the specification of a system for classification and coding of components. One is to study the use which the design/construct team makes of information and to model a system around established practice. The other approach is to define a logical structure of classification and to impose this structure on to practice.

Within long established practice there are likely to be traditional, even illogical, ways of working and any practical information system should recognise the strength of tradition. Computer aided systems however are confined within the logicality of computer sequences and it is difficult to cater for frequent exceptions to general procedures.

In this Section of the Thesis there follows a Survey, Study and Analysis of the present use of information. Some of the material is taken from the CACCI Report but relates to non-computer aided practice. The Survey and Study are neither critical nor analytical but accept present practice as it reveals itself. There is a separate Analysis of both practice and of previous attempts to define it.

2. 2 INFORMATION IN THE DESIGN PROCESS

A design for a building proceeds through stages of increasing detail and complexity. Each stage has input of information, which is processed and output to later stages. Attempts to model the flow of information are described in Section 2. 6. 1 but the generally accepted statement is given in the RIBA Plan of Work (19). Figure 2. 2. (1) shows these stages and the type of input and output data for each stage.

In terms of the parts of a building, the unit of the building is the component:- bricks are designed as wall panels, pipes and fittings are assembled into engineering systems, light fittings and ceiling tiles into ceiling systems. In this process, the designer uses only information about components and not the components themselves.

As information about components is fed into the design process some of it is used to size or shape other components or assemblies. The designer has little control over the form of the information he receives but is able to control the form of information output. Input information comes from other participants in the design and from external sources such as national standards and regulations, or manufacturers literature. Information is output to other participants in the form of drawings, specifications and bills of quantities.

Although data about components form a vital link between design input and output there is often no direct communication link between the component manufacturer and the designer. Indeed the provision of information, vital to the designer and user, may be an unrewarding overhead for the manufacturer.

RIBA PLAN OF WORK STAGE	INFORMATION	
	INPUT	OUTPUT
A Inception B Feasibility	Client brief, Data from previous projects, specialist reports	Feasibility
C Outline Proposals D Scheme Design	Site survey. Thermal, acoustic analysis. Spacial relationship studies. Regulations and Standards.	Sketch drawings Cost plan Room schedules
E Detail Design	Previous Stages. Information from manufacturers.	Drawings Specification. Final cost plan and Room Schedules.
F Production Information G Bills of Quantities	Previous stages.	Tender documents. Bills of Quantities
H-N Contract Stages.		

2. 2. (1) RIBA Plan of Work Stages and Information Input and Output

The demands for information about a component by the participants in the design team will vary depending on their speciality but the common factor is the real object which will become a component of the building.

Taking the example of a simple component, such as a brick, the Architect will wish to know its dimensions and surface appearance, ('common' or 'facing' brick). The Structural Engineer will also be interested in the dimensions of the brick panel but its weight and load-bearing capacity will be of greater interest than its appearance. The Quantity Surveyor will be interested in the surface appearance as a guide to the cost of the brick. The Environmental Engineer, calculating the 'U-value' of a wall, will be interested only in the brick-in-place as part of a composite wall panel. Even on so superficial an appraisal it is evident that the name 'brick' is insufficient to communicate the information needed by the design team and that the name must be enlarged or modified to convey this additional information. This has been done, traditionally, by adding adjectives to the name, or by giving a manufacturer's reference to gain access to other sources of information.

2.2.1 Drawings

A dimensional and component layout description of the building is the starting point for many building engineering design routines, for example structural dead load and wind loading, daylighting, natural ventilation, heat loss and gain. The building dimensions also determine the length of runs of engineering systems which use pipes or ducts and the location in which fittings such as bends must be used. Because the routines are separated by time and by the disciplines of the participants it is usual for the same dimensions to be measured many times during the total design task and even during a particular design routine. Information about dimensional and physical properties is communicated between participants by means of drawings and specifications. The former are two-dimensional representations, usually in plan and elevation/section,of a three dimensional structure and include many conventions to avoid the exact detailed portrayal of the building features. To fully describe the construction of a building, a series of drawings must be prepared showing an increasing detail of smaller parts of the building, passing from the general layout to assembly and component detail drawings.

2. 2. 2 The Specification/Description

Whilst it would be possible to write all the information about components on the drawing, the result would be confusing. It is more convenient to convey certain information in the form of a written Specification or as an item description in a Bill of Quantities.

For many years each design and measuring office had its own collection of specifications and description clauses, and presented them in different ways.

A component may be specified either by unique naming, by trade name or reference, or by specification of its properties and performance. There may be a combination of these methods by the use of a brief specification of properties coupled with a statement equating the component to a specific manufacturer's product.

One of the reasons for not always specifying by uniquely naming a component is the desire or obligation to allow several manufacturers to compete for its supply. This is not possible when the manufacturer is named or when the specification is written so that only one product meets it - for example by the inclusion of some minor and irrelevant feature.

Recently there have been attempts by Governmental Departments to standardize their Specifications (20). In 1967 the National Economic and Development Committee sponsored the development of a proposal by the Laing Committee that there should be a National Building Specification (NBS) (21)

The NBS Format separates the clauses for 'workmanship' and 'materials' and uses CI/SfB for indexing the work sections and the specification of the material. Schedules, which had often been separated from the specification descriptions, are included in the general text.

2. 2. 3 Regulations Standards and Guides

The use of components is controlled by several legal or good-practice guides such as Acts of Parliament, Building Regulations, British Standards and trade standards. Some of these controls will be referred to in the particular trade literature but more often it is the application that decides what is permissible. For example materials which may be used in general, low-rise, building may be prohibited, under Section 20 of the London Building Acts, in high rise buildings.

Non-statutory guidance is given in many ways, typical of which are application notes in manufacturers' literature, advice in text books, or guides published by the professional institutions. These sources also set down design parameters and provide basic data, such as thermal transmission factors for building materials, or pipe sizing tables, with which the calculations for the system design are made. In the case of guides the information is usually taken "on trust" in that the theory or test data supporting the processed data is not quoted so that reliance has to be placed on the authority of the publishing body.

2. 2. 4 Manufacturers' Literature

At some stage the designer's concept has to be translated into reality by the selection of components. Whilst it would be possible for the designer to 'invent' materials and forms for each part of the design it is usual for the selection to be made from existing components. For this a designer makes access to manufacturers' information about components in one or more ways, ranging through personal or office collections to specialist information bureaux such as the Building and Design Centres. There are firms who specialise in processing trade literature into classified and standardised forms such as the National Building Agency (22) and Barbour Index Limited (23).

How information is presented is the choice of the publisher although guidance has been given in a number of semi-official recommendations (24) (25) (26) about the contents, layout and binding of publications. A comparison of their main recommendations is set out in Fig 2. 2. 4 (1) from which it will be seen that there is no consensus of opinion about the ordering of information although there is general consent about the information to be included.

BS 4940 (26) is based on the CIB Master Lists but has changed the wording of some of the Main Headings. The British Standard recognises that manufacturers' literature has to accomplish different tasks, from sales-attraction to maintenance details, and that the style of presentation will vary.

The participants in the design team will seek different information from the literature, for example in the case of a component such as an air grille the architect will be concerned about its appearance and fixing whilst the environmental engineer will be seeking information about the air throw and spread and noise generation.

BUILDING CENTRE (24)	CIB MASTER LISTS (25)	BS 4940 (26)
Information on Products	**Document**	**Identification**
	Index code	
Description		**Description**
Source of supply	**Identification**	
Application	Brief description	**Context**
Types		(= Climate, site, etc)
Properties		
Drawing	**Description**	
Prices		
Standards & Tests	Shape	
Guarantees	Size	**Performance**
Specification clauses	Weight	(= Behaviour in use)
	Appearance	
Supply (delivery)		
Packaging	**Climate, Site occupancy conditions**	**Applications**
Information on services offered		**Construction**
		(= sitework)
Design	**Behaviour in use**	
Fixing	(comparable with properties)	**Operation, Maintenance**
Information on protection and maintenance.	**Applications, Design**	**Prices, conditions of sale**
Transport	Design details	
Storage	Specification clauses	
Handling		
Protection		
Maintenance	**Sitework**	
	Installation details	
Form & Layout		
Page size (A4)		
Classification by CI/SfB)	**Operation and Maintenance**	
Layout		
Binding		
Typeface	**Prices, Conditions of sale**	
Indexes		
	Supply	
	References	

2.2.4 (1) Comparison of Document Presentation Structure

2.3 SURVEY OF PRESENT PRACTICE (THE CACCI REPORT)

The CACCI Report (27) on information use and flow was prepared by sub-committees separated into, and operating amongst, the disciplines that make up the design/construct team.

Each sub-committee published a report on its findings and these were synthesised into an overall report covering the total building process.

Faced by the varieties of the relationships and roles of the participants in the design team, the researchers decided to seek the structure of information flow which underlies the organisation of the senders and receivers of information. The concept of 'functions' was used in which identifiable goals were taken as the divisions in information flow. Each function was sub-divided into a number of 'procedures' which comprise a 'routine' of 'operations' on sets of data. The concept is examined and analysed in subsequent Sections.

It was found that information about components is used in most of the design functions: selecting, detailing, specifying, measuring etc., and that it may be obtained specifically for a project or be held generally on record as features of the component. The information may be specific to a particular manufacturer of a component or be the generalised properties of a component irrespective of the source of supply.

Such is the dependence of the designer on component information that the Report concludes:

> "The need to exchange information about commodities alone could justify the initiation of a measure of data co-ordination reaching right across the industry and into the associated supply and manufacturing industries."

The contributing studies and reports are shown in 1. 1. (1) and the following clauses summarize their findings.

2. 3. 1 Architectural Design

Based on this concept of functions, routines were prepared, referenced to the RIBA Plan of Work for typical procedures such as 'Design of Windows' and a limited number of visits made to design offices to check the validity of the assumptions. It is claimed that these surveys demonstrated, in terms of information flow in a design sequence, that the concept was valid irrespective of the organisation of the design team. Some difficulty was found in preparing procedures for the outline and scheme design stages in which the sequence of activities is more likely to be influenced by outside constraints. This problem was not found in the other studies which were concerned more with procedures involving the manipulation of numerical data.

The Architect has a task of co-ordination of specialist designers which includes a duty to provide information to other participants both about his developing design and those of other specialists.

During the early stages of the design the Architect has to express his concept of the building as tentative forms and proposed materials to initiate a dialogue with the other participants. On receiving their comments the Architect has to understand and reconcile the inter-relationship between the building elements and give weightings to the advantages or disadvantages of each solution. In general the detail of information required about materials at this stage is coarse but, for one or two strategic decisions, very finely detailed information may be needed about component properties.

The Working Group Report (28) (29) was concerned with the improvement in the ability to analyse decisions which would result from the greater use of computers. Using manual methods, a lineal design and decision making technique must be adopted because the complexities of the amount of information and the number of design interrelationships prevent the designer from following at one time more than one train of relationships, resulting from a set of input data. The use of drawings to record decisions is also a limitation because of the time taken in their preparation and the fixed nature of the record.

Working Group 3 saw in the available mathematical modelling techniques, such as Queueing Theory and Linear Programming, a means of developing models for building design. In parallel with the development of such models, the Working Group saw a need for the development of data banks about all aspects of building materials, systems and uses.

Architectural design is not a process of assembling known components in a fixed sequence to produce a prototype product for testing (as is the case in automobile design), but it is a process by which, usually, known components are assembled uniquely to produce the final product without an opportunity for other than very limited testing. Even the known component may have an unknown relationship to other components, for example the different percentages of glazed fenestration. Levin (30) has described the building design process as a learning process by which the consequences of a design proposal are explored by the participants through a series of problem-solving steps until an acceptable decision is reached. The end result may not be the optimum.

The claim of validity for the CACCI procedures did not necessarily imply their acceptance by the architectural profession, even when their validity was recognised. This tension between what is recognised as 'good practice' and what is actual practice demonstrates the time lag that results from lethargy and the enthrenched position of traditional practice. Any practical information system must allow for this human element by starting from existing practice and advancing by gentle steps.

2. 3. 2 Quantity Surveying

This study group included representatives of product manufacturing and merchanting organisations but the main part of the survey was carried out amongst twenty-five quantity surveying teams associated with various organisations of differing size:- Government, private practice and state industries. A common approach to the task was found, probably because of the common use by Quantity Surveyors of the Standard Method of Measurement (SMM) (31), which provides a system for grouping components and includes rules for measurement. The SMM does not provide a method for uniquely describing the components nor is there a structure of classification apart from 'recognised' trade divisions of work.

There was an awareness amongst the teams of the importance of cost-in-location and the consequent need to provide the construction team, at tendering stage, with information about the location of components and the sequence of construction. The SMM takes Work Sections, many of which are trades, as the primary division and does not provide a standard means for giving locational information in a Bill of Quantities.

Reference is made in the Report to proposals for restructuring Bills to provide better information about those resources for, and operations of, building that generate cost, such as plant hire and sequence of work. In the Contractors study (32) there is a criticism of the content of the traditional Bill description of components and the failure to describe locations in a manner that can be costed by the contractor.

In one proposal (33) (34), for an 'Operational Bill', the work and material descriptions would be set out in operations rather than in overall measurements of the work. For example plastering would be quantified by the number of the areas of surface that could be plastered in one operation rather than being stated as the total area of plastering in the building.

The alternative 'locational Bill' continues to use the SMM system but separates the measurement into locations on the basis that identical work may require different resources depending on its location.

It was found to be common practice for the Surveyor to assume much of the detail of construction, especially when working frequently with the same design team. The normal direction of flow of construction information, from Architect to Surveyor, is often reversed, in that the Surveyor suggests to the Architect materials that may be used within a cost-planning constraint. The major task of the Surveyor is still that of quantifying the materials and construction shown by the Architect and sometimes other participants in the design team. Even when the design documentation is of a good standard, there is usually a need to refer again to source material which the designer has already used.

As part of the study of the flow of information required from suppliers, (the product manufacturers and retailers), a diagram was produced, (part reproduced as Figure 2. 3. 2. (1)), to show the information about a component which is required at each stage of the design. This diagram demonstrates the increasing detail demanded by the participants as the design develops.

2. 3. 3 Environmental (Mechanical and Electrical) Engineering

Separate studies were made of these 'specialist groups' but the Reports

RIBA Plan of Work Stage

			CD	E	E	F	G	H	J	–	–	K	K	K	L	L
			ASSESS	DESIGN	DETAIL	SPECIFY	MEASURE	ESTIMATE	ORDER	PRODUCE	TRANSPORT	STORE	INCORPORATE	INVOICE	OPERATE	MAINTAIN
1 **Identification**	·1	**Generic:** description sufficient to indicate type of product and its use; classification symbol	●	●												
	·2	**Specific:** information to identify the product without ambiguity (e.g. NATO stock number); it will signify size, colour, material, etc. and will include name of manufacturer, trade name or brand, manufacturer's own reference number, etc. as appropriate.		●	●	●	●	●	●	●	●	●	●	●	●	●
2 **Properties**	·1	Indication of performance	●													
	·2	Indication of composition/structure	●													
	·3	References to finished constructions—completed projects from which the performance of the product may be appraised	●													
	·4	Appearance, including finish	●	●	●		●									
	·5	Properties of building element in which product is incorporated	●	●	●											
	·6	Detailed composition/structure		●	●											
	·7	Physical, chemical and biological properties		●	●										●	●
	·8	Durability (related to maintenance, if appropriate)		●	●											
	·9	Performance details		●	●											
3 **Dimensions and measurements**	·1	Range of nominal sizes (e.g. window 1·5m wide x 1m high, etc.)		●	●		●	●								
	·2	Actual dimensions, including tolerances (e.g. window 1·524m x 0·914 m etc.)			●		●	●		●						
	·3	Rules for measurement (SMM, trade custom, etc.)					●	●								
	·4	Net quantity in completed project					●	●								
4 **Costs and accounting**	·1	Gross quantity						●	●	●	●	●				
	·2	Approximate cost as fixed	●	●												
	·3	Running costs	●	●											●	●
	·4	Prices, including accessories and fixings		●				●	●					●		
	·5	Delivery costs/charges		●				●	●		●					
	·6	Discount—customer		●				●	●					●		
	·7	—quantity		●				●	●					●		
	·8	—settlement						●	●					●		
5 **Application (general)**	·1	Range of accessories	●													
	·2	Methods of fixing/placing/erection	●													
	·3	Details of accessories			●											
	·4	Details of fixing/placing/erection			●											
	·5	Initial finishing treatments			●											
	·6	Architectural and constructional details including associated details, junctions with other work, etc.			●											
	·7	Working characteristics, use of special tools, etc.				●	●	●				●				
	·8	Materials constants, i.e. gross quantity per measurement unit of finished work						●								
	·9	Labour constants						●								

2.3.2 (1) Activity/Operation Matrix for Design Process shared authors and found "some common links". The studies followed the same procedure of analysing routines as that for Architecture. It was necessary to amplify the general Architectural routine for the preliminary stages of design which relate to the RIBA Plan of Work (19) Stages B and C. The latter document was criticised by the specialist designers for "the theoretical nature of the routines compared with practice" because the exigencies of project work preclude the adoption of such a rational, prearranged sequence of operation.

The Environmental Engineers were more aware of the interactive nature of their design processes. There is essential interaction between engineering systems and the building for which they are designed, so the integrated design has to proceed by a process of proposal and compromise.

Within each design sequence there is a chain of calculation which has to be carried out on each set of input data and this task can proceed independently of the other participants once the input data has been obtained.

Mechanical engineers are very dependent on engineering component data in that design solutions are based on the performance of available equipment, and plant spaces on the dimensions and arrangement of plant items. The Report contains little analysis of the flow of building component data between participants from which it would seem that the Environmental Engineers accept the task of remeasuring building elements and searching for their physical properties.

2.4 A SAMPLE OF PRACTICE

The CACCI Study was more concerned about flows of information than sources and did not include an analysis of how designers access the currently available information.

As a means of checking the use of information by practitioners, a small survey was made of selected Architects, Quantity Surveyors and Environmental Engineers. The survey was conducted by post using the questionnaire shown in 2.4 (1) (2) and (3). Answers, grouped by discipline, are shown on the overlays to these figures.

The intention of the survey was to discover who used what information at which stage of design.

2.4.1 The Survey Questionnaire

To concentrate the participants' attention on to a real situation, they were asked to consider only the case of an external window for a typical project. Questions were grouped in two series:

1. Asking about the use of sources of information in the forms of regulations, guides to good-practice, processed manufacturers data sheets, professional and in-house standards.
2. Using the CIB Master Lists (25) to indicate the relative importance of commodity features to the various participants at the outline and detail design stages.

2.4.2 The Sample

The sample number was too small to have random statistical value but the contributors had been selected, on the basis of personal knowledge, to represent areas of experience.

Methods of work in professional offices are well established as the result of common training systems and the mobility of staff between offices. This was demonstrated in the CACCI Study by the recognition

SAMPLE SURVEY OF THE USE OF COMPONENT INFORMATION.

Please base your answers on the case of an external window for a typical project.

Please indicate your use of information by ticking the appropriate boxes.

I. USE OF SOURCE MATERIAL

What use do you make of the stated sources during the two stages of design.

Architects / Quantity Surveyors / Mechanical/Electrical

1 = Always 2 = Often 3 = Rarely 4 = Never 5 = Source not known.	RIBA Stages (C) & (D) Outline Design					(E) Detail Design				
	1	2	3	4	5	1	2	3	4	5
Source										
a. CP3 chap 1 (B) 'Sunlight'		6	12	3	1/2		4	2	2	1
b. CP3 chap 1 Part 1 'Daylighting'	1	5	12	3	1/2	repeat other column				
c. CP152 Glazing & Fixing		1	4	12	1/2	1	3	2	3	1
d. BS 4873,644,990 Standard Dimensions	1	1	1	15	1/2	2	2	3	1	1
e. PD 6444 Part 1 Dimensional Co-ordination	1	1	1	5	2/2 2/2	2	11	1	2	1
f. BWMA/EJMA Standard Range		1	3	5	2/2	1	3	3	1	
g. NBA Commodity File		3	2	121	1/1		2	4	2	1
h. BRE Temperature Prediction Charts			2	241	21			4	2	2
i. IHVE Guide	1/	1/	2	31	31		1	2	2	3
j. National Building Specification		2	2	262		1	3	3	1	
k. Barbour Index	1	2	2	232		2	4		2	
l. Manufacturers catalogues	1	3 5	1 2/2	1		3 5	1 2/2			
m. Architects Journal		2	14	122			1	5	3	
n. RICS cost guides		3	3	232	2		3	3	2	2
o. Own 'office' standards	231	5	/1	1		3	5	1		
p. Previous projects	3	261	/1	1		3	34	1		
q. State other sources										

2.4 (1) Questionnaire: Use of Source Material

SAMPLE SURVEY OF THE USE OF COMPONENT INFORMATION.

Please base your answers on the case of an external window for a typical project.

Please indicate your use of information by ticking the appropriate boxes.

I. USE OF SOURCE MATERIAL

What use do you make of the stated sources during the two stages of design.

Quantity Surveyors

Mechanical Electrical

1 = Always 2 = Often 3 = Rarely 4 = Never 5 = Source not known.	RIBA Stages (C) & (D) Outline Design					(E) Detail Design				
	1	2	3	4	5	1	2	3	4	5
Source										
a. CP3 chap 1 (B) 'Sunlight'			1/	3	1/2				3	1
b. CP3 chap 1 Part 1 'Daylighting'			1/	3	1/2	repeat other column			3	1
c. CP152 Glazing & Fixing				13	1/2				3	1
d. BS 4873,644,990 Standard Dimensions		1		12	1/2 2/2	1	1		1	1
e. PD 6444 Part 1 Dimensional Co-ordination		1		2	2/2		1		2	1
f. BWMA/EJMA Standard Range			3	1	2/2			4		
g. NBA Commodity File		1		121	1/1			1	2	1
h. BRE Temperature Prediction Charts				231	/1				3	1
i. IHVE Guide	1/	1/		31	/1				3	1
j. National Building Specification			2	222				3	1	
k. Barbour Index				242					4	
l. Manufacturers catalogues		3	1 2/2			3	1 2/2			
m. Architects Journal			12	122				1	3	
n. RICS cost guides		3	1	2/2			3	1		
o. Own 'office' standards	2/1	3	/1	1			3	1		
p. Previous projects		231	/1	1			3	1		
q. State other sources										

2.4 (1) Questionnaire: Use of Source Material

SAMPLE SURVEY OF THE USE OF COMPONENT INFORMATION.

Please base your answers on the case of an external window for a typical project.

Please indicate your use of information by ticking the appropriate boxes.

I. USE OF SOURCE MATERIAL

What use do you make of the stated sources during the two stages of design.

Mechanical / Electrical

1 = Always 2 = Often 3 = Rarely 4 = Never 5 = Source not known.	RIBA Stages (C) & (D) Outline Design					(E) Detail Design				
Source	1	2	3	4	5	1	2	3	4	5
a. CP3 chap 1 (B) 'Sunlight'			1/		1/2					
b. CP3 chap 1 Part 1 'Daylighting'			1/		1/2	repeat other column				
c. CP152 Glazing & Fixing				1/	1/2					
d. BS 4873,644,990 Standard Dimensions				1/	1/2					
e. PD 6444 Part 1 Dimensional Co-ordination					2/2 2/2					
f. BWMA/EJMA Standard Range					2/2					
g. NBA Commodity File				1/1	1/1					
h. BRE Temperature Prediction Charts				2/1	/1					
i. IHVE Guide	1/	1/		/1	/1					
j. National Building Specification				2/2						
k. Barbour Index				2/2						
l. Manufacturers catalogues			2/2				2/2			
m. Architects Journal			1/	1/2						
n. RICS cost guides				2/2						
o. Own 'office' standards	2/1		/1							
p. Previous projects		2/1	/1							
q. State other sources										

2.4 (1) Questionnaire: Use of Source Material

SAMPLE SURVEY OF THE USE OF COMPONENT INFORMATION.

Please base your answers on the case of an external window for a typical project.

Please indicate your use of information by ticking the appropriate boxes.

I. USE OF SOURCE MATERIAL

What use do you make of the stated sources during the two stages of design.

1 = Always 2 = Often 3 = Rarely 4 = Never 5 = Source not known.	RIBA Stages (C) & (D) Outline Design 1 2 3 4 5	(E) Detail Design 1 2 3 4 5
Source		
a. CP3 chap 1 (B) 'Sunlight'		
b. CP3 chap 1 Part 1 'Daylighting'		
c. CP152 Glazing & Fixing		
d. BS 4873,644,990 Standard Dimensions		
e. PD 6444 Part 1 Dimensional Co-ordination		
f. BWMA/EJMA Standard Range		
g. NBA Commodity File		
h. BRE Temperature Prediction Charts		
i. IHVE Guide		
j. National Building Specification		
k. Barbour Index		
l. Manufacturers catalogues		
m. Architects Journal		
n. RICS cost guides		
o. Own 'office' standards		
p. Previous projects		
q. State other sources		

2.4 (1) Questionnaire: Use of Source Material

II. FEATURES

The following list of features is compiled from the CIB Master Lists. Use the weightings to indicate the relative importance of the feature to your profession at the two stages of design.

Architects/Surveyors/Electrical

1 = Very important 5 = Unimportant	RIBA Stages (C) & (D) Outline Design					(E),(F) & (G) Detail Design				
	1	2	3	4	5	1	2	3	4	5
Primary/Secondary Features										
Weight		1/	3	4	1/2	1	2	4	1	2
Appearance:										
:shape	6	2/	1/2		1	6	2	1		1
:size	6/2	2	1		1	6	2	1		1
:colour [reflectance]	2/2	5	1		2	2	4	1	1	3
:opacity	2/2	2	2	2	3	1	4	2	1	3
:lustre		1/	3	1/1	3/1	1	2	4		4
External Climate:										
:pollution	1/	4	2	1	14/2	3	4	1		4
:rain/snow	2	3	2	1/	13/2	5	2	1		3
:wind speed	4/1	4	2	1	3/1	5	1	2	1	3
:sunshine	3/1	3	2		21	5	1	2	1	2
:noise	3/	3	2		2/2	7	1	1		2
Strength:										
:wind defection		3	2	1	2/2	2	3	3	1	3
:impact		2	2	2	2/2	2	1	5		4
Fire resistance	5	1	1/	1	1/2	7	1	1	1	1
Tightness:										
:air	2/1	4	2	1	3/1	3	5		1	3
:water	2	3	2/1	2	21	8	1		1	2
Dust or dirt penetration	1/1	4	1	2	31	3	4	1	1	3
Chemical corrosion	2	3	1/	4	1/2	7	1		2	2
Biological (entry of):										
:mammals	2	3	1	1	2/2	4	3		1	4
:birds	2	3	1	1	2/2	4	3		1	3
:insects	1	3	2	1	2/2	3	3	1	1	3
Thermal:										
:insulation	3/1	3	2	1	1/1	7	1	2	1	1
:surface temperature	1/1	1	4	1	1/1	3	5		1	3
:condensation	2/1	2	1	4	1/1	7		1	2	1

repeat other column

2.4. (2) Questionnaire: Features (Sheet 1)

II. FEATURES

The following list of features is compiled from the CIB Master Lists. Use the weightings to indicate the relative importance of the feature to your profession at the two stages of design.

Quantity Surveyors Mechanical Electrical

1 = Very important 5 = Unimportant	RIBA Stages (C) & (D) Outline Design					(E), (F) & (G) Detail Design				
	1	2	3	4	5	1	2	3	4	5
Primary/Secondary Features										
Weight		1/	2		12/2		1	1		2
Appearance:										
:shape	1	1/	1/2		1	1	1	1		1
:size	2/2		1		1	2 repeat other column.		1		1
:colour [reflectance]	2/2		1		3			1		3
:opacity	2/2			1	3				1	3
:lustre		1/		1/1	4/1					4
External Climate:										
:pollution	1/				14/2					4
:rain/snow		1		1/	13/2		1			3
:wind speed	2/1			1	3/1				1	3
:sunshine	2/1		2		2/1			2		2
:noise	2/	1	1		2/2		1	1		2
Strength:										
:wind defection				1	23/2				1	3
:impact					24/2					4
Fire resistance		1	11/	1	11/2		1	1	1	1
Tightness:										
:air	2/1			1	3/1				1	3
:water		1	2/1	1	2/1		1		1	2
Dust or dirt penetration	2/1			1	3/1				1	3
Chemical corrosion			1/	2	12/2				2	2
Biological (entry of):										
:mammals					24/2					4
:birds		1			23/2		1			3
:insects		1			23/2		1			3
Thermal:										
:insulation	2/1		2	1	1/1			2	1	1
:surface temperature	2/1			1	3/1				1	3
:condensation	2/1		1	2	1/1			1	2	1

2. 4. (2) Questionnaire: Features (Sheet 1)

II. FEATURES

The following list of features is compiled from the CIB Master Lists. Use the weightings to indicate the relative importance of the feature to your profession at the two stages of design.

Mechanical / Electrical

1 = Very important 5 = Unimportant	RIBA Stages (C) & (D) Outline Design					(E), (F) & (G) Detail Design				
	1	2	3	4	5	1	2	3	4	5
Primary/Secondary Features										
Weight		1/			1/2					
Appearance:										
:shape		1/	1/2							
:size	2/2					repeat other column.				
:colour [reflectance]	2/2									
:opacity	2/2									
:lustre		1/		1/1	/1					
External Climate:										
:pollution	1/				1/2					
:rain/snow				1/	1/2					
:wind speed	2/1				/1					
:sunshine	2/1				/1					
:noise	2/				/2					
Strength:										
:wind defection					2/2					
:impact					2/2					
Fire resistance			1/		1/2					
Tightness:										
:air	2/1				/1					
:water			2/1		/1					
Dust or dirt penetration	2/1				/1					
Chemical corrosion			1/		1/2					
Biological (entry of):										
:mammals					2/2					
:birds					2/2					
:insects					2/2					
Thermal:										
:insulation	2/1				/1					
:surface temperature	2/1				/1					
:condensation	2/1				/1					

2.4. (2) Questionnaire: Features (Sheet 1)

II. FEATURES

The following list of features is compiled from the CIB Master Lists. Use the weightings to indicate the relative importance of the feature to your profession at the two stages of design.

1 = Very important	RIBA Stages (C) & (D) Outline Design					(E), (F) & (G) Detail Design				
5 = Unimportant	1	2	3	4	5	1	2	3	4	5
Primary/Secondary Features										
Weight										
Appearance:										
:shape										
:size										
:colour										
:opacity										
:lustre										
External Climate:										
:pollution										
:rain/snow										
:wind speed										
:sunshine										
:noise										
Strength:										
:wind defection										
:impact										
Fire resistance										
Tightness:										
:air										
:water										
Dust or dirt penetration										
Chemical corrosion										
Biological (entry of):										
:mammals										
:birds										
:insects										
Thermal:										
:insulation										
:surface temperature										
:condensation										

2. 4. (2) Questionnaire: Features (Sheet 1)

Quantity Surveyors Mechanical Electrical	1	2	3	4	5	1	2	3	4	5
Daylight:										
:transmission	3/2	2	2	1	1/4	4	2	2		4
:opacity	/1	31	3	12/	1/4	1	4	3		4
:colour rendering	/1	31	2	13/	1/4		5	2	1	4
:glare	1/2	2	1	3	1/4	4	3	1		4
Solar:						repeat other column				
:transmission	2/1	3	2	1	31	4	4	1		3
:heat gain	2/1	1	3	1	41	5	3			4
:shading	3/1	3	1	1	31	4	4	1		3
Acoustic:										
:transmission	2	2/	2	2	22	3	5	1	1	2
:absorption	1	3/	1	3	32	2	5	1	1	3
:reflection	1	3/	1	3	32	2	5	1	1	3
Durability:										
:accidental damage	1	2	1	12/	1/2	3	3	1	1	1
:vandalism	1	2	2	12/	11/2	3	3	2	1	1
:normal wear and tear	3	2	1	11/	11/2	4	4		1	1
Maintenance:										
:painting	3	1	1	3	21/2	5	2	1		2
:replacement	3	2	1	3	21/2	5	3	1		2
Availability:										
:stocks	3	2	2	1	21/2	3	4		1	
Delivery:										
:unloading	1	1	3	2	2/2	4	2	1	1	1
:lifting into position	1	1	2	3	4/2	2	3	2	2	
Cost-in-place:										
:material	4	4	3	2/	/2	14	4	2		
:labour	2	1	3	2/	/2	14	3	3		
Running Cost:										
:energy use	2/2	2	2	2	1	2	2	3	1	3
:cleaning	2	2	3	2	2/2	2	5	1		3
:maintenance	3	1	3	2	2/2	3	4	1		3
ADD any important feature which has been omitted and indicate your weighting.										

2.4. (3) Questionnaire: Features (Sheet 2)

Quantity Surveyors Mechanical/Electrical	1	2	3	4	5	1	2	3	4	5
Daylight:										
:transmission	1/2				1/4					4
:opacity	/1	/1		1/	1/4					4
:colour rendering	/1	/1		1/	1/4					4
:glare	1/2				1/4					4
Solar:						repeat other column				
:transmission	2/1		1		31			1		3
:heat gain	2/1				41					4
:shading	2/1		1		31			1		3
Acoustic:										
:transmission		2/		1	2/2			1	1	2
:absorption		2/		1	3/2				1	3
:reflection		2/		1	3/2				1	3
Durability:										
:accidental damage	1	1		1/	1/2	1	1		1	1
:vandalism	1	1		1/	1/2	1	1		1	1
:normal wear and tear	1	1		1/	1/2	1	1		1	1
Maintenance:										
:painting	1	1	1		2/2	1		1		2
:replacement	1	1	1		2/2	1		1		2
Availability:										
:stocks	2			1	2/2	3			1	
Delivery:										
:unloading	1			1	2/2	1		1	1	1
:lifting into position	1		1	1	2/2	1		2	1	
Cost-in-place:										
:material	4			2/	/2	4				
:labour	4			2/	/2	4				
Running Cost:										
:energy use	2/2	1		2		1				3
:cleaning	1	1		2	2/2	1				3
:maintenance	1	1		2	2/2	1				3
ADD any important feature which has been omitted and indicate your weighting.										

2.4. (3) Questionnaire: Features (Sheet 2)

Mechanical / Electrical	1	2	3	4	5	1	2	3	4	5
Daylight:										
:transmission	1/2			1/						
:opacity	/1	/1	1/	1/						
:colour rendering	/1	/1	1/	1/						
:glare	1/2			1/						
Solar:						repeat other column				
:transmission	2/1			/1						
:heat gain	2/1			/1						
:shading	2/1			/1						
Acoustic:										
:transmission		2/		/2						
:absorption		2/		/2						
:reflection		2/		/2						
Durability:										
:accidental damage			1/	1/2						
:vandalism			1/	1/2						
:normal wear and tear			1/	1/2						
Maintenance:										
:painting				2/2						
:replacement				2/2						
Availability:										
:stocks				2/2						
Delivery:										
:unloading				2/2						
:lifting into position				2/2						
Cost-in-place:										
:material			2/	/2						
:labour			2/	/2						
Running Cost:										
:energy use	2/2									
:cleaning				2/2						
:maintenance				2/2						
ADD any important feature which has been omitted and indicate your weighting.										

2. 4. (3) Questionnaire: Features (Sheet 2)

	1	2	3	4	5	1	2	3	4	5
Daylight:										
:transmission										
:opacity										
:colour rendering										
:glare										
Solar:										
:transmission										
:heat gain										
:shading										
Acoustic:										
:transmission										
:absorption										
:reflection										
Durability:										
:accidental damage										
:vandalism										
:normal wear and tear										
Maintenance:										
:painting										
:replacement										
Availability:										
:stocks										
Delivery:										
:unloading										
:lifting into position										
Cost-in-place:										
:material										
:labour										
Running Cost:										
:energy use										
:cleaning										
:maintenance										
ADD any important feature which has been omitted and indicate your weighting.										

2.4. (3) Questionnaire: Features (Sheet 2)

of flow patterns in the routines.

Completed questionnaires were received from:

1.	Architects in Private Practice	7
2.	Architectural Students (final year)	1
3.	Quantity Surveyors in Private Practice	3
4.	Quantity Surveyors in Government offices	1
5.	Mechanical and Electrical Engineers in Private Practice	4

With the exception of the one architectural student, the participants have had many years of experience in their profession and are in positions of responsibility for major projects.

2.4.3 Analysis of the Answers

General

1. The covering letter, sent out with the questionnaire advised participants that "if you give too much thought to the answers they will probably be wrong". This was done in an attempt to get 'instinctive response' but may have led to answers being based on an acquaintance with, rather than use of, the source as requested in the questions. There was probably also a tendency for answers to indicate a more thoughtful approach to design than is really the case.
2. From the viewpoint of their limited professional responsibility it would have been reasonable for some professions, in particular the Quantity Surveyors, to have no interest in many of the items of information. However, from the answers, there is a sharing of interest and knowledge.
3. Answers were sought under two headings to separate the groupings of the RIBA Plan of Work into Outline and Detail design. Judged by the different weightings, these groups seem to have more significance for Architects than for the other participants.

4. Most of the listed sources of information are used by Architects but three sources are used frequently by all the participants:

    : Manufacturers' catalogues
    : Own 'office' standards
    : Previous projects

    These sources are of the do-it-yourself type and gain more favour than the ready-processed types such as the Barbour Index (23) of manufacturers' data or the Architects Journal data sheets.

5. Although there is a significant grouping in the answers, there are some discrepant answers. It would have been interesting to discuss these answers but the purpose of the survey was to discover what information would be required and not why.

Architects

1. There was a surprising lack of knowledge about three sources:

    : NBA Commodity File (22)
    : BRE Temperature Prediction Charts (35)
    : IHVE Guide (36)

    The purpose of the Barbour Index and the NBA File is similar. The former was first published about 18 years ago and is used in many Architects offices, although 3 out of the 7 participants said that it is "never" used. The latter was first published about 5 years ago and has received wide publicity so it is surprising that 5 out of the 11 Architects who answered this question said that the source was unknown to them.

2. All the Architects considered solar heat gain and its prevention to be important features at the detail design stage, yet none of them made more than occasional use of the BRE Charts for the calculation of indoor temperatures during summer. These charts have received wide publicity and, since the other source of this information (the IHVE Guide) was also not used, it must be assumed that few attempts are made to assess the effect of

solar radiation. It is probable that this task is left to the Environmental Engineer.

Quantity Surveyors

1. The interest, by Surveyors, in the physical features of the particular component probably results from their involvement in proposing materials to the Architect which satisfy a cost limitation. By the strict interpretation of a Surveyor's duties there should be no reason for interest in these features.
2. Within the limited sample, there was less interest than expected in the physical handling and running cost features of the component. This may reflect the Surveyors concentration on capital cost and the, relatively, disinterest of the Standard Method of Measurement in manual and machine resources.

Environmental Engineers (Mechanical and Electrical)

1. The separation of the knowledge and use of the sources of information between the participants clearly indicates their dependence on particular sources. For the Mechanical Engineer the IHVE Guide, which contains collected data on building materials and engineering components, is the major source of information. There is no similar source for Electrical Engineers.
2. Own-office standards again have an important place which indicates the non-availability of reliable project and component data from common sources. For Environmental Engineers use-features tend to be clearly divided between 'very important' and 'unimportant', related to the participant's design responsibilities. It follows that detailed design information would be requested from suppliers on some features whilst information provided on other features would be redundant. Although the Environmental Engineer is concerned with certain properties of building components, other information such as price or delivery is not of importance.

2. 5 THE STUDY OF PRACTICE

The proceeding Sections have reviewed surveys of the use of information which had, as simplifications, the assumptions that data is used in a linear progression, without iteration, and that routines follow in direct succession. Disruption to the steady flow of information, caused by the interaction of several participants, was ignored.

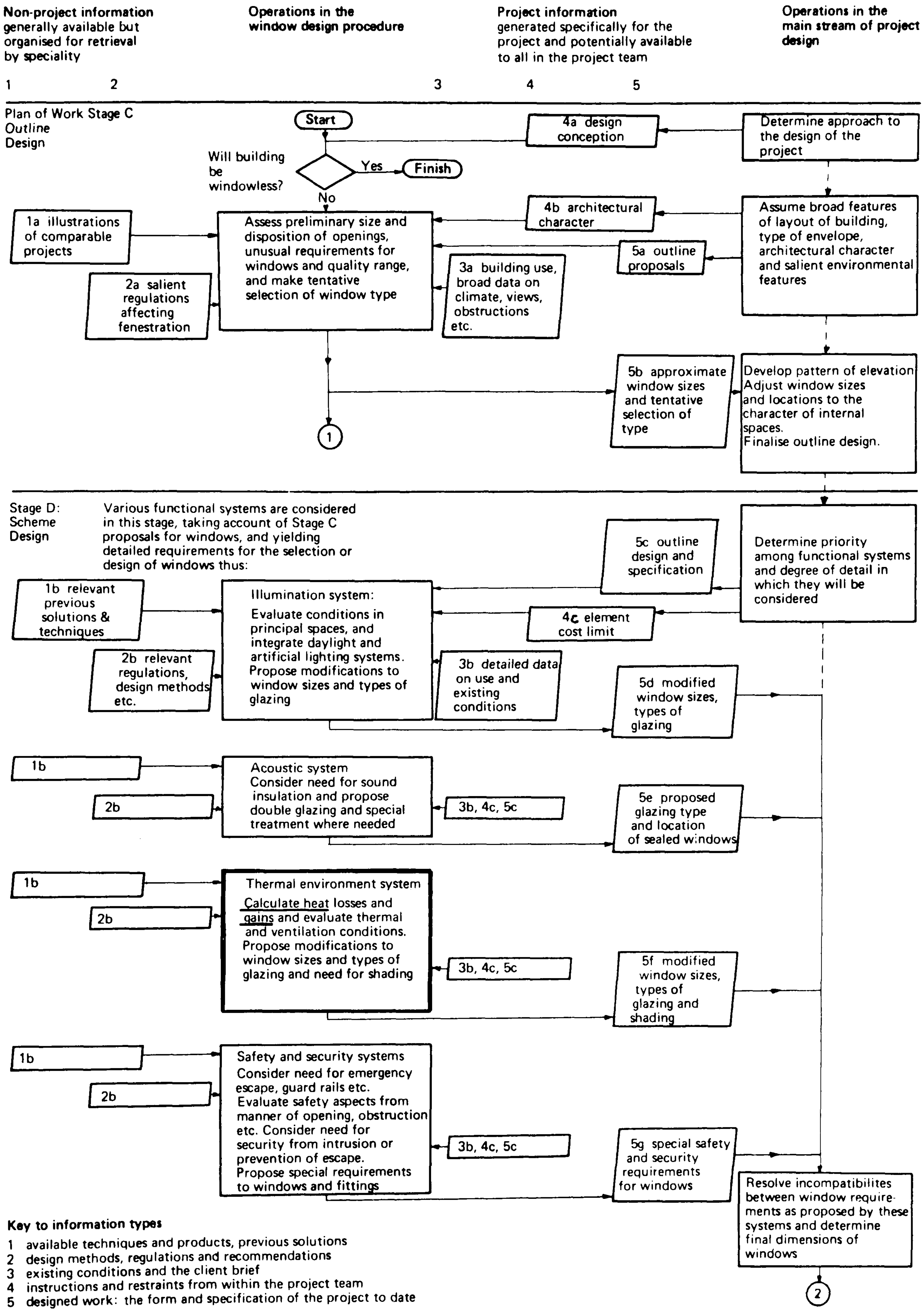
In practice the effect of iteration and participation is to cause eddies in the information flow in which the assumed direction of flow may be reversed.

To examine in detail the use of information one routine is examined by tracing all the data transactions. The example is the procedure for the design of windows, which was included in the CACCI Study (1). Contained in this procedure there is one part-operation "Calculate Heat Gains" which is examined in the following sections using the statements of a commercial computer program for cooling load calculation (37).

2. 5. 1 The CACCI Study

As part of the survey of practice made by the CACCI Sub-committee (1), which has been discussed in an earlier section, a study group of Architects examined the Procedures of Design. With the Study (28) there are several detailed studies of the design of functional systems and included in the procedures is one for the design of windows, which is copied here as 2. 5. 1 (1).

In the case of the design of windows it was recognised in the study that the design is an iterative process involving several specialists, although for clarity the process-flow was shown as sequential or parallel, without loops.



Key to information types

1 available techniques and products, previous solutions
2 design methods, regulations and recommendations
3 existing conditions and the client brief
4 instructions and restraints from within the project team
5 designed work: the form and specification of the project to date

2. 5. 1 (1) The CACCI Procedure for the Design of Windows

A window is, in terms of heat loss and gain, acoustics and security, the weak point in the building envelope. The weakness is associated with its function of letting in light. For most buildings the heat loss/gain through the glass of the window dominates the total room heat loss/gain. Details of window framing and surround dimensions and material become relatively unimportant, compared with those of the glass. Each factor has to be weighted to obtain a balanced selection.

For the operation 'Thermal environment system' and the routine 'Calculate heat gain', the information inputs and sources are defined in the study as:-

1b Relevant previous solutions and techniques.
2b Relevant regulations, design methods etc.
3b Detailed data on use and existing conditions.
4c Element cost limit.
5c Outline design and specification. (This includes the initial selection of window size, location and type).

2. 5. 2 A Computer Cooling Load Program

The same routine 'Calculate heat gains', is expanded in 2. 5. 2 (1) (2) and (3) to show in detail parts of its information flow and the sources of information. The program statements are three sub-routines from the listing of the cooling load program (37), which have been selected to show activities which are independent of, and dependent on, information supplied by others.

The types of information used are conveniently classified by the CACCI groups 1 to 4 but the scope of information is shown to be very great, ranging from macro to micro systems of knowledge. For example the sun path calculation requires truly 'universal knowledge' whilst the refractive index of glass is particular to that material. In addition to the types of information defined in the CACCI Study it will be seen that

TYPE OF INFORMATION

```
C. SUBROUTINE CALCULATES ALTITUDE
   AND AZIMUTH OF SUN THROUGH YEAR

        BL=BL * Cl
        T SUNH=TSUN/60. 0
        (where BL=building latitude,
        Cl is a constant =π/180
        TSUN is the difference between
        sun time and local time).
```

(4) From project data or atlas.

```
        DO10 M=Ml, M2
        DO11 NH=1, 24
        (where M is the number of the
        month.
        NH is the number of the hour).
```

Selected by designer

```
C DECLINATION OF EARTHS AXIS

        D=23. 5 * COS (M*30. 0*Cl)
        D=-D*Cl
        COSD=COS(D)
        SIND=SIN(D)
        TAND=SIND/COSD
```

(1) Calculation of angle of declination

```
C HOUR ANGLE ACCORDING TO LOCAL
  TIME

        HANG=15. 0 * (12. 0-NH+TSUNH)*Cl)
        IF (HANG) 13, 14, 13
        14 HANG=0. 0001
        13 CONTINUE
```

(1) Calculation of hour angle

```
C ALTITUDE OF SUN

        SINA=SIND * SIN(BL) + COSD
        * COS(BL) * COS (HANG)
        ALT(NH)=ATAN(SINA/SQRT
        (1. 0-SINA **2)
```

(1) Calculation of solar attitude

2. 5. 2 (1) Example of sub-routine independent of project data

```
                                                   TYPE OF INFORMATION
C  SUBROUTINE CALCULATES DECREASE
   IN WINDOW EFFECTIVE AREA DUE TO
   SHADING

         BETA=AZW-AZ(NH
         (where AZW is the orientation of          (5) Measured from the
         the window)                                   Architects drawings

C  SHADING DUE TO TOP PROJECTION

         TOP =OH*TAN(ALT(NH))/COS(BETA)-POT
         IF (TOP) 1,1,2
         2  EHS = EHS -TOP
         1  CONTINUE
            (where OH=overhang projection          (5) Measured from the
                   POT=overhang offset                 Architects drawings

C  SHADING ON LEFT OR RIGHT SIDE OF
   OPENING DEPENDING ON SUN POSITION

         IF (BETA) 3,4,5
         3  SIDE=FINL*TAN(-BETA)-POL
            GO TO 6
         5  SIDE=FINR*TAN(BETA)-POR
         6  CONTINUE
            IF (SIDE) 4,4,7
         7  ELS=ELS-SIDE
         4  CONTINUE
            (where FINL & FINR are the fin         (5) Measured from the
            projections, POL & POR are the             Architects drawings
            fin offsets).
```

2.5.2 (2) Example of sub-routine dependent on project data

```
                                                  TYPE OF INFORMATION

C SUBROUTINE CALCULATES TRANSMISSION
  AND ABSORPTION OF SINGLE OF DOUBLE
  GLAZED WINDOW GLASS FOR A GIVEN
  ANGLE OF INCIDENCE

        AMU = 1.526
        (where AMU is the refractive index        (1) Standard data (text
        for glass)                                    book or manufacturer)

C CALCULATE PARAMETERS FROM
  TRANSMISSION AT NORMAL INCIDENCE

        RN=(AMU-1)**2/(AMU+1)**2                  (1)
        (where RN is reflectance at
        normal angle)
        G=TN*(1.0/(1-RN)) ** 2
        (where G is reflectance at
        normal angle)

C ANGLE OF REFRACTION AND POLARISED
  COMPONENTS OF PARAMETERS

        SAR=SIN (AI)/AMU
        AR=ATAN(SAR/SQRT(1.0-SAR**2))
        R(1)=SIN(AI-AR) **2/SIN(AI+AR)** 2
        R(2)+TAN(AI-AR)**2/TAN(AI+AR)**2
        G=EXP(AKL/SQRT(1.0-SAR**2))
        (where AKL is the glass extinction        (1) Standard data (text
        coefficient for radiation x the               book or manufacturer)
        glass thickness)
```

2.5.2 (3) Example of sub-routine dependent on manufacturers data information may be grouped also by use:-

1. Information used by one operator only.
   (for example the refractive index of glass)
2. Information used by more than one operator.
   (for example the shading angles of a balcony for thermal environment and appearance).
3. Information used by every operator.
   (for example the basic dimensions of the building).

The three routines show:-

1. The extent and detail of non-project, general information used in the routines.
2. The iterative routine which follows from any change in the input data.
3. The extent of calculation which can be carried out independently of other participants, once the input data is agreed.
4. The dependence of component performance on location within the building and on the location of surrounding components.

In practice the design is developed by interaction between the operators and by iterative procedures. If the architect shows features such as fins or balconies they are unlikely to have optimum dimensions for the thermal environment and a design balance has to be established between performance and appearance.

2. 6 ANALYSIS OF USE OF INFORMATION

2. 6. 1 Use of Information as Researched in the CACCI Study

In analysing the use of information, the Study made the following, simplifying, assumptions:

1. Variations in the existing arrangement of design teams are such that there is no identifiable consensus of approach to the use of information.

2. Procedures of design can be identified independently of the participants who use them.
3. Patterns of education and organisation may be ignored.
4. Operations in a routine can be illustrated by a sequential chart.

These simplifications were useful in pinpointing the start and end of functional units in the design process but their use must be questioned in a study of the actual, as opposed to ideal, flow of information.

It would indeed be most fortunate if these assumptions were valid because it would remove a great problem from the task of analysis. However it is hard to see any justification, other than expediency, for the assumption that "prior experience (including education and training) of the person observed" is not central to the development a computer aided information system for costing and design. In the further study made by the Quantity Surveyors Working Party, (38) (39) they reverted, significantly, to a matrix based on Operator/Procedure.

The scope of operations in 2. 6. 1 (1) is similar to the activity matrix 2. 3. 2 (1) and demonstrates that every participant in the client/design team is active in providing or assessing information. Single functions such as 'design' are carried out by several operators: Architect, Structural Engineer, Environmental Engineer, specialist consultants.

The flow of information between operators is therefore as important as, but more difficult to control than, the flow of information between functions.

A further, simplifying, assumption was made in the CACCI Report about the direction of information flow in the building process model. Whilst recognising that there may be "several stages, (in a design task), perhaps involving iterations or revisions as more information becomes available", the procedure flow diagrams only showed one path between the

	CLIENT					PROJECT MANAGER	DESIGNERS				QUANTITY SURVEYOR
	Admin Policy/ Finance	Estate Surveyor	Legal	Advisers Generally (Economists Etc)	Users (inc R&D)		Architect	Structural /Civil Engineer	M&E Engineer	Specialist Consultants (eg acoustic)	
1. Establishing need within clients organisation	▨	○	○	○	○						
2. Funding generally	▨					○					▨○
3. Establishing & controlling overall timing for design & contract letting	○	○	○			▨○	○	○	○	○	○
4. Procuring resources for last	○					○					
5. Determining human activities to be accommodated	○			○	○	○	▨				
6. Establishing environmental criteria & user equipment	○			○	○	○	▨○		▨○	▨○	▨○
7. Identifying individual accommodation spaces & groups of related spaces	○			○	○	○	▨○		▨○		
8. Selecting site (purchasing etc as necessary)	▨	○	○	○	○	○					
9. Investigating site constraints (including site survey)		○	▨○			○	▨○	▨○	▨○	▨○	▨○
10. Testing alternative layouts & main structural & servicing solutions. Selecting solution	○	○	○	○	○	○	▨○	▨○	▨○	▨○	▨○
11. Obtaining planning consent (outline & firm)						▨					
12. Detailed component selection, preparation of working drawings, schedules, BQs etc	○	○	○	○	○	○	▨○	▨○	▨○	▨○	▨○
13. Contractor selection / tender announcement	○		○			○					▨
14. Evaluating desirability of making bid (tender selection)											
15. Establishing bid											
16. Checking bid / letting contract	▨		○			○					○
17. Establishing & controlling overall timing for construction	○		○		○	▨○	○	○	○	○	○
18. Establishing overall construction programme						○					○
19. Establishing detailed construction / ordering programmes											○
20. Establishing construction budget											

KEY : ▨ : Inputting data to file ○ : Accessing file only ▨○ : Inputting data & accessing file

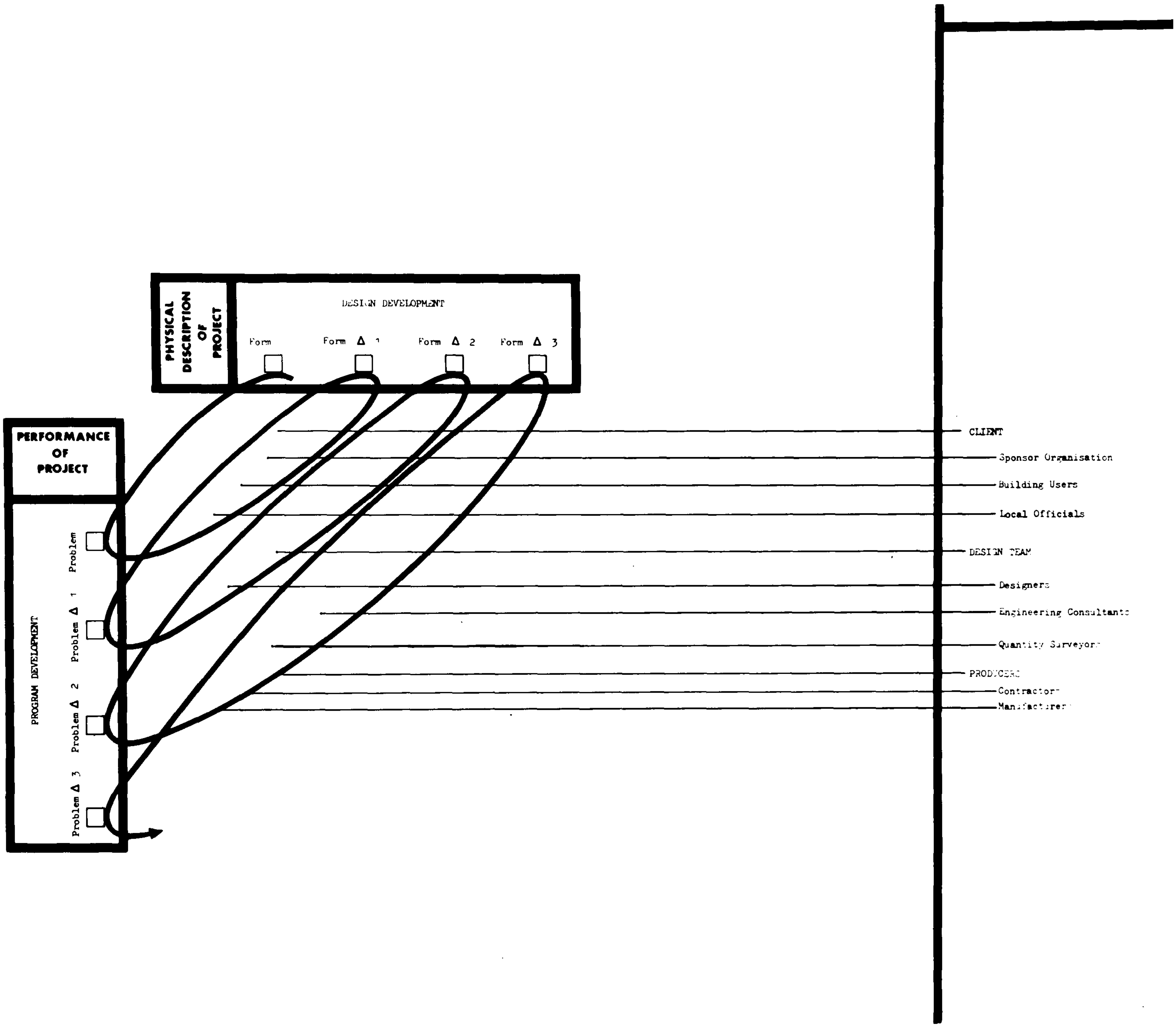
2.6.1 (1) Activity/Operator Matrix for Design Process "identifiable end-paths". It is however in the iterations, and revisions, to achieve an optimum solution that both the greatest demands are made on information about components and the most frequent interaction occurs between the participants.

In the flow diagrams which illustrate the grouping of procedures into routines, the procedures are assumed to be sequential and "parallel processes are avoided as far as possible". This part of the model does not allow adequately for the nature of the design task which is separated, both in time and place, by the organisation of the design team and the sources of information. In practice many parallel stages of design are generated individually and reconciled communally.

An alternative three dimensional or vectored model of the building design processes was proposed by a team which included some of the members of the Quantity Surveying Working Party. Their study (40) used this model, 2.6.1 (2), to show the problem-solving interaction of the design team operations and the co-incident and iterative design procedures.

Although the CACCI Study was useful in demonstrating the flow of logic in design procedures, it failed to allow for the division of the flow into specialist operator channels, except to conjecture that the use of computers would cause all flows to combine. The flow of the routine is interrupted when input information is required from a source other than the operator. This is, in practice, a major problem.

If the carrying out of a Function is distributed between operators, there has to be a flow of information between them. Whilst it is true that "it would have been extremely difficult to mount a study to encompass every aspect of this shifting scene", not to do so led to the study failing to come to terms with the reality of the problem of information flow.



2. 6. 1. (2) Three Dimensional Model of Design Information Interchange

The study also failed to mention the redundancy in data storage which would be caused by making information, needed by only one operator, available to all.

2.6.2 Use of Information as Indicated by the Particular Study

In contrast to the construction industry-wide study made by CACCI, the study in Section 2.5 is concentrated on a single member of the design team and, in detail, part of a single design procedure.

Viewed at this resolution the use of information takes on a new appearance. Within the routines the demand for information about components from other members of the design team is more than matched by the demand for information from manufacturers, national standards, research organisations and various standard references. Much of this information is researched and used within the task of one operator and no other operator need know about it.

Equally, features of a component, such as window orientation, assume an importance to the operator which is not shared by others.

There is, from this analysis and from the practice of design firms, a need for the individual operator to have a 'private' file of information about components which, although of great importance to the individual, is of little or no use to others. The file would contain both 'Project' and 'Non-Project' information and exist as a series of data banks to to accessed as required.

This study of a very small part of the total design process has shown how much Non-Project data is required as input. It would be uneconomic to attempt to store this data in the Project file, and unrealistic to assume that anyone, other than the particular participant, would be willing to accept responsibility for its provision.

2. 6. 3 A General Statement of the Use of Information

Conventional, manual, systems for the exchange of information about components already operate to allow effective communication between members of a design team. These systems rely almost exclusively on the naming and specification of components and on their representation on drawings.

Inefficiency in the design process results from the various operators having to rediscover information about components. A simple but common example is the necessity for the receiver of some data about a component to research further data when the required information was already in the possession of the sender.

Because of the specialist nature of building design, no individual specifier of components can be expected to know all the facts about each component, or even what facts might be required. Except in single-client or multi-discipline organisations it is not possible for the originator, or selector, of components to parcel-up all the required information about a component. The sender may only be able to provide the key or indicator which will enable the receiver to locate further information.

It follows that the problem changes from "How much" to "How little" information about components needs to be communicated between participants, in order that both may gain access to further information. The source of the further information may be the manufacturer or, one day, a co-ordinated national system for commodity information.

As a corollary, it becomes the responsibility of the sole-user of specific information about components to maintain the files of data which will be required for his own task.

Most of the information needed for design already exists. What is needed is a classification system which allows all users to access it. With the increasing use of computers there is becoming available a means for rapid communication of design data but for economy it must be presented in a logical manner.

SECTION THREE : THE THEORY OF CLASSIFICATION & CODING

3.1 GENERAL

Classification was used historically to enhance mans' understanding of his world, by placing natural objects in an order that related them to man. It was extended to include abstract ideas and the creative arts. By this means one word could be used to cover a number of related words:- 'mathematics' included arithmetic and geometry. Classification aided identification in that it helped to isolate a particular object. Because knowledge was recorded by writing, classification was first applied to books and most of the formal study of classification has been made by librarians.

Other disciplines use classification or consider its structure within their studies. Logic and mathematics combine in a study of set theory; computer programing languages use rigid YES/NO classification to describe complex relationships. These users have developed classification systems which have contributed to the overall study of classification.

The purpose of classification in a library is to bring together documents dealing with a particular subject, even though this subject may not be obvious from the document title. When classifying a document, the indexer may have a problem in deciding what is its main subject and thus have to record its title under two or more headings. In the extreme, an encyclopaedia has to be classified as 'general'.

When classifying building components, the name of the component is known (although there may be more than one common name). The user may wish to know features of the component which are not apparent from its name. Also the user may wish to link similar features from different components, such as thermal properties or dimensions, and would want to enter the data file from the direction of a feature, rather than from a name.

However, the absence of an internationally accepted, all inclusive, classification of objects and knowledge is an indication of the complexity of the task of classification. All classification systems have to include limiting assumptions to reduce them to a usable size and complexity. These assumptions are empirical and are made by the classifier, hopefully, for the convenience and understanding of the user.

A succinct definition of classification was given by Sayers (41):

> "The actual or ideal arrangement together of those objects which are like and the separation of those which are unlike. The purpose of this arrangement being primarily to facilitate the operations of the mind in clearly concentrating and retaining in the memory the characters and the objects in question and the recording of them that they may be quickly and conveniently referred to and secondarily to disclose the correlation of laws of union of properties and circumstances".

There are two broad approaches to classification. The first is hierarchic, which is the division of information by the consistent application of a criterion so that the parts are mutually exclusive. It has the weakness that it does not allow for future knowledge which may not fit into the pattern. The divison tends to be subjective with the result that the searcher does not necessarily apply the same criteria as the original analyst.

The alternative faceted classification starts with categories and builds up a description by selecting sets of terms to describe the original concept. Faceted classification is a form of pre co-ordinate indexing in that the indexer allocates terms, from lists at a number of levels, to describe aspects or features of the component or document but it suffers from the weakness that the user has to know the terms in the authority list.

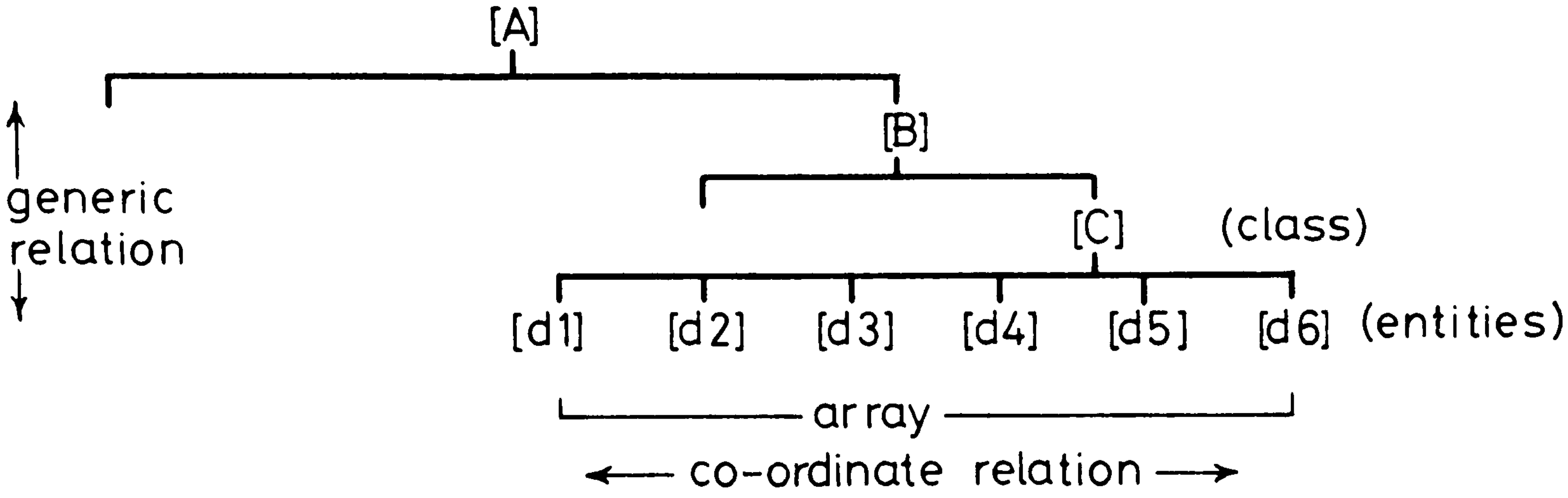
In some applications of information retrieval the structure of the information is not important, as in the case of a reader wanting books about a subject which may be named. Relevant books may be found if their title, or index, includes the subject. Because the linking of terms takes place after the enquiry, the retrieval system is known as 'post-co-ordinate'.

This Section includes a review of general purpose historical and modern classification systems and an analysis of their structure , with comments on their application to the subject of the Thesis.

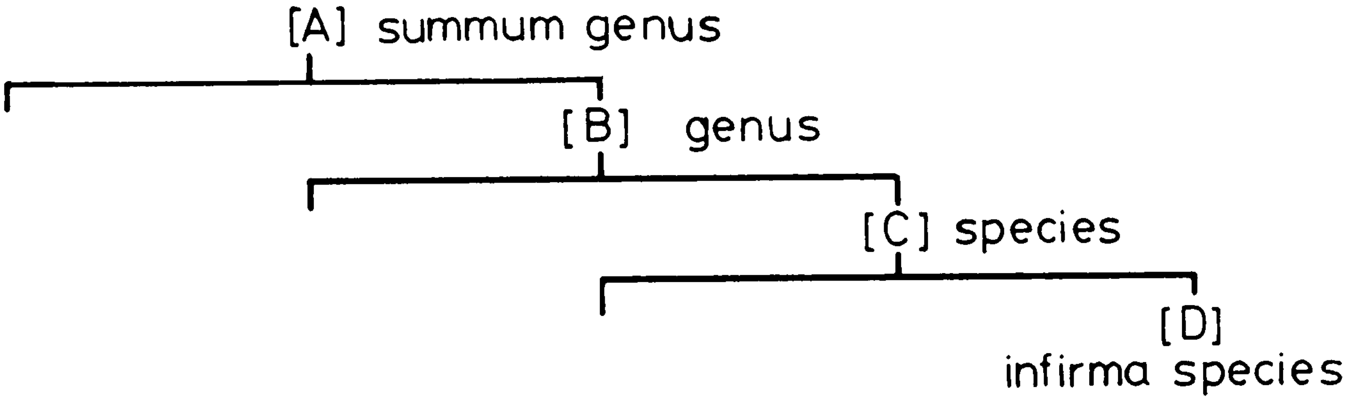
3. 2 HIERARCHICAL SYSTEMS

This was the dominant system from the Aristotellian classification until the end of the 19th century. It was adequate for a simple understanding of the world, in particular the assumed order of nature, but failed to cater for a developing technology. The main feature of hierarchical, or deductive, systems are the generic and co-ordinate relations by which any class is immediately subordinate to only one other class. Fig 3. 2. (1) shows these relations and the terms by which they are now known.

Each Class is formed by the division of an Entity by a Characteristic to produce a more detailed Array of Entities. The order in which Characteristics are applied, the citation order, can produce various hierarchies. For example if 10 Characteristics are applied to 10 objects,



3.2.1 (a) Modern Terms



3.2.1 (b) Classical Terms

3.2. (1) Structure of and Terminology for Hierarchical Classification Relationships there are factorial 10, (3,628,800), possible resulting hierarchies if order is considered to be significant. For hierarchical systems to be effective, the Characteristics and their citation order must be known. Only a single Characteristic may be applied at each level and this will frequently separate entities that share another Characteristic. The latter is called the distributed relative,for example, division by the Characteristic 'shape' would separate round and square objects which share a Characteristic 'colour'.

Many divisions are obvious to both classifier and user but in other cases the selection of the dividing Characteristic is subjective with the consequent probability of confusion. In some library systems this problem is overcome by the use of duplicate, or multiple, entry of hierarchical references with the order of the primary and secondary terms being changed. There is an early limit to this technique however, because of the large number of possible citations or hierarchies.

All hierarchical systems rely on a preconceived structure of knowledge which in practice, or theory, allows all subjects to be pre-classified so that the user arrives at the classification reference by working downwards from the general to the specific content of a subject. To ensure success this would require the classification to be fully enumerative which is impossible in a situation of rapidly expanding knowledge.

Even as late as 1725 the Royal Society's classification contained only 18 headings and excluded technology such as Engineering, though Francis Bacon in 1605 had included Engineering as a sub-division of Mixed Mathematics. There was a rapid development in hierarchical classification systems at the end of the nineteenth century.

Hierarchical structure forms the basis of the widely used Dewey System (42) which was introduced in 1876 and continues, after several revisions, to be the standard classification system in the USA. This system is referred to again in 4.1.

3.3 FACETED SYSTEMS

The alternative pre co-ordinate classification system provides the preferred terms, or descriptors and a set of rules for their assembly into a description by the selection of a term from each level or facet. The direction of classification of a subject is reversed from the hierarchical system in that terms are selected to build up to a subject description rather than the subject being broken down into its elements. In a strictly hierarchical system, all the combinations of terms to form subjects must be enumerated, whereas in a faceted system the terms are assembled by the user. The form of the final faceted listing may be similar to its equivalent hierarchical entry, but each term appears once only.

The main advantage of faceted systems is that they can start from the limited, although perhaps specialised, knowledge of a sector user, for example the building industry, to produce an efficient system. Such a system usually requires from the user some knowledge of the detail of the subject, .In a hierarchical system the user is guided from the general to the particular and may stop at a coarse analysis, whilst in faceted systems the user has to decide at which level to commence.

In selecting the terms to be included and in stating the rules for their combination, the indexer again has to make subjective decisions. Even when these are educated decisions, there is no assurance that the user will be able, or will want, to follow them.

3.4 NAMING, THESAURI AND KEYWORD INDEXING (Post Co-ordinate Systems)

One answer to the objection to the subjective nature of classification is to dispense with classification structures and substitute a list of all the names of the objects and their features. The user states the name(s) and/or feature(s) he requires and he is then guided to, or a machine searches for, the required combination. This system is known as post co-ordinate, in that the joining together of terms takes place after the user's enquiry and it requires no knowledge by the user of the structure that has been used in filing the data. Pre co-ordinate systems have terms joined in fixed and pre-determined relationships as in the faceted classification.

In the case of a library based on post co-ordinate indexing the user, seeking information on a subject, has only to select suitable terms without regard to their relationship. The system can search for all documents which contain reference to them. At an earlier stage the librarian or indexer, will have allocated terms to the document and identified it, usually by an accession number.

The major problem is that the indexer may not have used the same names or terms as the user who has therefore to be guided to the preferred name by the use of an index so that, entering by any of several synonymous terms, the user finds the preferred term. The description of Thesaurus has been given to this index which guides the user from his initial terms to the preferred terms. Even then the user may have to search for the term which corresponds most closely to the feature he wishes to describe. A preferred term Thesaurus usually has to be classified to simplify the search task. As a first step the preferred term may be referenced to its higher genus-species term which widens the area of available information. Then the terms may be grouped by a very coarse classification which makes it almost certain that the required information will be included in the search area whilst excluding the mass of irrelevant data.

As an alternative to listing all the terms at a level, the generic class terms may be used instead as key-words. For example, in a library catalogue, 'sanitary fittings' could be used as a term to cover the many types of baths, basins etc. Whilst the use of key-words reduces the size of the index, it increases the amount of redundant information provided to the user.

3. 5 STRUCTURE OF CLASSIFICATION & STRUCTURAL MODELS

Underlying any information retrieval system there is a structure which relates the items of information to allow their retrieval either individually or in relationship with other items. All practical systems include means for coarsening these relationships to reduce their number. In the UDC system, (Section 4. 1), the relationships are reduced to downward spreading, singly-linked, non-overlapping trees and all other relationships are discarded. In other systems the terms or elements, are pre-combined into groups and cannot be handled in finer detail.

A measure of the exactness of a system is given by the number of links it provides, both horizontally and vertically. Fairthorne (43) has proposed two characteristics to describe these links: 'Connectivity' for the links between elements and 'Dimensionality' for the number of links between the extreme elements in a chain.

3. 5. 1 Tree Structure

Hierarchical classification is based on division of terms by a simple YES/NO analysis - 'Is B a member of class A. . . ?'.

This division produces the classical 'tree' structure, with each item having one, and only one, link to another item. It is singly-connected.

Faceted Classification allows the links to be multiplied by the variable combination of terms to reflect different facets and provide multiple connection. The tree model is not adequate to portray these relationships for other than the smallest, simply related, terms.

3.5.2 Mesh Structure

If provision is to be made for unknown relationships, the simple YES/NO has to be amplified to include 'may be' and 'may not be'. 3.5.2 (1a) shows this diagrammatically.

When the same question is asked about membership of two classes, A and X, the structure remains simple. 3.5.2 (1b)

However the addition of a third class produces a much more complicated mesh, 3.5.2 (1c), and the extension of the search for membership of six classes produces a mesh with nearly eight million nodes.

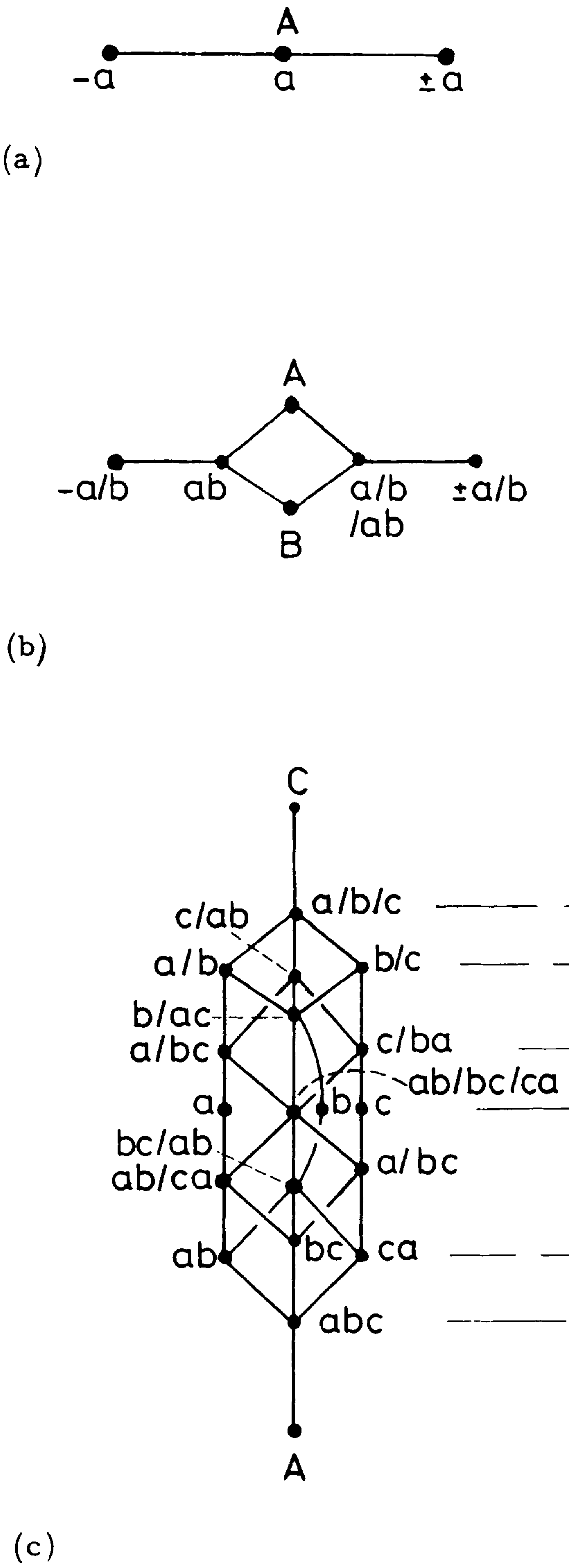
3.5.3 Venn Diagrams and Set Theory

The mesh shown under 3.5.2 (1c) can be represented as a Venn diagram, 3.5.3. (1), which provides a visual guide to the relationship of the terms, but this diagram again becomes complex with multiple terms.

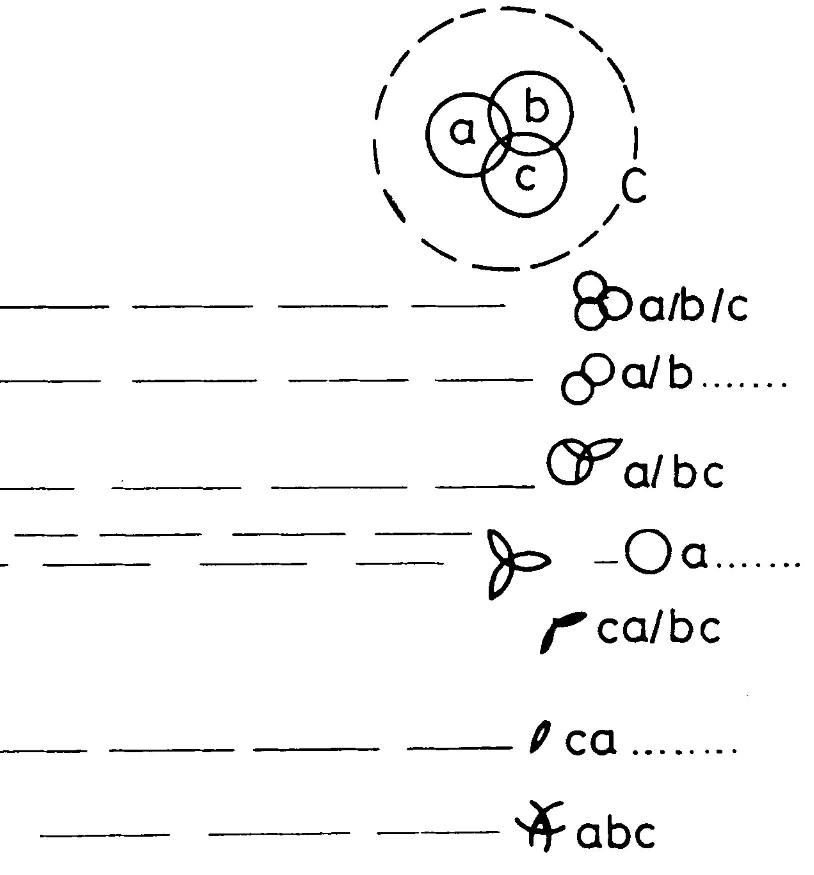
The use of Venn diagrams is associated with set analysis in that the relationships between terms can be expressed as operations. Gray of the Department of Architecture at the University of Cambridge has proposed a computer language based on the use of sets (44) to handle building description and data bases.

3.6 THEORY OF CODING

The use of coding, instead of plain language, introduces possibilities of error in coding and transcribing, and changes the record from a readable to an often meaningless form. There must therefore be compensating advantages from its use.



ab = 'a and b'
a/b = 'a or b'
-a = 'not a'
± = 'may, or may not be'



3. 5. 2 (1) Mesh Diagram of Class Membership

3. 5. 3 (1) Venn Diagram of Class Membership

3.6.1 Reduction in Description Length

This has been one reason for the use of UDC codes in libraries. A numerical sequence of five or less digits can lead the user to a book title of many words. In the case however of a complex subject title which includes more than one class, an equally detailed UDC code string might have more digits than the characters of the title. In libraries the use of UDC codes works only because a coarsening of the book title and subject description can be accepted. The user will search and select within the coarsely defined shelf area or will approach the subject by a number of classes.

With faceted descriptions, the use of codes at each level can greatly compress the length of the written description and yet provide a significant identification.

3.6.2 Demonstration of Relationship

This is again illustrated by the use of UDC in libraries. The code indicates the position of the book on the shelf. A faceted description code can also indicate relationships at each level but this is done at the expense of redundancy in every indicated relationship which is not required by the user. When there is more than one user of the information the redundancy will tend to increase until, if every possible relationship is included, the code although highly significant would become unacceptably long.

3.6.3 Code Length Reduction

The ideal is to provide the maximum information at each code position and the minimum of positions in the code string. The digit at each code position may be either a number or an alphabetic character, although some computer applications limit the selection to numerics because of hardware limitations. Use of the 26 alphabetic characters increases the available digits from the numerical 10.

Stagger techniques can be used to reduce the code sequence length when the full capacity of sections of the code is not required. This technique has been used in some trade systems, in particular the International Standard Book Numbering system. If the code has to signify three levels of information, a fixed field code length using numerals would require digits as the following example from the Draft BS (4) for 12,000 manufacturers, the largest of which produces 100,000 commodities:

Industry identification	3 digits	(capacity 999)
Manufacturer identification	5 digits	(capacity 99,999)
Commodity identification	6 digits	(capacity 999,999)
Total	14 digits	

It is probable however that there is a distribution in size of manufacturer and number of products, with many firms producing a few products and only a few large manufacturers producing a wide range of products. If the large manufacturers are given small identification numbers a stagger can be introduced. 3. 6. 3 (1) shows this arrangement.

When the code sections are combined in a string there can be confusion from the compacting of the digits so that spaces have to be introduced, thereby elongating the code string. Use of a mixed alpha-numeric code reduces its potential capacity but provides indication of the sections without the introduction of spaces. This technique is applied to the proposed British Standard Code, as 3. 6. 3 (2).

Vickery (45) has demonstrated the mathematical basis for the selection of field widths.

(N = Numeric)

a	b	c	d	e	f
NNN	NN	NNNNNN	01-99	99	999,999
NNN	NNN	NNNNN	001-999	999	99,999
NNN	NNNN	NNNN	0001-9999	9,999	9,999
NNN	NNNNN	NNN	00001-99999	99,999	999
Total No. of Manufacturers per Industry				111,096	

Code Fields:—
(a) Industry
(b) Manufacturer
(c) Commodity
(d) Range of Manufacturer references
(e) Number of Manufacturers
(f) Products per Manufacturer

3. 6. 3 (1) Identification Code Stagger

(A = Alpha, N = Numeric, E = Either Alpha or Numeric)

a	b	c	d	e	f	g
NA	NA	EEEEE	E	1A-9Z	216	339,996
NA	NNA	EEEE	E	01A-99Z	2,376	33,966
NA	NNNA	EEE	E	001A-999Z	23,976	3,366
Total No. of Suppliers per Sector					26,568	

Code Fields:—
(a) Sector Coding Authority reference
(b) Supplier reference
(c) Commodity reference
(d) Check-digit (based on Modulus 37)
(e) Range of Supplier References (not using the letters I or O)
(f) Number of suppliers
(g) Number of Commodities per Supplier

3. 6. 3. (2) Proposed BS Code Identification

If an encoded message is:

$$N_1 n_1 + N_2 n_2 + N_3 n_3 \ldots\ldots\ldots N_m n_m = T$$

where N is a field
n is the number of characters
T is the total message characters

A field of n_x characters would appear, with a normal distribution probability

$$P_x = N_x / G$$

The number of messages (P) of length T, which can be assembled by interchanging the position of different fields is given by

$$\log n\, P = G \Sigma\, p_x \log n\, P_x$$

Maximum brevity in coding results when P is a maximum

$$\log n\, P_x = A\, n_x$$

Therefore maximum economy is achieved when the length of field n_x is inversely related to the probability of its occurence.

It follows that the identification or common-trading part of a code should be as short as possible, whilst it is permissible for a detailed code belonging to a specialist sector to be as long as is necessary to convey the intended information.

3.7 RETRIEVAL EFFICIENCY

An ideal information system would enable an experienced user to retrieve all, but only, those documents or data which the user would have selected had he had full access to the information file with unlimited time. In practice the user is the greatest cause of error because of inexperience or inability in formulating his demands.

3.7.1 System Efficiency

At the Western Reserve University (46), the efficiency of retrieval has been expressed by a number of functions: (N) the total number of data items; (R) the number of items retrieved; (X) the number of available relevant data items and (W) the number of relevant data items actually retrieved. The relationships are:

R/N : resolution factor
(N-R)/N : elimination factor
W/R : pertinency factor
(R-W)/R : noise factor (or interference)
W/X : recall factor
(X-W)/X : omission factor

3.7.2 Operator Efficiency: Check Digits

In plain language data transactions there is an obvious control in that if nonsense is written down it will read as nonsense to the next user. This control is more difficult to achieve in coded, machine, operations and a commonly adopted control procedure is the use of 'check digits' or self-checking numbers.

Errors are of a number of types and occur with varying frequency, as the following examples of errors in transmitting '122897'

Error		Frequency
Omission	$1\underline{2}897$	Infrequently
Addition	$122\underline{2}897$	
Transcription	$122\underline{3}97$	Common
Transposition	$122\underline{9}87$	
Random	(combination of above or completely wrong)	Rare

A simple control is to add the numbers in the code, (or numerical equivalents of alpha-characters), at the coding and decoding stages. This gives some protection against omission, addition and transcription errors but none against transposition.

More complex, but much more effective, is the check-digit technique and there are a number of applications of the technique with improved control efficiency for particular errors. The common elements are multipliers (the weight), a divider (the modulus) a remainder, and the resulting check-digit.

Modulus 10 is applied to a widely used component identification system (47), the weights are 7, 3 and 1, recurring, applied from the right hand end of the number to be coded.

Identification to be coded: 122897

	1	2	2	8	9	7	
	x	x	x	x	x	x	
Weight	1	3	7	1	3	7	
	=	=	=	=	=	=	
Product	1 +	6 +	14 +	8 +	27 +	49	= 105

105 ÷ 10 = 10 (remainder 5)
10 - 5 = 5 (check-digit)
Code number = 1228975

The control program repeats the multiplication, adds the check-digits, and divides by the Modulus, which should result in a whole number. Any remainder being an indication of error. If the check-digit is 10, X is substituted to avoid a two character check-digit.

Modulus 11 is used in ISBN (Section 4. 4) with weights 2, 3, 4 . . . n, again applied from the right hand end. When used in the same way as Modulus 10, it is very effective in discovering errors of transposition.

Modulus 37 was proposed in the Draft BS Code for application to a mixed alpha-numeric code. 37 is the first prime number after the numbers used as numerics and alpha-numeric equivalents. The remainder is written as a numeric if less than 10, and as the alphabetic equivalent if 10 or greater.

Identification to be coded: 8 B 9 A
with A = 10, B = 11

	8	B	9	A	
	x	x	x	x	
Weight	5	4	3	2	
	=	=	=	=	
Product	40 +	44 +	27 +	20	= 131

131 - 37 = 3 (remainder 20)
37 - 20 = 17(check-digit)
Alphahetic equivalent of 17 is 'H'
Code Number: 8 B 9 A H

Equivalent Performance. Calculations have shown (14) the following equivalent performance:

Error	Percentage Detection		
	Modulus 10	Modulus 11	Modulus 37
Omission	99.9	99.9	99.9
Addition	99.9	99.9	99.9
Transcription	100	100	100
Transposition	88.9	100	100
Random	90	90.9	97.3

SECTION FOUR : GENERAL COMMODITY CLASSIFICATION SYSTEMS

Construction is only one of the many activities in which articles are manufactured and traded. Some building construction trades, such as concreting, use basic materials whilst others, such as plumbing, use mainly pre-manufactured components.

The selection, specification and description of these components have many parallels with other trading activities and the classification systems developed or used for other purposes may have application in building.

Some of the more significant classification systems are described and analysed in this Section.

4. 1 UNIVERSAL DECIMAL CLASSIFICATION (UDC)

Is derived from the Dewey Decimal Classification (DC) and is widely used in Europe under the aegis of the British Standards Institution (48) as part of the International Federation for Documentation (FID). The main divisions of DC and UDC are similar but devices have been added to the latter to handle some inter-relationships which, by allowing synthesis, make the system a hybrid of hierarchical and faceted systems.

4. 1. 1 Viewpoint

UDC is a library classification system although its use was extended to some trade literature in the early CIB/RIBA combination of UDC and SfB (8) (49). UDC is a comprehensive library classification system of which only small parts are applicable to any one subject. The classifier is 'aspects' of a subject which does not have a direct application to the real object such as a building component.

4.1.2 Classification/Identification Structure

UDC is hierarchical and general, although it was intended to cater also for the needs of specialist and technical libraries. Ten areas of knowledge are divided, by decimal, without limit but in practice it is usual to stop at five or six levels. Each level is identified by a single digit and a decimal point is introduced between each group of three digits to aid reading.

Within each level the material is enumerated as a simple list but some order has been introduced so that sequences in different classes are similar.

4.1.3 Coding

To overcome some of the limitations of a hierarchical system, a number of symbols have been introduced which enable classes to be co-ordinated and provide a degree of synthesis by faceted grouping. As well as symbols representing relationships, others allow reference to the common sub-divisions of DC:- language, form, place, time etc. Use of these symbols to achieve a precise classification can result in long numerical chains and a subjective element is introduced into their ordering.

4.1.4 Application

The generality of the system results in peripheral aspects of a subject being widely distributed across the Sections. The International Council for Building Documentation (CIDB or CIB) accepted UDC for general use and the International Building Classification Committee (IBCC) was established in 1952 to study the appropriate Sections and compiled a selection from UDC, known as the Abridged Building Classification (ABC) (8). During the intervening period, the disadvantages in use of UDC compared with SfB, have led to the rejection of UDC as the preferred classification system for the building construction industry.

4.2 THE NATO CODE

This system which was developed from the American Federal Cataloging System for the military stores of the NATO Forces, has been described in detail both by the issuing body (50) and by O'Connor (51) and Mitchell (52). Its importance comes from the extent of the items classified, by type and number, and its international multi-language use. It is, in size, the most developed and used commodity system although its use is limited to military applications.

4.2.1 Viewpoint

This is a users system, not a manufacturers, so items are classified according to function, irrespective of the source or supplier. The descriptive term is 'Items of Supply', in opposition to 'Items of Production', but 'Items of Purchase' might have been a more precise term.

The advantage to the user of this approach is that it avoids the confusion caused by manufacturers using different names to describe an item which the user would consider to be identical in function. The question which still has to be answered by the classifier is "How identical is 'identical'?" In precision engineering one, small, dimensional difference could prevent components from being interchangeable. In building construction a greater dimensional variation might be acceptable whilst a feature variation, such as fire resistance, would not. NATO, as a large purchasing organisation, is able to set standards and specifications against which components are manufactured but this control is not available to the building construction industry.

At present the construction industry does not have a central classifying authority to co-ordinate and control the demands of the many sectors who use commodity information. It may be that, after each sector has applied its criteria, the grouping of items of supply would be so fine that there would be little advantage over identifying the items of production.

4. 2. 2 Classification/Identification Structure

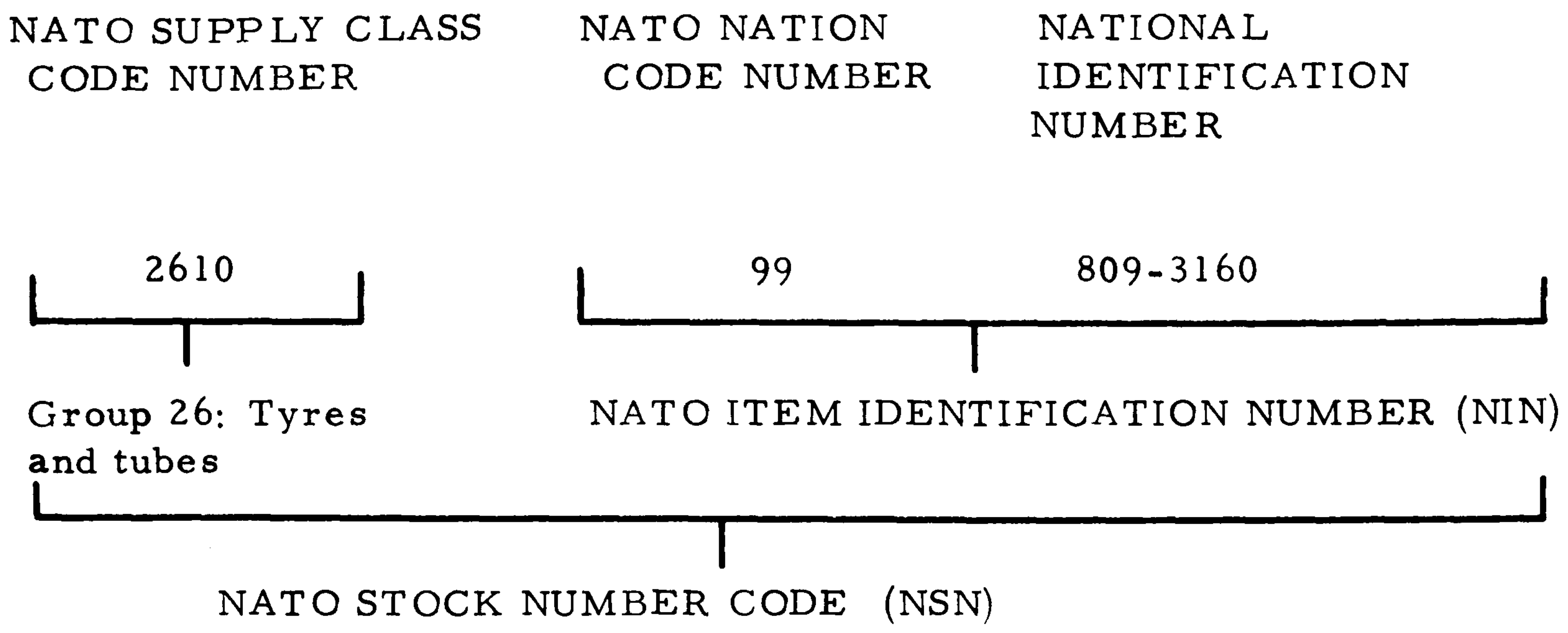
The NATO Code separates classification and identification. The former is a relatively coarse classification based on Group and Class. In the system there is provision for 90 Groups each of 89 Classes and, although over two million items are already classified, there are still many unassigned Groups and Classes.

Identification of items is made by national organisations who use a standard Guide to the grouping of items but produce a non-significant identification code. There is provision for producing NATO-wide classifications. The rules in the Guide constitute an extension to the classification by providing two or more levels of sub-division.

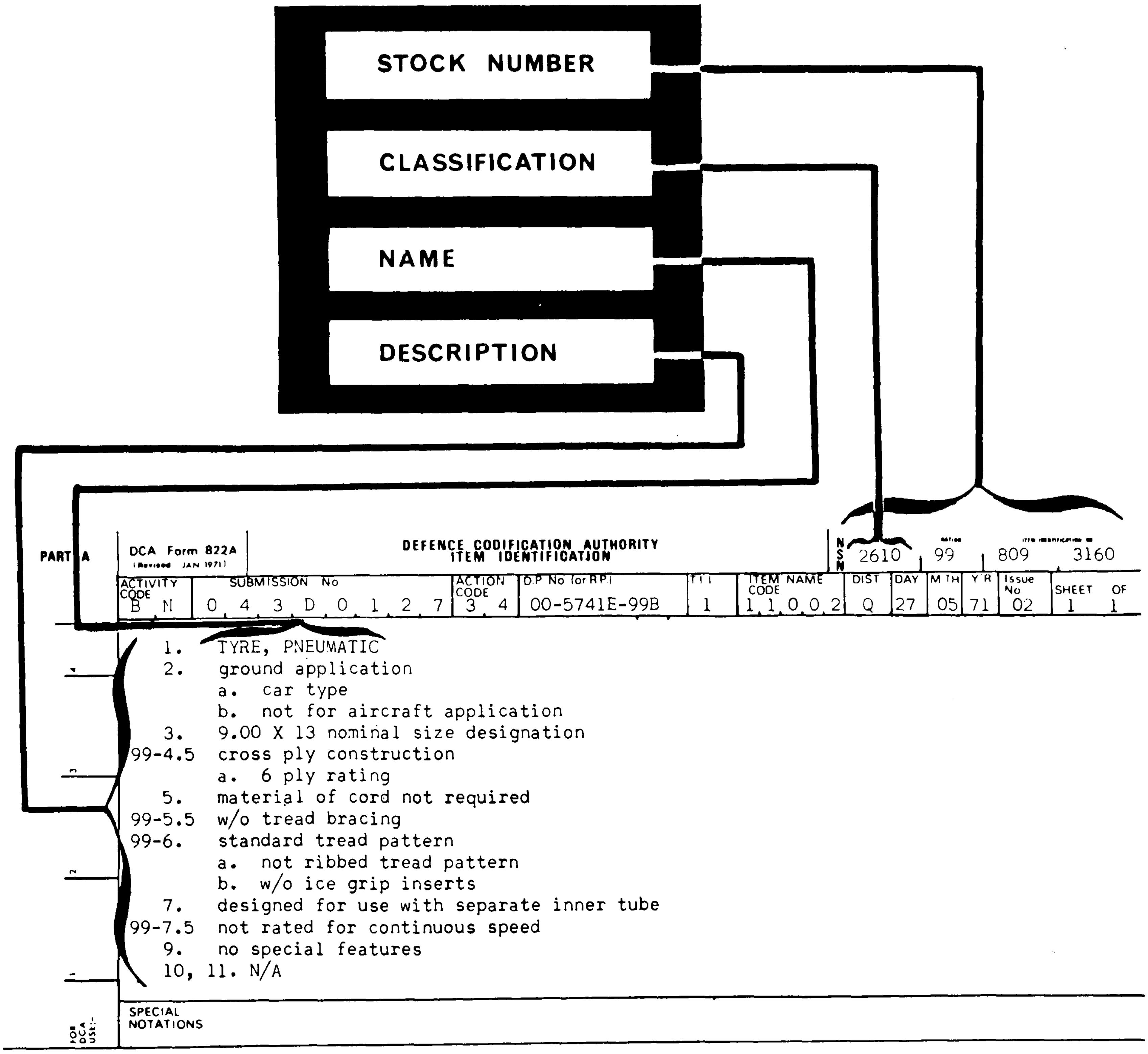
Commodities are identified against descriptions in a thesaurus, or index of item names, and the system is dependent on this thesaurus which guides the user to the preferred name and then to any existing identification code. In addition to naming, the thesaurus provides a brief item description which assists in defining the limits to uniqueness.

4. 2. 3 Coding

The complete NATO Stock Number Code (NSN) comprises three numeric groups; the NATO Supply Class Code, the Nation Code and the National Identification Code, see 4. 2. 3. (1). Within each National Identification Number Code (NIN) there is capacity for ten million items arranged in sequential and non-significant order. The NIN may be used on its



a) Code Structure



PART A

DCA Form 822A (Revised JAN 1971)

DEFENCE CODIFICATION AUTHORITY
ITEM IDENTIFICATION

NSN 2610 99 809 3160

ACTIVITY CODE	SUBMISSION No	ACTION CODE	D.P. No (or RP)	T I I	ITEM NAME CODE	DIST	DAY	M TH	Y R	Issue No	SHEET OF
B N	0 4 3 D 0 1 2 7	3 4	00-5741E-99B	1	1 1 0 0 2	Q	27	05	71	02	1 1

1. TYRE, PNEUMATIC
2. ground application
   a. car type
   b. not for aircraft application
3. 9.00 X 13 nominal size designation
99-4.5 cross ply construction
   a. 6 ply rating
5. material of cord not required
99-5.5 w/o tread bracing
99-6. standard tread pattern
   a. not ribbed tread pattern
   b. w/o ice grip inserts
7. designed for use with separate inner tube
99-7.5 not rated for continuous speed
9. no special features
10, 11. N/A

SPECIAL NOTATIONS

4.2.3 (1) NATO Stock Number Code and Description own within the country of origin, but the full code is required for unique identification throughout the NATO countries. Use of non-significant codes for the NIN leads to the possibility of member nations using different codes for identical items. When this is recognised, the other countries adopt the originating country's stock code.

Improvement of the descriptive patterns is being made to allow computer handling of the Identification Guide and this involves a detailed classification and coding of characteristics.

4. 2. 4 Application

Proposals have been made for the extension of the NATO Code to general use. It has been estimated however by O'Connor (51) that only about one per cent of the uncontrolled combinations of goods in commercial use are included in the code. The system could be used in controlled applications, such as the major nationalised industries, but the subjectiveness of the classification and description would involve a very large central organisation for the construction industry. Following the lack of interest shown by the industry in the Draft B. S., it is unlikely that the, even more disciplined, NATO Code would be acceptable.

4. 3 BRUSSELS TARIFF NOMENCLATURE (BTN)

The use of this system appears from the full title 'Nomenclature for the Classification of Goods in Customs Tariffs'. It is used widely outside America and the Eastern Bloc countries and forms the basis for a number of derived systems such as the UK Classification for Overseas Trade Statistics and its EEC equivalent. It derives from the 'Geneva Nomenclature' produced by the League of Nations in 1931.

4. 3. 1 Viewpoint

As a customs system, it is concerned with the practical identification of all types of goods and gives advice to Custom Officers and both importers and exporters. In this sense it is a link between buyers and sellers.

4.3.2 Classification/Identification Structure

It is a hierarchical system and was originally analysed on the basis of the relationship of commodities to man but this is not apparent from its format. At a practical level there has to be only one possible classification for commodities for customs purposes and this requirement produces a rigid classification which lacks the flexibility to respond quickly to changing patterns in trade. Commodities are classified at three levels; Sections, Chapters and Headings.

4.3.3 Coding

Commodities are listed in groups which have a common feature. Coding is incidental to the Chapter and Headings (clauses) listing. Derivatives of BTN, such as the Guide to the Classification of Overseas Statistics, use the Chapter/Heading numbers as a Code and add sequential, non-significant codes to the items.

4.3.4 Application

The international use of BTN, and its related statistical analysis systems, favours its adoption (following its current revision) as the classification system for international trade.

For use in the exchange of design information further levels of classification would be needed to cater for feature and property information. These could be developed as sub-classifications to the relatively coarse classification of BTN.

4.4 INTERNATIONAL STANDARD BOOK NUMBERING

This system is included because of its rapid acceptance by national and international publishers and the economy of its identification system.

4.4.1 Viewpoint

The system is intended only to uniquely identify books, without providing any reference to their content.

4.4.2 Classification/Identification Structure

Within the UK the Standard Book Numbering Agency issues to each publisher a block of numbers. The publisher then allocates numbers from the block sequentially to book titles as they are published and the Agency records the details. The classification was originally only Publisher and Title but, with international use, a further digit has been added to indicate the country of origin.

4.4.3 Coding

The code structure is similar to that proposed in the Draft BS and Modulus 11 is used for checking. Characters are all numeric and the stagger technique is used to compress the code string. Division of the code string into the Country, Publisher, Book Identification and Check Digit blocks is indicated by gaps.

4.4.4 Application

The system covers a single task, identification for a single commodity and, as such, is not directly applicable to the building construction industry. Its rapid growth however has shown that, with acceptance of the principle, a system can easily be adopted and used within a limited industry. By not seeking to classify, the system has avoided the delays inherent in standardising structure and yet it has provided an agreed identification which could be used by some subsequent classification system.

SECTION FIVE: BUILDING CLASSIFICATION SYSTEMS

Several classification systems are used widely in the construction industry and there are others which are used by individual organisations. Few of the structures are the result of a disciplined system of classification and some record only 'trade practice' which is a traditional grouping. In this Section a number of the systems in use are described and their structure is analysed.

5. 1 CI/SfB

This faceted system has established itself as the most widely used system for the classification of trade literature in the building construction industry and it has been used as the basis of computer systems for documentation and data handling.

It was developed in the immediate post-war years by Giertz (53) for SfB (Samarbetskommittén för Byggnadsfrågor) a group of 32 Swedish organisations concerned with the construction industry. The development of the system is described in (54) and its adaptation for British Practice in (49) (55) (56). Control of the system is now vested in CIB.

5. 1. 1 Viewpoint

SfB developed as a means of classifying and arranging trade literature and reference specifications used in the building industry. The original system's strengths and weaknesses stem from this.

5. 1. 2 Classification/Identification Structure

The original structure reflected the concern with building commodities and was divided into three tables:

Table	Description	Identification	Example
I	Functional Elements	(1) - (8)	(21): External Walls
II	Construction	E - X	F : Bricks
III	Materials	a - z	g : clay

Table I (9) was used for types of buildings and Table II A - D was allocated to "special purposes".

A review of the system, with a limited re-structuring, was carried out in 1955/6 on the initiative of the RIBA. A comparison between the versions is tabulated in (57) and the RIBA version is identified "CI/SfB".

The faults of the original system were its lack of exclusivity between the Tables and exhaustivity in their contents. Whilst the classification analysed the component and the building element in which it was contained, it needed extension to include the location of the element in the building, as well as the application of a more consistent system of analysis.

CI/SfB provides two additional Tables to SfB but combines Table II and III:

Table	Description	Identification	Example
0	Built Environment		Follows UDC analysis
1	Elements	(00) - (99)	
2	Form	E - Y	
	Construction		
3	Material	e1 - y9	
4	Abstract concepts	A1 - z9	Activities. Requirements. (included in Table III, A, B, C of original edition)

The (-9) position of Table 1 is used as a summary for that level of information. The similar positions for Tables 2 and 3 are identified by 'Y' and 'y' respectively.

The building fabric part of Table 1 is formed by a matrix between a location (external, internal,etc) and an increasing detail (primary and secondary element, finishes). This logic does not extend to the Services and Fittings elements in which, for example, no relation is shown between Sanitary Fittings and Drainage. Tables 2/3 are formed by the matrix of Form and Material which works well for typical building components such as bricks and wood but again is inappropriate for descriptions of most engineering services components. This demonstrates the Architect/Builder orientation of SfB.

Table 2 'K' (Quilts) is almost empty whilst, for a Mechanical Services Engineer, Table 2/3 Xh (Metal Components) would be too general to be of use.

Table 4 has been used to absorb items not covered by the other Tables and to provide a means of extending SfB, from component identification, to component performance specification and project classification by including features from the CIB Master Lists (25) and also more general management concepts. In the application of SfB to CBC (Section 5. 2) there is a clearer statement and development of the logic of the construction of the Tables.

For project documentation use it is permissible to combine facets from a Table to provide a more explicit identification. Not all the Tables need be used so that the levels of the Tables need to be easily recognised. The use of mixed alpha-numeric characters and the auxillary bracket provides an inherent pattern to the citation order.

5. 1. 3 Application and Appraisal

CI/SfB is a system for identifying components and its descriptive levels are sufficient for that purpose. The system proves to be inadequate when it is used to define a component and its features, or to detail the operations to be carried out on a component.

The separation by form/material into different elements introduces differences that do not exist in practice. A pipework fitting which is interchangeable between heating and water supply systems would, in a full classification, have two identification references because the systems are different 'Elements'.

Most building materials and components are simple in form and material and can be identified easily by the classification. Many components used in building, especially those associated with the engineering systems, are more complex and the classification by form/material does not provide an identification. For example, the central control panel for an air conditioning system may be thought of as a block made from steel (Fh -) or as an item made from formed sheet (Mh 2). Neither classification is used, the correct classification being 'a complex single purpose product' (**X**), without a material classification.

The British National Building Specification (NBS) (21) 1973 Edition uses CI/SfB classification Table 2/3 for Product Clauses and Table 2 for part of the Workmanship Clauses. In the 1976 Edition general classification by Table 2 has been retained but use of Table 3 has been discontinued. Use of the CI/SfB classification combination of Tables 2 and 3 results in sequences which are inconvenient in use and the associated code lengths are long without providing flexibility for the addition of new items. This is illustrated, 5. 1.3 (1) (58)

P43 Mastic asphalt external waterproofing

As in 1973 text

COMMODITIES

P43:H **Sections**

Hh4.10 *Mill finish aluminium edge trim and pre formed angles:* Manufacturer and reference: FPA Pitchmastic Ltd, Elcelsior Works, Sandiacre, Nottingham.

P43:L **Flexible sheets**

La0.10 *Isolating membrane:* a type recommended by the asphalt contractor.

P43:Y **Asphalt/compounds/sand**

Ypl.10 *Rubbing sand:* clean, coarse sand from natural deposits, to pass a 600 micro-metre sieve and be retained on a 200 micro-metre sieve. Test sieves: to BS 410.

Ysl.30 *Rubber bitumen emulsion primer:* Manufacturer and reference: as recommended by asphalt sub-contractor.

Ys4.10 *Roofing asphalt:* mastic asphalt (limestone aggregate) to BS 988, with asphaltic cement to table 3, column 2.

WORKMANSHIP

P43:1 **Generally**

1051 **Approved firms:** the mastic asphalt work specified in this section is to be carried out by: a member of the Mastic Asphalte Council & Employers Federation.

1101 **Guarantee** the work specified in this section for one year from the end of the defects liability period in the form issued by the Mastic Asphalte Council and Employers Federation. Submit a copy of guarantee to SO on completion.

P43:2 **Preparation**

2051 **Generally:** ensure that surfaces to receive asphalt are true and even, with adequate falls.

	Work section code		Clause code		
coding	E	21	H	1	05
code origin	CI/SfB Table 2	NBS	CI/SfB Table 2	NBS	NBS
interpretation	Cast in situ work	Reinforcement	Product form: sections, bars.	Sub-grouping, based on different product characteristics, eg: 0—General 1—Steel 2—Galvanised steel 3—Stainless steel	Clause identificati every fifth digit is use leaving the space between fo insertion o future claus

As in the revised subscription service text

PRODUCTS/MATERIALS

P43:H **Sections**

H105 *Mill finish aluminium edge trim and preformed angles:* Manufacturer and reference: FPA Pitchmastic Ltd, Elcelsior Works, Sandiacre, Nottingham.
Ref. Section FL.

P43:L **Flexible sheets**

L105 *Isolating membrane:* a type recommended by the asphalt contractor.

P43:Y **Asphalt/compounds/sand**

Y120 *Rubber bitumen emulsion primer:* Manufacturer and reference: as recommended by asphalt sub-contractor.

Y305 *Roofing asphalt:* mastic asphalt (limestone aggregate) to BS 988, with asphaltic cement to table 3, column 2.

Y705 *Rubbing sand:* clean, coarse sand from natural deposits, to pass a 600 micro-metre sieve and be retained on a 200 micro-metre sieve. Test sieves: to BS 410.

WORKMANSHIP

P43:1 **Generally**

1051 **Approved firms:** the mastic asphalt work specified in this section is to be carried out by: a member of the Mastic Asphalte Council and Employers Federation.

1101 **Guarantee** the work specified in this section for one year from the end of the defects liability period in the form issued b the Mastic Asphalte Council and Employer Federation. Submit a copy of guarantee to SO on completion.

P43:2 **Preparation**

2051 **Generally:** ensure that surfaces to receive asphalt are true and even, with adequate fal

NBS Volume 4 provides a table of cross-reference of NBS codes to the Sections of SMM, part of which is shown in 5. 1. 3 (2) . It is significant that the lower levels of the SfB code are not used for Section 5 which covers engineering systems and that these are referenced to the Element level. For other SMM Sections there is a mixed use of Element and Form/Material codes.

This difficulty in SfB coding of trade headings illustrates the limitation of a classification by Form/Material.

5. 2 CBC (CO-ORDINATED BUILDING COMMUNICATION) (9)

Is linked to SfB, in that it uses it as the basis for component classification and coding, but it has developed the SfB system to make it suitable for the documentation of building projects, in particular by data processing systems.

5. 2. 1 Viewpoint

Although originally conceived as a system which could be used manually, its development has been towards a computer based system built up from a number of self-contained packages using a common data base. Whereas SfB is a guide to the position of data in literature, CBC is a guide to the position of information about components in the documents for a specific building. Locational data is added to the component descriptive data and is then linked to building design/construct operations such as drawing, estimating and site work programming.

5. 2. 2 Classification/Identification Structure

The structure, as shown by the code string, comprises a general component classification and identification followed by a project-specific locational identification.

N CARPENTRY	Fillets, grounds,		
	Carpenter's metalwork		
P JOINERY	Flooring		
	Eaves and verge boarding	H43	
	Plain or panelled linings, casings and partitions	—	
	Doors, windows	(3)21	—
	Skylights and lanterns	—	(3)
	Frames, sills and kerbs	(3)21	—
	Fillets, glazing beads and grounds	H23, H61	—
	Skirtings, picture-rails and cornices	H61	—
	Architraves	(3)21	—
	Shelves, table tops and seats	H24	—
	Sinks, draining-boards and back-boards	(7)21	—
	Fittings and fixtures	H24	—
	Staircases	H24	—
	Standard units	(3)21	—
	Ironmongery	(3)21	—
Q STRUCTURAL STEELWORK	Grillages and girders	H11	—
	Stanchions, columns and portal frames	H11	—
	Roof members, braces, struts and rails	H11	—
	Sundries	H11	—
R METALWORK	Work in plates, bars, sections and tubes	H14	—
	Work in sheet metal	H14	—
	Work in wire mesh or expanded metal	H14	—
	Composite units	H14, (3)11	—
	Standard units	H14, (3)11	—
S PLUMBING AND ENGINEERING INSTALLATIONS	Plumbing and engineering installations are arranged as follows:		
	Pipework and gutterwork for plumbing, i.e. rainwater, overflow, waste, soil and vent, coldwater services	(5)21, 22, 31	—
	Sanitary appliances	(7)21	—
	Engineering services		(5)

5. 1. 3 (2) Comparison between SMM and SfB Classification

The general part of the classification applies SfB to classify the item of work. Use is made of the unallocated characters of the SfB code to extend its meaning:

Facet	Description	Identification	Example
1	Functional element	(00) - (99)	(21) External walls
2	Construction	A - Z	
3	Resources	AO - Z9	

The matrix arrangement of SfB has been applied more rigorously to the "1 - Facet" and used to indicate the cost generators in a project, rather than literature identification. If the total project cost, signified by the summary code (--) , is represented by a square, the sub-summaries for site and building costs are (-0) and (-9).

(-0) SITE	(-9) BUILDING

Alternatively the total cost may be divided into production and non-production costs, signified by the summary symbols: (0-) and (9-).

(9-) PRODUCTION
GENERAL (0-)

By overlaying these divisions and making sub-divisions, the product is the Functional Elements for the building and site production: (10) - (99), 5.2.2 (1).

Also shown are the non-production building costs: (01-08).

(11) excavation	(21) external walls	(31) external wall completion	(41) external finishes	(51) refuse disposal	(61) panel installations	(71) entrance fixtures	(81)	(91)	(-1)	(01)
(12) land drainage	(22) internal wall	(32) internal wall completion	(42) wall finishes	(52) drainage	(62) lighting installations	(72) room fixtures	(82)	(92)	(-2)	(02)
(13) floor boards	(23) floor	(33) floor completion	(43) floor finishes	(53) water services	(63) power installations	(73) kitchen fixtures	(83)	(93)	(-3)	(03)
(14) ramps and stairs	(24) stairs	(34) stair completion	(44) stair finishes	(54) gas services	(64) communications installations	(74) bathroom fixtures	(84)	(94)	(-4)	(04)
(15)	(25) balconies	(35) suspended ceilings	(45) ceiling finishes	(55) refrigeration services	(65)	(75) laundry fixtures	(85)	(95)	(-5)	(05)
(16)	(26)	(36)	(46)	(56) heating services	(66) lift installations	(76) storage fixtures	(86)	(96)	(-6)	(06)
(17) piling	(27) roofs	(37) roof lights	(47) roof finishes	(57) ventilation services	(67) transport installations	(77)	(87)	(97)	(-7)	(07)
(18) foundations	(28) elements above roof	(38)	(48)	(58) special services	(68) security installations	(78) special fixtures	(88)	(98)	(-8)	(08)

(19) building sub structure	(29) building super structure	(39) building completion	(49) building finishes	(59) building services	(69) building installations	(79) building fixtures	(89) building furniture	(99) building production	(-9) building	(09) building general

(1-) sub structure	(2-) super structure	(3-) completion	(4-) finishes	(5-) services	(6-) installations	(7-) fixtures	(8-) furniture	(9-) production	(--) total	(0) general

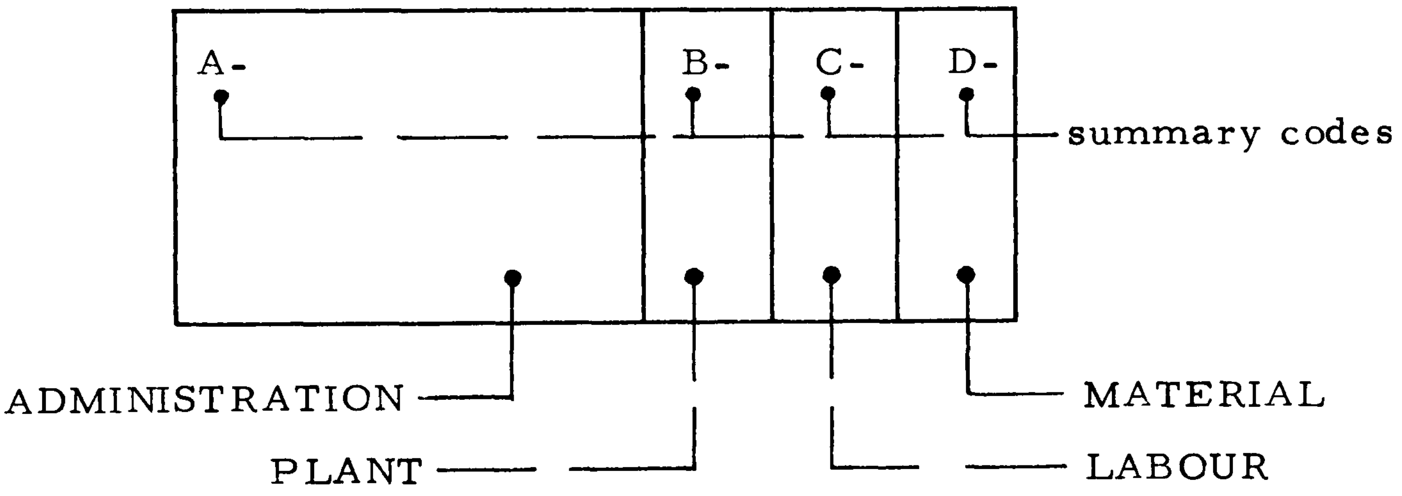
(10) site sub structure	(20) site super structure	(30) site completion	(40) site finishes	(50) site services	(60) site installations	(70) site fixtures	(80) site furniture	(90) site production	(-0) site	(00) site general

5. 2. 2 (1) CBC Table of Functional Elements.

A similar treatment of "2-Facet" 'construction' divides them into Production and Preliminaries costs with the Construction part of the square layered into types of construction.

Y	CONSTRUCTION 'E - X'
C	EXCAVATION
B	DEMOLITION
A	PRELIMINARIES

The matrix to the 2-Facet square is formed by 3-Facet 'resources', for which the main division is between Administration 'A-' and Works 'Z-'. Works is divided into operation costs 'D-' and Material costs 'Y-' with Operations divided into Plant costs 'B-' and Labour costs 'C-' and into types of material 'E-' to 'X-'.



One alphabetic character is not sufficient to signify all the various types of material so each class may be further sub-divided numerically by 'O' - '9' with the latter being a general symbol for 'sundry' items.

Even this further division is not sufficient to uniquely identify components and the CBC system uses an additional '4-Facet', usually of 4 digits, to provide for up to 10,000 items within each class, for example :

G2. 5432 "A well-defined material made
of heavy burnt clay" = A brick.

These facets may be assembled and combined in sufficient detail to convey the required level of information, with any unused facets being indicated by a dash:

(21) --- 6543 "A well-defined external wall"
e. g. A cavity wall formed by two skins of heavy burnt clay bricks on a cast concrete strip foundation.

(21) FG2. 5432 "A well-defined material made of heavy burnt clay (a brick), belonging to a brick construction, belonging to an external wall".

The 4-Facet Locational Classification is used to allocate the items covered by the General Classification to particular trades and parts of the specific building.

Work on site is carried out by various trades which may be part of the main contractors organisation or be separate firms. From the CBC system viewpoint of establishing costs, it is important to know which trade carries out particular tasks and where the work location is in the building. A 2 or 3 digit code is used for the Trade part of the Specific Code which normally takes the form:

nnn	nnnn	nn	nn	nn	nnn
Trade	Project	Block	Storey	Section	Room

5. 2. 3 Application and Appraisal

Included in the CBC suite of application programs are sub-systems for classification and identification, preparation of Bills of Quantities, drawing coding, contract time programmes and material scheduling.

The CBC system is very detailed and requires the users to be trained and experienced in its use. Its advocates claim (59) that when it is used all stages in the project, by both designers and contractors, there is a considerable benefit. This may be true for an organisation which encompasses all the aspects of the documentation of a project but it must be questioned in the traditional and fragmented arrangement involving a number of separate organisations both for design and construction.

To be effective, such a system requires the use of a common data file and computer, or at least compatible and directly communicating computer systems. The addition, to SfB, of the 4-Facet listing of up to 6 digits indicates the need to extend the identification provided by SfB and is a negation of the principle of a faceted system. With 10, 000 item identifications normally available against each 2/3 -facet, the SfB part of the classification is used only as a 'chapter heading'. In classes in which the majority of the available item identifications are used, the task of sorting through them is formidable. Unless additional facets are introduced, there is no significant advantage over a simple sequential number identification system. This has been recognised to some extent in the preparation of the CBC Catalogue for which a further series of matrices have been used to lead in to the 4-facet.

5. 3 THE UNIFORM CONSTRUCTION INDEX (UCI)

The publication of the American Uniform System for Construction Specification Data Filing and Cost Accounting (10) in 1966 brought together three, previously separately published, documents:

> CSI Format for Building Specification (CSI Format for Construction Specification) originally published by The Construction Specification Institute in 1963.
>
> Standard Filing Systems and Alphabetical Index originally published by The American Institute of Architects in 1920.
>
> Guide for Field Cost Accounting originally published

by the Association for General Construction of America in 1961.

In parallel, the Specification Writers Association of Canada published the Building Construction Index which was based on the CSI Format. In 1970 both the American Uniform System Joint Industry Conference and the Canadian Building Construction Index Committee were preparing revisions and it was decided to produce a joint document, now known as the UCI.

5. 3. 1 Viewpoint

UCI is intended for manual use and is based on trade practice. Because it is only an outline classification it has flexibility to incorporate additions or amendments. Each Division and Section has headings which enable the design team to handle general information although a particular participant would need to further divide a specialised field.

5. 3. 2 Classification/Identification Structure

The history of the UCI is reflected in its classification structure in that the strands of: specification - filing - costing are reflected in the Parts of the Index.

Part One :	Specifications Format
Part Two :	Data Filing Format
Part Three :	Cost Analysis Data
Part Four :	Project Filing Format

Classification is common to each Part and is based on the CSI format using 16 'Divisions' of building elements, mechanical and electrical systems and equipment. Divisions are broken down into 'sections' and 'units of work'. The latter is still a coarse division, which is defined as "a single entity that generally describes a particular material or product and its installation". In justification of the coarseness of the classification, the Authors claim that the variations in procedures in the industry would nullify any finer divisions.

For Part One, the classification provides headings for specification clauses without proposing their content,unlike that provided in the British National Building Specification. In Part Two the use of subscripts is proposed to further classify documents as relating to design, manufacturers products or accessories (such as the material used).

Part Three is the only Part to be coded and the code is a sequential number attached to Sections. There is an Index of Key Words, cross-referenced to the other Parts, and the Key words are used in the handling of Divisions and Sections.

5. 3. 3 Application and Appraisal

UCI is broader based than SfB and was developed by representatives of a cross-section of the industry. For this reason it has been adopted more generally by,but, on the evidence of the Canadian study (15), not as extensively within each of, the sectors: architecture, engineering, costing and construction. There is no report of a computer based development of UCI on the pattern of CBC.

5. 4 THE CACCI CODE ILLUSTRATION

An Appendix to the Study of Coding and Data Co-ordination (27) provides an illustration of a classification structure which could be used for the construction industry. Although it was not intended to be a developed system, the proposal was made in detail.

5. 4. 1 Viewpoint

The proposal was intended only for the construction industry but, within the many trades of that industry, it was expected that the structure would accomodate the needs of manufacturers, designers and installers. Amongst other proposals in the study is the setting up of a central authority to allocate codes and develop a national commodity file. The structure of the code assumes that such a central information source would be available.

5. 4. 2 Classification/Identification Structure

Information would be grouped into four, broad, fields as demonstrated by the proposed code format

1. Primary classifier P (Naaa N)
2. Subclassification C (NNNNNN)
3. Location L (NNNNNN)
4. Specification - sub divided into four groups
    1. General specifier : X-Z (the 'utility tag') plus a free alpha or numeric field.
    2. Local specifier: A-W (the local 'utility tag') plus a free alpha or numeric field.
    3. Property Indicator : (a-z)
    4. Text: free field

Although the code is mixed alpha-numeric, the changes are not used to separate the fields which have therefore to be of a fixed field format and thereby incur redundancy.

The Primary Classifier is the coarse identification of the information and includes three sub-fields of which the central 'aaa', plus a numeric character, identifies the broad area of the information and is similar to the combination of Tables 0 and 1 of CI/SfB although, because of the very limited field size, the grouping is coarse. This limitation is recognised to some extent by the application of the final numeric character which is called the Unique Classifier and provides a further level of division for the information.

The Sub-Classification field provides a more detailed statement of the major features of the information and the digits may be divided into a number of facets of variable length, within the constraint of the overall field length.

The Location field has a wide application depending on the nature of the information. For project data the facets within this field are used to provide an appropriate level of information about the location of the component in the building and could be taken from a structure such as CBC. When used with manufacturers' trade literature, the Report suggests that this field could be used to identify the manufacturer, for example by the inclusion of the firm's GIRO number.

The Specification field is used, with little restraint, to include any other relevant information by a combination of coding and free text. Utility-tag Codes and their associated data strings could be interpreted only by reference to a listing of codes and field descriptions.

5. 4. 3 Application and Appraisal

The Report includes an example of the, possible, central computer file record for a single manufacturer's range of five similar doors. Included are dimensional, constructional, material, application, cost and availability/delivery details, which predictably form a large volume of data. Each enquiry into the file, no matter how trival, involves a search through this data, and even with a powerful computer and careful program writing, the search must cover a large irrelevant area. Conversely the record does not include data of specialised, but important, application such as thermal values.

5. 5 THE CIT (CONSTRUCTION INDUSTRY THESAURUS)

Is related to, and chronologically follows, the CACCI Report and was a study prepared for the National Consultative Council Working Party on Data Co-ordination by the Department of the Environment and CIRIA (60). The study was carried out at the Polytechnic of North London and the Polytechnic of the South Bank, (previously the Brixton School of Building). A development edition of the Thesaurus containing about 9000 terms was published in 1972 and publication of an enlarged edition of some 14000 terms is due.

5. 5. 1 Viewpoint

Effective storage and retrieval of information is the use intended by the Authors. In particular the Thesaurus is intended to provide the preferred terms for post co-ordinate indexing systems for general and project documents. It is expected that the terms could also be used as the basis of a technical library and they provide also a standard terminology for use in trade or British Standard publications. General use of the terms in project documentation should aid communication between users.

5. 5. 2 Classification/Identification Structure

Although it is not primarily a classification system, it was found necessary to structure and display the CIT using a classification based on the use of terms in the industry. This structure is shown in the ten facets and in the hierarchical displays within the facets. A comparison of the structure with that of other classification systems is made in 7.3 (1).

There is a set of rules for ordering the sequence of terms by which the least significant term has been displayed first, so that the Properties of a material are listed before the Material and the Material before the

Part of Construction:

thermal transmittance → brick → wall

Within the facet or category there are, apparently non-structured, divisions. For example 'thermal transmittance' is in the division 'transfer properties' and is separated from the associated heat transfer concepts of 'thermal conductance' 'thermal resistance' or 'thermal loss'. Thermal transmittance does not appear in the alphabetical index to terms because it is regarded as a heading to a section which includes the colloquial term 'U - Value' even though use of this alphabetical index is the normal entry to the classification.

5. 5. 3 Application and Appraisal

Use of the CIT has been limited to the sponsoring authorities and one research association, although the terms have been translated into Swedish for the Building Documentation Centre and the Netherlands Government is proposing a similar translation and use. The CIT Keywords are added, by the thesaurus Authors, to CIRIA publications and to the Property Services Agency standards.

5. 5. 3 (1) is an extract from a CIRIA Publication Summary and shows the number of terms needed to include most aspects of a technical document. The Cement and Concrete Association have recently commenced use of CIT and found it necessary to add and amend terms in certain specialist areas, such as the structural properties of concrete. Government support for this development will probably ensure its continuation and expansion.

5. 6 THE FACET CODE

This code was developed by the Author (61) as part of the system illustrated in 1. 1. (2). It is used by a firm of Consulting Engineers in a suite of environmental and structural engineering design, specification

129 Circular composite columns (filled tubes) – derivation of design formulae

A.K. BASU and S.K. GHOSH

CIRIA Technical Note 58, July 1974. pp34, including diagrams, graphs, two tables and 10 references
Available to members only £0.50
CI/SfB: (28) Iy (K4) UDC: 624.075.23.016

Part 1 presents a computer method for calculating the strength of pin-ended concrete-filled tubular steel columns of circular cross-section and having equal or unequal eccentricities. The method is similar to the one previously employed (TN8, No.24) for rectangular composite columns. This method assumes conservatively that the deflected shape of the column centre-line at failure forms part of a cosine curve and makes other assumptions which have negligible effects on the exactness of the calculated strength. *Part 2* presents an approximate design office method of calculating column strength. A semi-empirical approach is proposed for incorporating the effect of long-term loading on column strength. An interaction formula is suggested for eccentric loading with respect to two perpendicular axes. This formula is needed when the eccentricity ratio and/or the effective lengths are unequal in the two corresponding planes of bending. The possibility of local buckling of the tube wall with the concrete supporting it on one side has not been considered.

CO-ORDINATE INDEXING TERMS from *Construction Industry Thesaurus*
Columns; Composite; Computer-aided design; Concrete; Cores; Loading properties; Steel; Structural analysis; Testing; Tubular sections

READER INTEREST
Architects, Concrete Designers, Structural Steel Designers

5. 5. 3 (1) Example of CIT Keywords

and costing programs.

5. 6. 1 View point

Environmental engineering, (which includes air-conditioning, electrical, water supply and public health engineering), is part of building design but it makes different demands on an information system from those of architecture. For instance, engineering is a numerical task, allied to physics, and requires numerical data about the physical properties of building components and those components which are combined by calculation to form the engineering system. The degree of detail of this information is shown in 8.6.3 (1).

Within the sequences of design for components is the chain: select-measure-size-specify-cost, with more detailed information being added at each stage to the original component selection. Using traditional, manual, techniques it is necessary to refer back continually to the original selection and the purpose of the FACET System is to allow the accumulating information to be made available without a lengthy manual search through files. Many of the features of the system are illustrated in Chapter 8.

5. 6. 2 Classification/Identification Structure

Before the decision was made to develop a new code, the SfB system was examined but found to be inadequate to describe engineering components. It does not handle the statements which were required about standards nor are engineering components conveniently described by the classification of Form/Material.

An important use for the developed code was to be the listing of component item descriptions in a Bill of Quantities for which the nationally agreed procedure and sequence is set down in the Standard Method of Measurement (31). It was realized that the order of and references to the paragraphs of this document provide, unintentionally, a classification and code. Subsequently other, independently developed,, systems have used the same classification (61).

Following the general format of the CACCI Code Illustration, see 5. 4, this paragraph number was used as the Primary Classifier, with the addition of an alphabetic character to indicate 'material' when this was significant at the primary level. The Primary Classifier acts as a parent-link for a number of sub-or secondary classifiers which provide further description, technical data or specification.

5. 6. 3 Application and Appraisal

5. 6. 3 (1) is a sample page from the Library of Descriptions which shows how the Secondary Classifier is compiled to produce an item description in a Bill of Quantities.

> S29L/KT/FH/BR/BM/DH:
>
> "Flat oval cross section mild steel, bend 90 deg; angle radiused; slip joint ends; g. a. m. "

Other sections of the Library of Descriptions allows statements to be made about the size and fixing (including immediate location) of the bend.

For the corresponding Specification Clauses the same Primary Classifier is used with a series of paragraph numbers, to call up text and schedules. There is an option to delete code and substitute a sequential clause numbering. 5. 6. 3 (2) shows a typical page of text and schedule.

When the code is used in design operations, such as duct sizing on systems having a common specification, the Primary Classifier need be stated only at the commencement. Design data is attached to a high level of the code so that the abreviated code, KT/FH/BR is sufficient to define the fitting and call up,in this instance,the resistance factor.

S29 DUCTING FITTINGS

S29L STEEL DUCTING FITTINGS - LOW VELOCITY (M=HIGH VELOCITY)

- 2 DV/ plug
- 2 FB/ spigot
  - 3 FF/ diffuser
  - 3 FD/ grille

- 2 FF/ tee
  - 3 FK/ branch, 45 deg.
  - 3 FP/ straight, 90 deg.
  - 3 FT/ reducing, 90 deg.
    - 4 BH/ self flanged ends, drilled
    - 4 BM/ slip joint ends
      - 5 DH galvanised finish
      - 5 DM g.a.m.
      - 5 FH painted red oxide

- 1 KR/ Extra over mild steel flat oval ducting for
- 1 KT/ Flat oval cross section mild steel
  - 2 FH/ bend 90 deg.
  - 2 FM/ bend 45 deg.
  - 2 DD/ branch
    - 3 BR/ angle radiused
    - 3 BT/ main
    - 3 BV/ outlet
    - 3 DB/ shoe

  - 2 DF/ cap

AMENDMENTS

5. 6. 3 (1) Example of FACET Classification and Code

S27L.31213.1.

Longest Side of Duct mm.	Sheet Thick -ness mm.	Longitu -dinal Seams.	Mastic Sealed Transverse Works Joints.	Mastic Sealed Transverse Site Joints.	Minimum Stiffening Requirements.
Up to and inc. 305	0.80	Grooved or Pitts -burgh lock.	Plain slip joints.	Plain slip joints.	None.
From 306 To 610	1.00	Grooved or Pitts -burgh	25x25x3mm. angle re-inforced slip joints.	25x25x3mm. angle frames, with 3mm.thick gaskets.	25x25x3mm. angle girths a approximately 1.20m.centres along length o duct.
From 611 To 915	1.20	Grooved or Pitts -burgh lock.	40x40x4mm. angle re-inforced slip joints.	40x40x4mm. angle frames, with 3mm.thick gaskets.	40x40x4mm. angle girths a approximately 1.00m.centres along length o duct.
From 916 To 1220	1.20	Grooved or Pitts -burgh lock.	50x50x5mm. angle re-inforced slip joints.	50x50x5mm. angle frames, with 3mm.thick gaskets.	50x50x5mm. angle girths a approximately 1.00m.centres along length o duct.
From 1221 To 1525	1.60	Butt welded.	50x50x5mm. angle re-inforced slip joints.	50x50x5mm. angle frames, with 3mm.thick gaskets.	50x50x5mm. angle frames a approximately 0.60m.centres along length o duct.
1526 and above	1.60	Butt welded.	50x50x5mm. angle re-inforced slip joints.	50x50x5mm. angle frames, with 4mm.thick gaskets.	50x50x5mm. angle frames a approximately 0.60m.centres along length o duct.

S27L.41000.1. STIFFENERS OUTSIDE DUCTING.

S27L.41001.1. CIRCULAR CROSS SECTION DUCTING.

S27L.41100.1. Fabrication.
Roller form mild steel angle section rings.
Ensure cut ends are square,then join by welding.

S27L.41201.1. Attachment and Sealing.
Place rivets at a circumferential pitch not exceeding 50 mm.
Apply filler compound between rings plates,sheet or strip,before peening closing rivets.
Apply filler compound over external rivet heads.

S27L.41002.1. FLAT OVAL CROSS SECTION DUCTING.

S27L.41102.1. Fabrication.
From mild steel rods,ends cut square and screwed UNC thread.

S27L.41202.1. Attachment and Stiffening.
Pass screwed ends of rods through ducting at right angles to the flat sid with internal and external washers and nuts at each flat side.
Limit the projection of tie rods to 3 mm. beyond the external nuts.
Apply filler compound between washers and ducting sides before tighten nuts,and over nuts and rod ends.

5.6.3 (2) Code Controlled Specification Text

Trade literature, Design Manuals and Standard Drawings also use the Primary Classifier, with additional levels to suit the particular use. For example, Standard Drawings have an additional non-significant sequential number.

The extensive use of this code-series for project work has proved that such a code can improve standardisation and accuracy. However, the secondary classifiers have been used in isolation with manual transfer between programs and work has started on routines to translate between the Secondary Classifiers.

5. 7 POST CO-ORDINATE SYSTEMS

The SELECT System used by the Architects Department of West Sussex County Council (62) (which was developed in association with the Department of Architectural Studies at Leeds Polytechnic), and the University of Liverpool Acoustics Databank system (63) are interesting, and of importance, because they were early attempts to provide the designer interactively with a performance oriented entry into a classified data file. In these systems the designer does not select a component and seek information about it but, conversely, he states the required features and the system provides details of components which meet the performance specification.

5. 7. 1 West Sussex County Council

Although the SELECT system does not adopt CI/SfB classification, it uses a similar analysis. There is a limit of 8 attributes or parameters for each product file and a hierarchy of 6 levels covers the range from Building Type, through Components to Installation Details. Features or attributes, of components are set out as a matrix of Property and Variant

	A	B	C	D	E	F	G	H	I	J	K	L	
04 thickness	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	in.
15 sound insulation	25	27½	30	32½	35	37½	40	42½	45	47½	50	52½	dB
18 weight	8	12	16	20	24	28	32	36	40	44	48	52	lb/sq-ft
11 Fire resistance	½	1	1½	2	2½	3	3½	4	-	-	-	-	hours
22 Transparency etc	opaque					translucent					transparent		

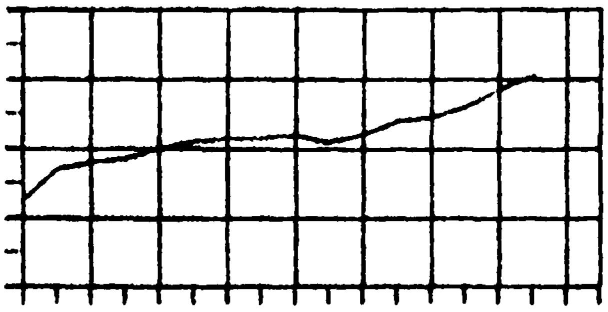
A series of matrices from this Table can be applied to a manufacturers product. For example: O4E, 15C, 11B, is a 4½ inch thick wall having a sound reduction of 30 db and a one-hour fire resistance. When this series is entered into the search program, all components having these properties are presented to the user. An extension of the program allows the user to weight the individual attributes so that components having most of the important, but lacking less important, attributes will not be overlooked. This is combined with an option to state 'relation factors' of equal-to, greater-(or less)-than, to improve recovery without excessive redundancy.

5. 7. 2 University of Liverpool

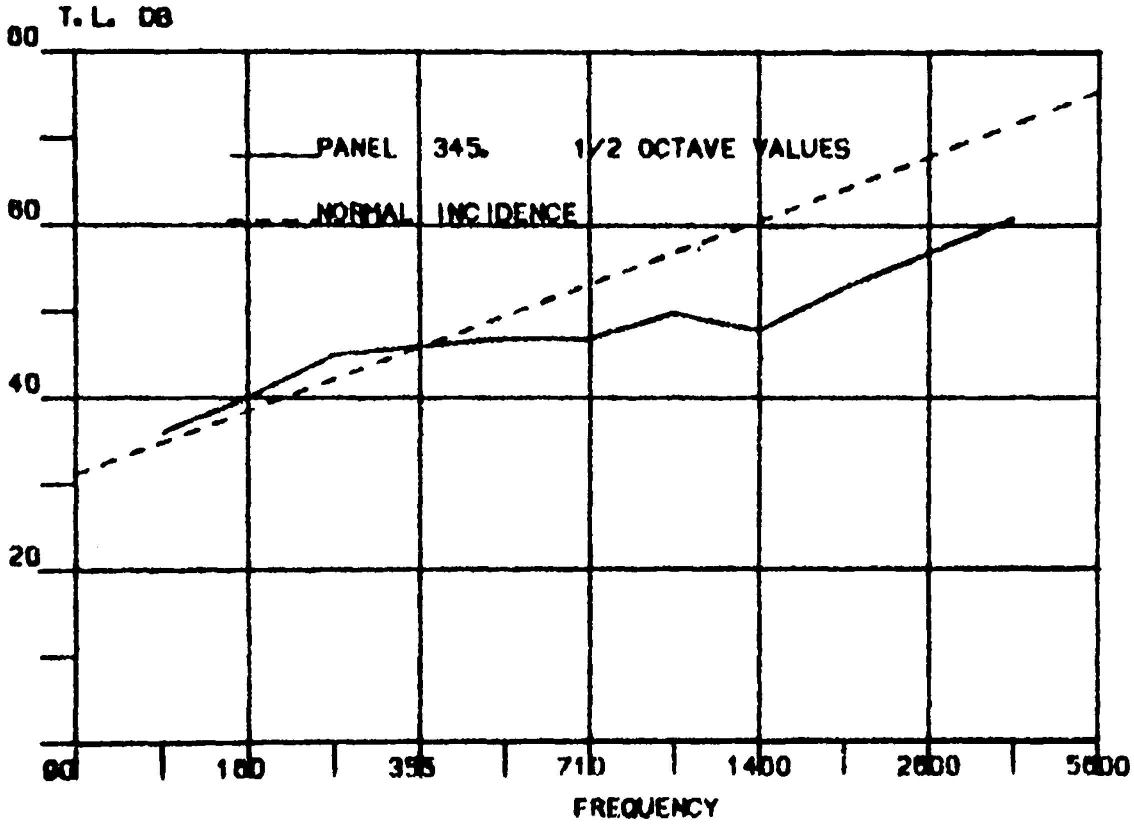
The acoustics databank was a development system which demonstrated that very detailed technical data could be displayed using a post co-ordinate search to trace, and a visual display unit to present, the available data. In the data file there were details of the acoustic properties of over 1000 wall panels. To select panels the user input the desired transmission loss characteristics by drawing the curve, or keying in points, or by asking for a comparison with another panel on file. Alternatively, the user selected the construction of the wall, by stating materials and layer thicknesses. An example of the output display is shown, 5. 7. 2 (1).

ACOUSTICS DATABANK
OPTIONS-

- A1. FORWARDS SCAN
- A2. BACKWARDS SCAN
- A3. SPECIFY NEXT PANEL NUMBER
- A4. DISPLAY FULL-SCALE
- A5. COMPARISON BETWEEN PANELS
- A6. OTHER OPTIONS



PANEL 888.
8 LAYERS. 49 KG/SQ.M. 185 MM. 1 AIR GAP



PANEL 345. 5 LAYERS. WT. 69 KG/SQ.M. 68 MM. THICK 1 AIR GAP

1/2 OCTAVE VALUES

PANEL 345. -1 36 40 45 46 47 47 50 48 53 57 61 -1

5.7.2 (1) Illustration of Post Co-ordinate Databank

SECTION SIX : THE DRAFT BRITISH STANDARD CODE

In 1968 the National Computing Centre (NCC) published a report (64) on a study for a national commodity code which had been made by Scientific Control Systems, a firm of computer consultants. The code was intended for use in business transactions and on trade literature by all sectors of manufacturing and retailing as well as by those responsible for specifying and using commodities. Other aspects studied included statistical records. A further study was made by a joint committee of the NCC and BSI and published as a report (65); and in an abridged form as Draft BS70/10431 (4). The draft dealt only with commodity identification which was considered to be the most urgent need.

Reaction to the proposal was varied and there was not sufficient support to ensure that the system would be adopted by enough manufacturers to achieve national acceptance and use of the system. As a result the proposal has been withdrawn and there is at present no national system under consideration. The study included the most advanced thinking there has been on the national problem and its supporters included those most concerned in the use of commodity information.

6. 1 VIEWPOINT

Because the system was intended for national application the committee sought to balance the needs of the various users and decided to base the system on the identification of all 'Items of Production'. Each unique product would be separately identified by the manufacturer even if some products were identical to another manufacturer's product. The only exception to this rule would be in the case of trade associations who were willing to institute a formal control procedure for a particular sector.

To provide overall control and finance for the system a central, government financed, authority was proposed although trade sectors would be encouraged to set up and operate the relevant organisations. It was intended that the system could be used manually even though it was designed to aid computer transactions.

The committee decided that, from a national view point, the early implementation of an identification system offered the greatest advantage to commodity trade and had the least problems. Subsequent classification and specification systems would involve all sectors and users with inevitable delays in analysing their separate needs and preparing reconciliations.

6. 2 CLASSIFICATION/IDENTIFICATION STRUCTURE

The total information to be communicated between any two users, whether within or outside of the organisations concerned, is defined by the 'commodity record'. This information would include that for manufacture, distribution, selling, specification and use as well as peripheral information such as national trading statistical returns.

To limit the code length and reduce redundancy in the information conveyed, it was proposed to divide the commodity record into three parts:

identification/classification/specification

6. 2. 1 Identification

The identification section uniquely identifies commodities. Reference to the manufacturer is considered to be part of the conveyed information, so otherwise identical commodities have different identification reference numbers. This follows from the adoption of the 'item-of production' classification rather than that of 'item-of-supply. Within the identification section there are three elements: Industry, Supplier and Commodity.

No attempt is made to provide a significant identification because the study showed this to be impracticable in a national system.

Allocation of identification codes would be by a central authority. In practice the central authority would usually allocate only the Industry code and a sector coding authority would control the allocation of manufacturer/supplier codes, leaving it to the individual suppliers to allocate commodity codes to their products in accordance with a standard procedure.

6.2.2 Classification and Specification

These parts of the system were not examined in detail and no firm proposals were made. A standard approach was considered less important for these parts because they would be used mainly by the sector concerned. In the case of the building construction industry it may be possible to adopt existing, widely used, classification systems such as SfB and standard specifications and terms such as NBS and CIT.

6.3 CODING

NCC/BSI proposed, for the identification section,a non-significant alpha-numeric code with the alpha character in each of the first two elements having meaning as well as acting as visual separators between fields. By this device it is possible to use a staggered technique for economy in code string length and to allow variable string lengths. Objections were raised by some computer users who would have difficulty in using alpha-numeric codes with their existing hardware.

The proposed format included in the first Draft Standard was :

	INDUSTRY	MANUFACTURER	COMMODITY	CHECK
Form	NA	NA	E	E
Range	-	1A - 999Z	001 - ZZZZ	-
Stagger	-	NA - NNNA	EEEE-EEE	-

A = Alphabetic
N = Numeric
E = Either Alphabetic or Numeric

The use of stagger and of the Modulus 37 check digit is as described in 3. 6. 3 and 3. 7. 2.

6. 4 APPRAISAL

In that the British Standards Institution proposal was heavily criticised by all sectors of industry and eventually abandoned, the proposal must be considered to be a failure. The Secretary to the Draft Committee has commented (66) "Perhaps the scope of the work was too wide".

A contrary view is that the presentation of the proposal in detail for the first stage of the full commodity coding, without an outline of the proposal for the following stages, made the proposal too narrow. The Identification Section was producer based and the adoption of this 'lead-in' to the code results in additional work for the retailer and user, who have to link these codes with other commodity based codes such as CI/SfB. Now that the National Building Specification has used CI/SfB, this link to the specification stage of the code becomes even more important.

When the use of computers for data processing becomes more widespread the linking of codes will be a simple, although not inexpensive, task and the direction-of-flow of the code stages will be less important.

Almost certainly, the greatest and continuing obstacle is that of self-interest. During the implementation of the system the early users have the least immediate return for their effort. Manufacturers fear that greater access to comparative information about commodities will lessen, rather than improve, their market position.

Users of information will gain no benefit from the identification part of the code until the classification and specification sections become available.

The fully developed system has great attraction for many users, but the disadvantages of the interim development stages are more immediate and obvious.

SECTION SEVEN: COLLATION OF DESIRABLE FEATURES

The proceeding Chapters have reviewed and analysed the use of information in the design process and a number of general and specific information systems which, with some success, have been used in the building construction industry. That no single system has achieved dominance is an indication of the complexity of the task and of the varying, and even opposed, demands of the users. Acceptance of this starting-point avoids the later obstacles which have destroyed more grandiose attempts to produce all-purpose systems.

The direction of development of the system is pointed by the desired end use. Many of the existing information handling systems, such as SfB, UDC or UCI are based on library or document classification systems which were not designed for extension to more general commodity information.

A general information system must encompass all the uses of information in: trading, designing, detailing, specifying, building. Generality has to be achieved without the loss of specificity.

7. 1 AS EVIDENCED BY USE OF INFORMATION

Tradition is a strong force in determining how the design team uses information. Tradition is the product of training, both academic and practical. Unfortunately the divided training of the participants in the design team results in there being several traditions, sometimes in conflict. An example of this is the preferred use of SfB by Architects to describe building 'Elements', whilst Quantity Surveyors prefer to use SMM 'Trades'.

Reporting on the early field tests of IMAGE, a MIT Department of Architecture interactive graphics system, Weinzapfel and Johnson (67) said:

> "it seems that practicing professionals are too strongly wedded to their present processes to enjoy learning new 'tricks'. They are either sufficiently successful with their own intuitive work methods not to be satisfied with the results from IMAGE's generator or they are unwilling to examine their design process in a way which would externalize it. These factors, plus the pressure of most office scheduling, combine to make an unfavourable climate for the introduction of IMAGE in the average architectural practice".

The CACCI Report suggested, without having carried out detailed case studies, that there are 'numerous arrangements of designers'. Whilst it is true that there are many stages and sets, it is the Author's experience that the actor/designers respond more to their learned roles than to the scenery. By tracing only the sequence of operations in a design routine and ignoring the operator sequence, the CACCI study overlooked the major practical problem of information flow, which is the fragmented nature of the design team.

It follows that any system should cater for the non-chronological sequence of design activities, the exchange of information between separated participants (probably having different computer hardware) and the need, or desire, of some participants to translate information into different formats.

The Sample Survey disclosed the narrow angle of vision of the individual participant. Although the Architects expressed a wider interest in features than other designers, they showed a suprising lack of knowledge of source data considered to be very important by others. If a participant does not know the needs of others, he cannot be the originator of the information they require. It is not realistic to expect one participant to be able or willing to compile the design data file.

From the detailed study of part of one design routine (2. 5. 2) it is evident that much, if not most, of the data used by the design numerators is of no interest to other participants. Nor is the specialist component data which is used by only one participant.

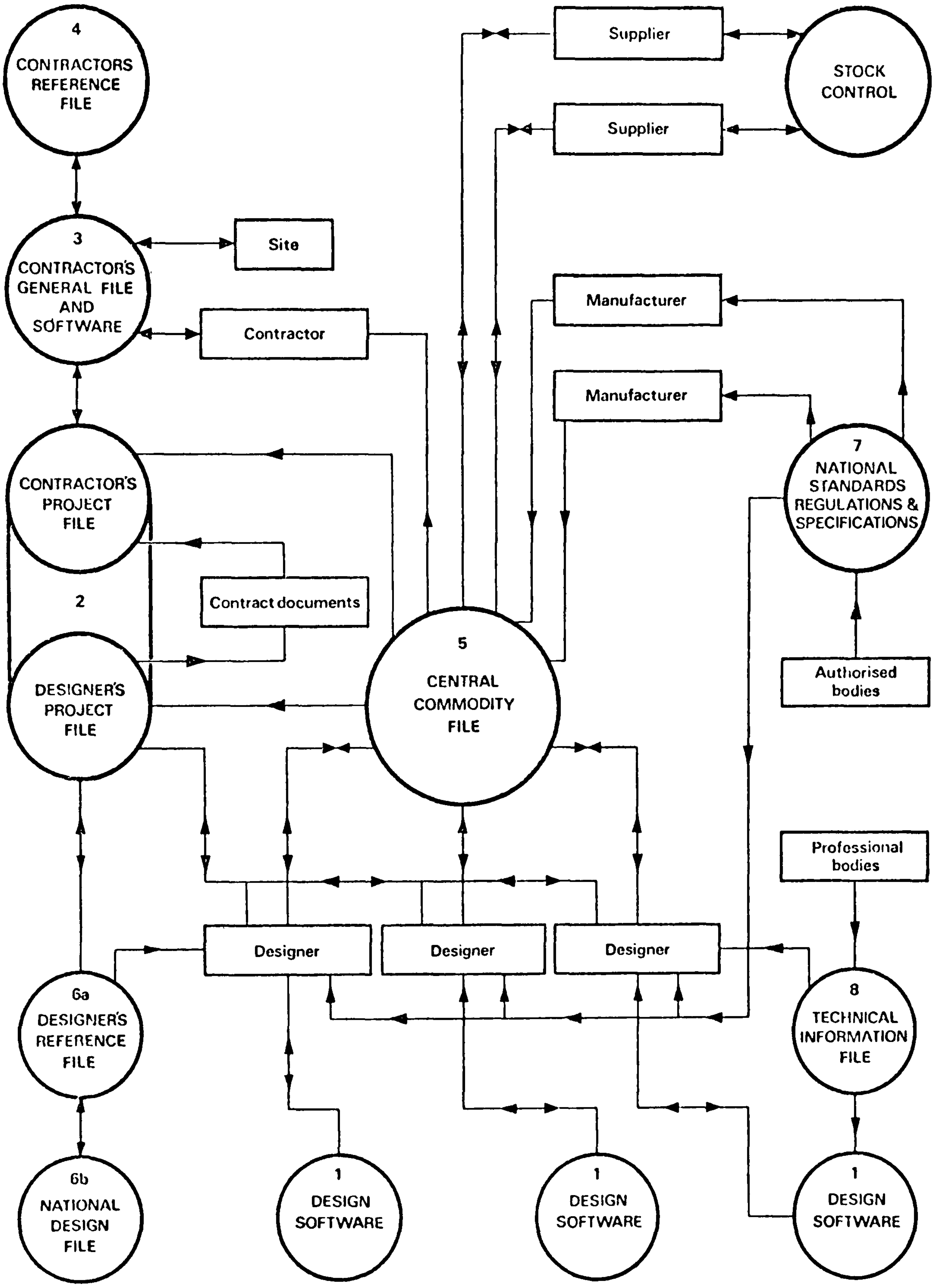
The information system should be able to link separate files, held by specialist designers, so that detailed information may be accessed without the need to take the detailed information into the Project File. A diagram in the CACCI Report,7. 1. (1), attempts to show the major files and links required for all stages of a project and it indicates some of their complexity, even without showing the repetition resulting from the fragmentation of the design team.

7. 2 THE CONTRIBUTION FROM THEORY

Before discussing the merits of various classification systems, the question 'why classify' has to be answered. An individual component may be described without reference to its class relationship to other components. However, when the many features of the innumerable components used in building are considered as a whole, it becomes necessary to provide sign-posts to direct users of information to its source. A listing, by name only, of all components would provide little assistance to those seeking a particular component.

Use of a classification structure to rationalise information does not require that the classification structure be apparent from the name or code. This is the approach taken by the Draft BS Code in using an identification code as the key to commodity information.

At the simplest level a 'non-significant' reference/identification code has sufficient significance to access information although it does not convey that information. However, an identification code can only be applied to a discrete object, it is of no assistance to the searcher who



7.1. (1) CACCI Information Flow Chart

asks "what components have the following features". The designer most frequently approaches a component through its features: appearance, size or physical properties, for which an identification code is of no assistance. Only a feature, or property, classification can lead to the required information.

A significant code can convey feature information, but in most cases, the code either conveys too much, and therefore redundant, information or too little. Someone has to decide what is significant and it has been shown that no single number of the design team has this skill. The ideal coding system has the optimum significance for each information transaction link.

Significance can also mean the use of mnemonic codes, as in the ENVIRO System (68), to provide visually readable codes but these tend to fail when applied to an extensive system or when the system is used by several participants of differing disciplines.

7.2.1 Pre-and Post Co-ordinate Systems

These are sometimes presented as opposing systems. They may better be thought of as the opposite search directions. Each of the thesauri examined has been constructed using a classification frame work and most classification systems employ standard and abreviated terms whenever possible. The West Sussex County Council system, although it has the first appearance of being a post co-ordinate system, only puts together questions in accordance with a faceted list.

Unrestricted post co-ordinate systems are probably limited to use in searching documents which have been analysed and keyed by a skilled librarian. The two approaches come together when the user is allowed to select terms, or statements, from a faceted list of features to seek for information about an unknown component which may possess these features.

7.2.2 Coding Techniques

Coding follows classification and reflects the logic of the classification structure. Coding techniques cannot be imposed on a classification system but a rationalisation of the code can produce greater accuracy in use and savings in computer storage and processing charges.

In the first Draft BS Code (4) a mixed alpha-numeric code was suggested, to take advantage of the greater character capacity of an alpha code and to use the mixture to define code fields, thereby allowing a stagger technique. The second draft (5) showed an alternative all numeric code because of the difficulty that some existing computing equipment has in calculating check-digits for mixed alpha-numeric codes.

A check-digit is desirable as part of the identification code because this is the code section which is used in business transactions. Its use with the specification or classification sections is less important because the eventual deciphering of the code into plain language is likely to expose errors, by the incorrectness of the statement. It is possible to limit the misuse of codes for classified lists by a combination of: a stagger display of compatibility in the levels of the library of phases, 5.6.3 (1); a random ordering of the code spacing, as shown in the same illustration; and a code compatibility check in the processing program.

7.3 FEATURES FROM EXISTING CLASSIFICATIONS

Continuing use of the general and specific information classification and coding systems which have been described is evidence that they satisfy a need and perform reasonably effectively. The fact that one of these systems has not dominated, indicates either that the ideal system has not yet been discovered or that there is a need for different systems to handle various aspects of information.

The structure of information, assumed by each classification system, is displayed in 7. 3. (1) which provides a comparison of included features with the CIB Master Lists. Although the various systems have some correspondence in the included items, their naming and grouping is very different.

It is desirable to provide flexibility in the classification system, and even more so in the information handling system, so that the blocks of information may be assembled in a number of ways.

The existing systems separate into those which use:

7. 3. 1 Non-significant, non-classified 'identification
7. 3. 2 Significant, classified 'names'
7. 3. 3 Significant, classified 'descriptions'
7. 3. 4 Post co-ordinate assembly

7. 3. 1 Non-Significant, Non-Classified Commodity Identification

These systems are represented by the Standard Book Number, the Draft British Standard (ignoring the significance of the country/sector sections) and the NATO Code National Item Identification Number. The two latter each belong to a comprehensive system, which includes classification and specification sections, and act as a key to the full record.

Simple identification has the major benefit of compactness but it requires interpretation. Its use is dependent on the identification being understood by all users and this assumes the general adoption of an agreed system, at least within a particular sector of trade. In that the identification code has no inherent meaning it cannot be compiled by the user, who therefore cannot take the initiative in introducing the system. The stand-alone use of identification coding is limited and, in the sense of use between participants, it is useless for most of the data needs in building design. However, when used as a key to

7.3. (1) Comparison of Information System Content

CIB MASTER LIST	CACCI (APPENDIX H) (Primary Classifier Group N)	CI/SfB	CONSTRUCTION IND. THESAURUS
1. BUILDING Name Type Location Size Drawings	BUILDING & SITE Type Location	Table 0 Built Environment	C Time D Place K Construction works Buildings Wings Storeys Rooms Building Types E Properties and measures Location Orientation
2. BUILDING EQUIPMENT Constituents, parts Foundations Walls & partitions Floors Stairs Roof Services Equipment	AGGREGATIONS Functional system Building element Work section	Table 1 Elements	J Parts of Construction Work Walls (vertical dividing elements) Floors (Horizontal dividing elements Services/Fitments Equipment
3. COMPONENTS Name Type Description Materials Shape Size Weight Appearance Strength Physical properties Sitework Operation & maintenance Prices & conditions Supply	RESOURCES Components Materials (formless)	Table 2/3 Construction Form/materials	J Parts of Construction Works Blocks Boards
4. MATERIALS (Formed Materials) as COMPONENTS	included in Resources	included in Table 2/3	J Parts of Construction Works Sands H Materials
5. SERVICES (Heating, lifts etc) as COMPONENTS	WORKS PIECES :Operation times and sequences OPERATIVE OCCUPATIONS CONSTRUCTION METHODS :Technical solutions DESIGN	included in Table 1 (Elements) Table 4 Activities and requirements Physical properties (3) Sitework (3) Operation & Maintenance (3) Prices & Conditions (3) Supply (3)	included in J G Operations and processes Sitework (3) F Agents of Construction E Properties and Measures Physical properties Price Shape Strength

data, an identification code assumes a focal position.

7. 3. 2 Significant, Classified Commodity Names

Both this Clause and 7. 3. 3 describe systems in which the alphanumeric characters in the code convey a sequence of meaning and are therefore significant, even if not intelligible without deciphering.

Although plain word single names could be used, these usually do not convey sufficient meaning and are difficult to list in an obviously significant order, other than alphabetic.'Code Name' is used here to describe an abreviated code, or quick-code, which conveys sufficient information to uniquely classify a component for the design team.

Examples of code-name systems are those developed primarily, or originally, for document filing, such as UDC and SfB. The component code of the latter conveys a number of levels of description of 'what it is' but no information about how it performs. SfB Classification being by form/material, brings together physically similar components but not necessarily those having a similar ability to satisfy design performance parameters.

The main advantage of the code-name is that it can be compiled by each participant in the design team because it is the common part of their description-code. If the component exists, it should be straightforward to bring its identification code and name-code together, although from opposite directions: the identification code as an 'item of production' and the name-code as an 'item of supply'. The manufacturer/producer would have also to produce, independently, the name-code and thereby become the information interface between the supplier and user.

7. 3. 3 Significant, Classified, Commodity Descriptions

Included under this heading are those systems which go beyond identification or naming, to describe features of the component.

Typical of a number of specification and cost systems are those developed by Quantity Surveyors, several of which are described in (69). These descriptions add to the component description further information about its location in the building and method of fixing.

The CACCI Illustration (5. 4) has sections to describe technical and constructional features. In the Specification Section of the code there is the facility to use Utility Tags to add descriptive information relating the component to the building. Some of this data could be provided by the manufacturer but data on programming, location, or associated labour, is particular to a project and can be added only by the design team.

Use of the FACET Code (5. 6) for specification, description and design, as well as for trade literature, shows how a name-code can link several specialist classification-codes and act as a clearing-house between files of information.

7. 3. 4 Post Co-Ordinate Systems

These systems are not an alternative to, but are additional to, classification systems and in some applications of faceted systems their use merges.

The user, who knows the component to be described by a faceted system, will select terms or phrases at the different levels and combine them into a description of the component. Another user, who does not know of a specific component, could combine the same terms into a question "which component has these features?". This is an example of the desirable two-way flow in an information system, which can be achieved by a combination of classified order and a thesaurus of terms, or phrases.

For the more detailed sections of an information system, the use of a thesaurus of single or two worded terms such as CIT is insufficient and rules, for the assembly of levels of terms, have to be provided. The greater detail required for specialist users would also lead to the preparation of specialist thesauri or libraries of terms.

7.4 SUMMARY OF DESIRABLE FEATURES

1. A division of the mass of information into blocks of specialist knowledge which may be prepared, and maintained, by the participant most conerned.
2. A structure which would allow all the blocks of information to be attached, without being dependent on any one block.
3. Recognition of the traditional divisions and uses of information.
4. Separation of information, within a block, into 'general' and 'specialist' use.
5. 'Item of Production' identification coding for use by manufacturing/retailing.
6. 'Item of Supply' name-code for general use by design/construct.
7. Use of a Modulus for self-checking codes.
8. Faceted assembly of name-code and classification/specification sub-codes.
9. Thesaurus of terms and names for use with faceted classification and with post co-ordinate document retrieval.

SECTION EIGHT : OUTLINE OF A PROPOSED SYSTEM

The system outlined in this Chapter contains elements of sub-systems developed under the Author's control and used by a multi-disciplined firm of Consulting Engineers. However, the structure of the information system, its classification and the format of code presentation have been modified greatly as the result of the research and reasoning described in earlier Chapters.

After a description of the features of the proposed system there is an illustrated example to show how requests for data are routed through the system and how the classification and code structure produces a data file arrangement which could be set-up and maintained by the construction industry.

An analogy to the component reference part of the proposed system is an arrangement of a punch-card file in which the 'Identification code' is the individual card bearing a particular manufacturer's component identification and component information. The 'Detailed code' is the drawer section in which all manufacturers' cards for identical components are filed together, in accordance with the filing classification. The 'Name code' is the label on the drawer which directs the user to the general area containing the information. In the manufacturer's office there will be another file drawer which contains only details of his products. The relevant component cards will bear the same information and Identity code but may be filed using different filing classifications. Cross-reference between the cards is possible if each has a note relating it to the other system, but is probably impossible if such cross-reference is not given. The latter instance is the present state of information flow in the construction industry.

The analogy may be extended to illustrate the Project File which contains only the Name Codes for those components which have been selected for use in the project.

8.1 STRUCTURE OF INFORMATION

Figure 8.1.(1) shows the outline of the structure, it recognises three divisions of responsibility for information generation and storage.

1. the manufacturing/retailing files
2. the participant's files
3. the project files: a (project design)
   b (project contract)

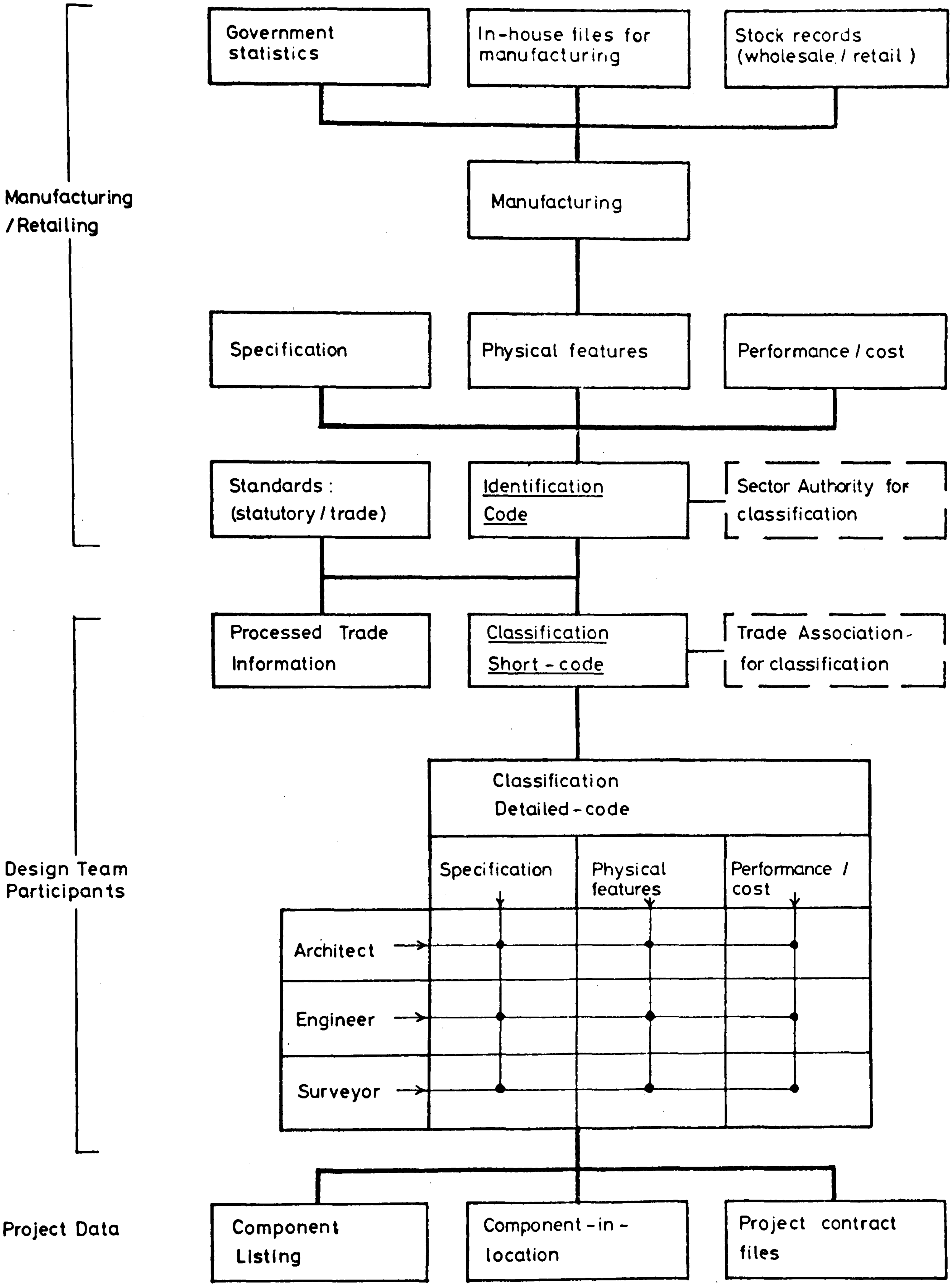
This study concentrates on 2 and 3a and refers only incidentally to 1 and 3b.

Responsibility for the content and upkeep of the manufacturing/retailing files would rest with the commodity supply sector, under the control of the Sector Authority. The project contract files would be the responsibility of the contractor.

Within the limits of factory gate - site gate, set at the commencement of this study, there is the information contained in the Files which are addressed by the Name code and the Detailed code. These files and codes are discussed in detail in this Chapter.

At the centre of the fully developed system is the Identification code linked to a Name/Classification code, both of which would be controlled by a central authority.

It will be seen that information about a component flows from the manufacturer and is divided between a number of participants before being brought together again in the specific Project File. In practice the participant may obtain information from sector authorities rather than from the manufacturer. This applies to 'processed data' such as



8. 1 (1) Structure of the Proposed Information System

standard tables of properties published by the professional Institutions. Not all of the information will flow through to the Project File because much of the data will be processed to contribute to the selection of systems or components.

This structure differs from the CACCI proposal, see 7.1 (1), by the absence of the Central Commodity File. It was the cost of establishing a similar file for the Canadian Construction Information Corporation (15) that led to the abandonment of that proposal. Whilst the creation of a central information source may be most desirable, and eventually attainable, an interim and more modest structure is the aim of this proposal. Although some control would be necessary to establish the structure, this is a more limited task than the preparation of a commodity file.

8.2 THE IDENTIFICATION CODE

In the absence of an accepted national standard, the proposal uses the example of the Draft BS (18) which recommended a non-significant code in terms of the commodity, although the code would signify the trade sector and the manufacturer's allocated identification. It would be based on the 'Item of Production' which is the unit preferred by the manufacturers. This has the benefit of allowing the manufacturing industry to proceed with identification separately from the construction industry. The function of the Identification code is to act as a link between, or a key to, the various files. By uniquely identifying a single component the code is able to convey, between source and user, everything that has been mutually classified.

Although there are advantages to the general adoption of a standard Identification code, the proposed information structure could operate without it, if the manufacturer/retailer also used the Name code. The use by manufacturers, of CI/SfB for trade literature illustrates how this could be done. Indeed, for the user there would be a benefit from this use of the Name code but the advantage of a unique identification of a component would be lost.

It is possible for a trade sector independently to develop an Identification code and the examples of ISBN book numbering and EWF electrical component listing, demonstrate an answer to the problem of the absence of a national standard.

8. 3 THE NAME CODE

Would be used in all data transactions for which the source of manufacture is not significant, so that it would be the usual 'name' used in communication within the design team. The Name code would also link manufacturers' Identification codes and convert them into 'items of supply'. It would be the filing level for trade literature.

There would have to be a compromise between the need for standardisation and national control, and the need of some users for greater detail - but the latter need is met at a lower level by the Detailed code. Reduction in specification detail would result in a loss of accuracy in data retrieval but usually as an over, rather than under, supply of information.

Classification was not part of the Draft BS Code proposal and there is no existing national classification which would be applicable. Within the construction industry either CI/SfB, (perhaps using the NBS listings), or SMM could provide a starting point for the development of such a code, or both could be used with automatic translation from a table of compatible SfB/SMM classification (19).

The illustration of the outline system uses the SMM paragraph numbers as codes, as described in 5. 6. 3. These do not have the advantage of faceted assembly, as would CI/SfB, and have been used only because of the deficiency of the CI/SfB classification/code in describing engineering components.

Significance at the Name code level is not important and, if the list of 'item of supply' component groups is classified, a non-significant code is acceptable. It has been suggested by O'Connor (51) that an international custom based code such as BTN (70) or SITC (R) (71) would provide a recognised and widely available classification at this level. There is good compatibility between BTN and SMM, within the latters limited field.

Example:	"Zinc tubes and pipes including fittings but excluding valves".
BTN	Heading 79.04
SMM/ FACET	S8H. PU/S11H. PU

The double FACET Code is the result of pipes and fittings being classified separately 8. 3. (1). Within the framework of SMM it would be acceptable to combine these under clause S7 "Pipework Generally" as a short code 'S7H. PU'.

The Name code is similar in function to the Resources group of the Primary Classifier of the CACCI Code Illustration (11), described in Section 5. 3, and this outline influenced the structure of the FACET classification/code.

8. 4 THE DETAILED CLASSIFICATION/CODE

This is a continually expanding and almost endless classification of all those features of a component which any user may wish to describe, either for transfer to another user or for in-house data transactions. It follows that no exhaustive classification can be prepared and that the proposed system must allow flexibility in capacity and use within the structural framework of the system.

Recognition of the divided process of design between participants leads to division of the Detailed data, with parts of the total information being located in several files. Such a system can not be as efficient as a single system, because of the need for repetition of and translation between the computer operating systems.

For those transactions which are between two users there must be a mutually understood procedure and, for economy in data processing, there also must be sufficient structure in the information system to avoid unnecessary searching of files. The proposed system divides data between those sectors of trade and sections of information which are recognised by trade practice, some of which are shown in 8. 1 (1). This could be achieved using the CIB Master Lists (25).

For the purpose of illustration, the CIB headings have been grouped into 'Specification', 'Physical features' and 'Performance/cost'. As a matrix to these lists there would be a division into participant responsibility, because it is a tenet of the proposed system that the most-interested-user maintains the relevant data file.

8. 5 THE PROJECT COMMODITY LISTING AND LOCATION FILES

These are the project-specific files, created by the design team for a limited period of time. They serve to answer the questions 'what' and 'where' about components included in the project.

It would be possible to use these files to accumulate all the project data, for example specification clauses, but this practice would introduce the possibility of oversight in updating project data at the same time as the corresponding Detailed code file data. Therefore the proposal is that the project files contain only the Name codes, locational details and the Detailed codes and that all the associated detail or text is held in the corresponding Detailed code file. The exception to this rule would be for components specific to the project, such as purpose-made windows, for which data would be stored on the Project File.

In addition to being the store for the accumulating project data, the

```
1     PU/ Zinc,BS.1431

          2     UJ/ fabricated

                    3     CG/ flanged and bolted joints,with asbestos gaskets
                    3     CJ/ flanged and bolted joints,with mastic sealer
                    3     CL/ flanged and bolted joints,with metal faced jointing rings
                    3     CP/ flanged and bolted joints,with neoprene gaskets
                    3     CS/ flanged and bolted joints,with rubber gaskets
                    3     CU/ spigot and socket joints

                              4     CE/ coated tar based compound
                              4     CJ/ natural finish
                              4     CL/ painted black bitumen

                                        5     C  (pipe supports measured separately)
                                        5     E  with screw fixing supports
                                        5     G  with long shank building in supports
                                        5     J  with short shank building in supports
```

8.3. (1) Comparison of BTN and FACET Codes

Project File would provide a buffer-store during the interactive design routines for data not confirmed to the project.

8.6 EXAMPLE OF USE BY ONE PARTICIPANT

Following the proposed 'evolutionary' approach to the growth of information systems, it is probable that some design participants will have developed systems before others. To encourage early development, the system should have use-benefit within a single participant's design sequences.

The present study is about the classification and structure of information but it has shown that the way in which information is used should be allowed to influence its structuring.

The series of examples of the application of the proposed system is based on existing design/documentation routines. To provide a sequence, the case is taken of a ventilation system, from the stage of system assembly and sizing, through to specification and measurement. This sequence lies within the shaded areas of 8.6 (1) which is an overlay of part of 8.1 (1). The content of the sequence is shown in summary, diagramatic, form in 8.6. (2).

Of necessity, because there is no existing external classification system, the routines are those used within one participant's computer programs but instances are given of how an external system could be used.

8.6.1 System Selection

8.6.1 (1) shows a 'menu' display which is used in connection with an interactive twin-screen visual display computer routine to select the system and locate the service runs and components.

Selection of 'Ventilation High Velocity' (by digitising the appropriate box) causes a pre-selected range of ductwork fittings to be displayed. These components may then be assembled, by manipulation, through the options provided on the 'menu' display. A typical assembly is shown, 8. 6. 1 (2). By stating the space co-ordinates, the assembly may be located within the building. Up to this stage there has been no, apparent, use of classification or coding because the dimensional information required to draw the components has been accessed through the computer routine - this direct access to information is a future stage.

At the present stage of development of software, the location in the building of the assembly has to be stated as a three-dimensional co-ordinate but the extension of the technique back in the design process, to describe the building components, assemblies and layout, is a natural next-step.

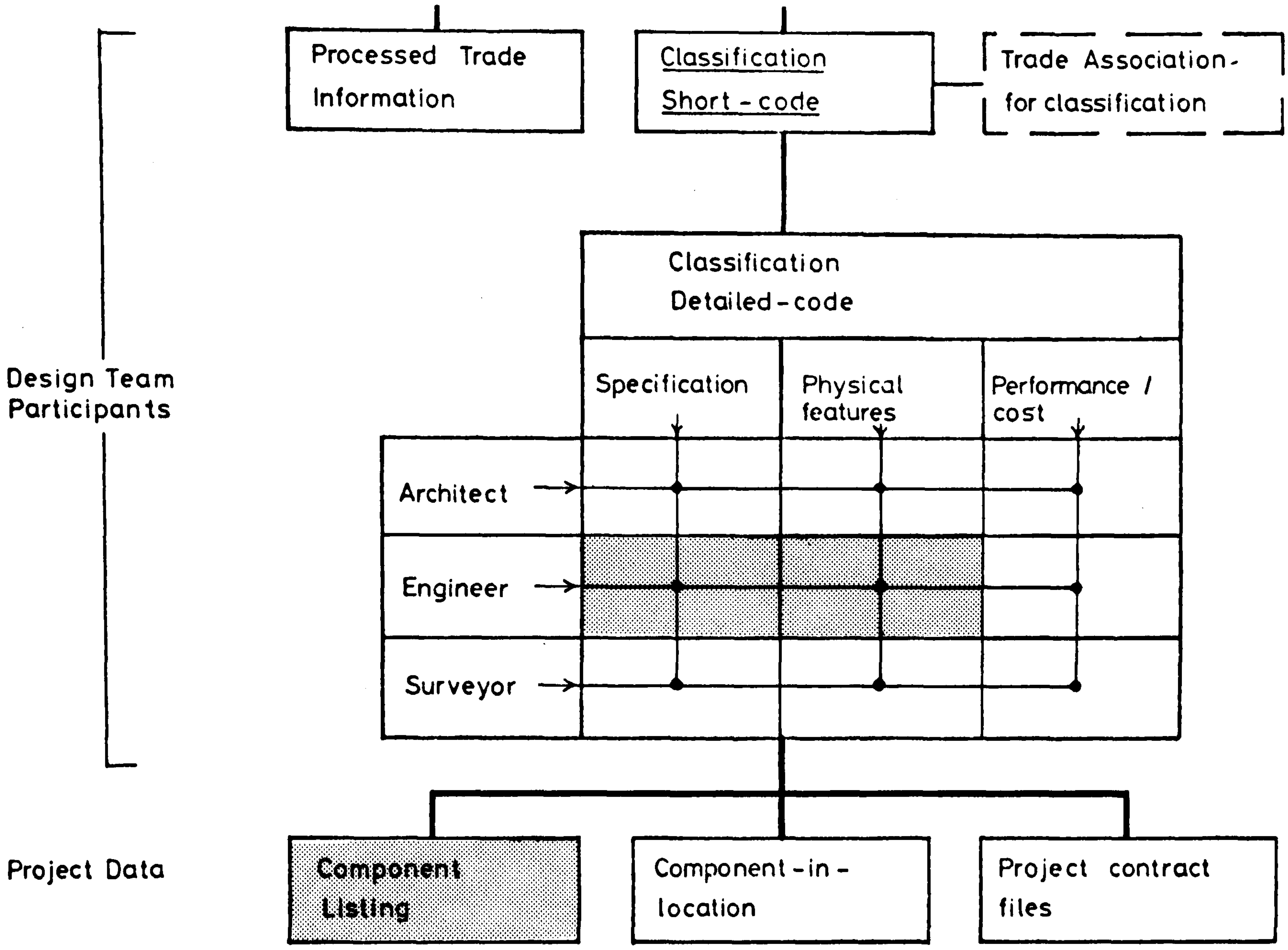
8. 6. 2 Component Selection

In the parallel 'manual' selection routines, selection of fittings is made from a sheet of drawings, see 8. 6. 2 (1), which provides the Name code: S29 = Ductwork Fittings, to which is added an alphabetic character to indicate the material. Each fitting type has an additional two-character code.

8. 6. 3 Component Description

Component Detailed codes for description are built up from a five-level library of faceted descriptions. 8. 6. 3 (1) shows the available phrases for the relevant ductwork fittings.

A decription is assembled by combining one phrase from each level, taking into account the 'stagger', which is designed to prevent incompatible combinations. Other sections of the classification/code allow



8. 6. (1) Outline of Part of Detailed Code

SHORT-CODE
S29L
'Ductwork Fittings
Steel'

DETAILED CODE SECTIONS			
COMPONENT SELECTION	COMPONENT DESCRIPTION	LOCATION DESCRIPTION	COMPONENT SPECIFICATION
From Pre-selected lists For Drawing System Assembly and sizing Example Code: S29L BH Meaning: Pressed bend, 30°, 1D throat radius	From Standard Phrase Library For Measurement description Example Code: S29L/KP/BH/-/BM/DH Meaning: Steel ducting fitting, circular cross section mild steel, bend, 30 deg, slip joint ends, galvanised finish, 200 mm dia....	From Standard Phrase library and ad hoc For Measurement description Example Code: S29L/HV/PC Meaning: "In high level void, fixed to concrete". To which would be added service/floor/room codes & descriptions.	From Standard Specification For Additional Materials/workmanship requirement Example Code: S26. 31. 100. 1 etc Meaning: "Joints Make transverse joints on site similar to those detailed in the component fabrication schedules " Etc

8.6 (2) Example of Detailed Code Sections

SERVICE	OPERATION	COMPONENTS			SLOPE	HEIGHT/
		BASIC	MOD 1	MOD 2		
Hot Water	Add	Coupling (socket)	Male	Running	Horizontal	
	Delete Line	Bend	Female	On Branch	Vertical	
Cold Water	Delete Component	Transition	Reducing	Concentric	1 / 100	1500
	Continue from	Tee	Twin	Eccentric	1 / 50	
Steam	Connect to	Branch	Square	Union	15°	1000
	Save Temporary	Stop	Sweep	Long Radius	30°	
Ventilation Low Velocity	Digitise	Flange	Cap	Short Radius	45°	
	Change to	Valve	Plug	Gate	60°	500
Ventilation High Velocity	Display	Flexible	Special	Globe	75°	
	Window	Mixing Box				0

8.6.1 (1) 'Menu' Selection Display

statements to be made about the method of fixing, the immediate location such as "fastened to" and the component sizes.

8. 6. 4 System Sizing

This is a numerical task which involves adding the air flows required at points in the building, and calculating the sizes of ducts and fans to supply this air. The fan has to overcome the resistance of the ductwork, the unit resistance of which is given as 'K-factors'.

8. 6. 4 (1) is a statement of the input data to the sizing program and shows the coded component descriptions, without sizes, in the column 'Joint Type". The codes address the appropriate 'K-factor' to enable the system to be sized.

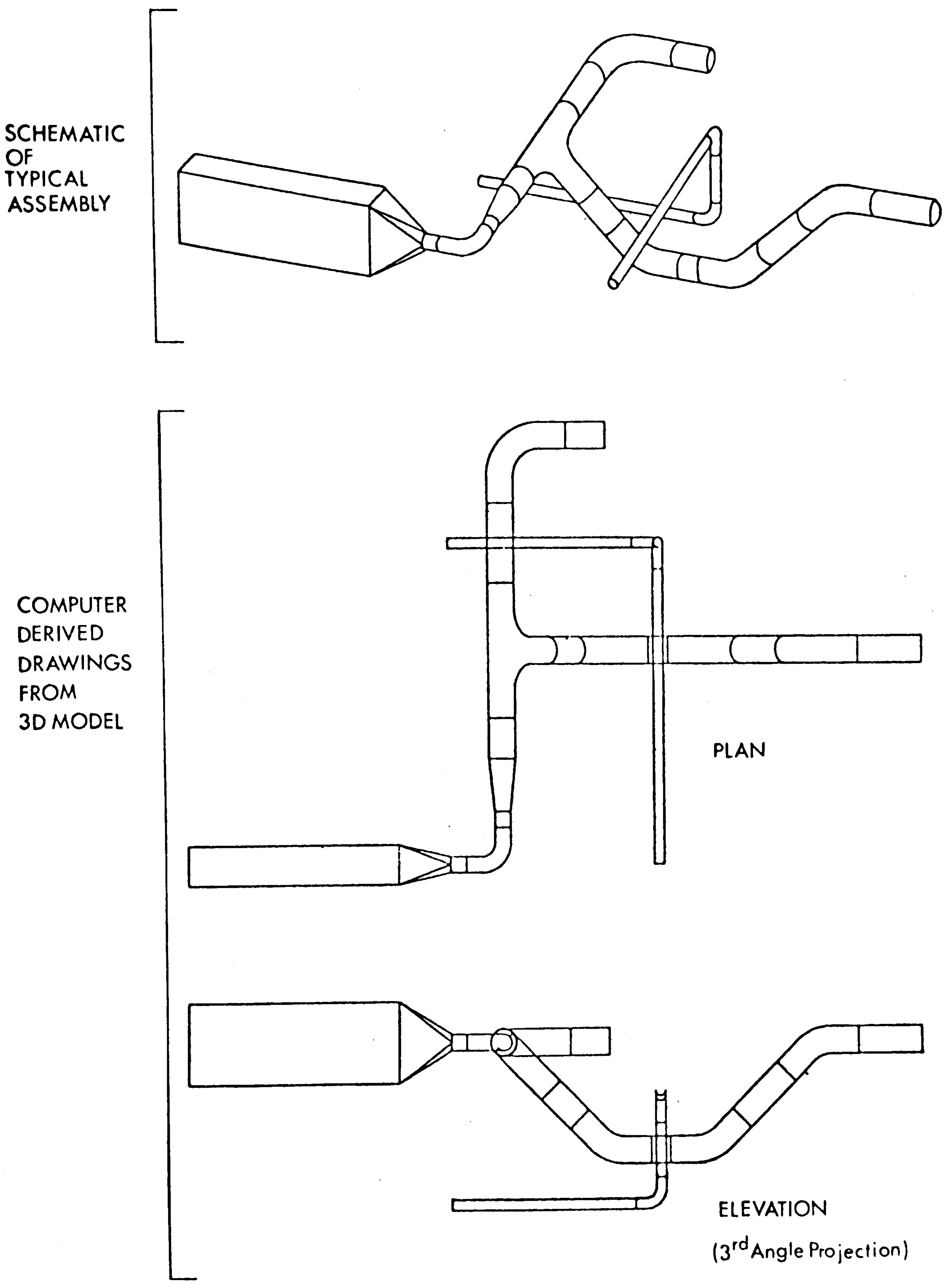
As part of the output from the program, the components are listed by code with the addition of sizes which have been calculated by the program. 8. 6. 4 (2) shows part of such a 'List of Parts'.

In the developed computer system, in which the components can be located in space, it will not be necessary to measure and enter the lengths of duct runs because these will be automatically generated. Equally the output will define the location of components.

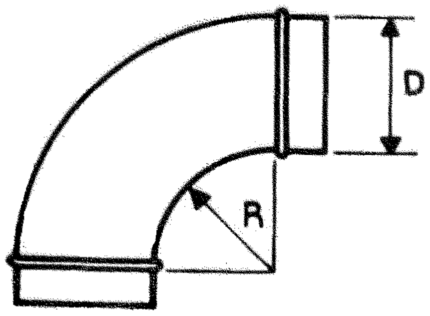
8. 6. 5 System Description and Measurement

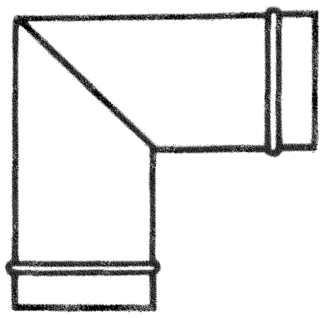
This, manual, task is a repetition of 8. 6. 3 and 8. 6. 4 to combine them for the purpose of costing, usually in the form of a Bill of Quantities. 8. 6. 5 (1) shows a typical take-off sheet from the measurement and coding stage, and 8. 6. 5 (2) the resulting Bill.

Heading the take-off sheet are boxes to describe the location and services to which the component belongs. These are used to allow sorting of the component information and costs into groups under each heading.

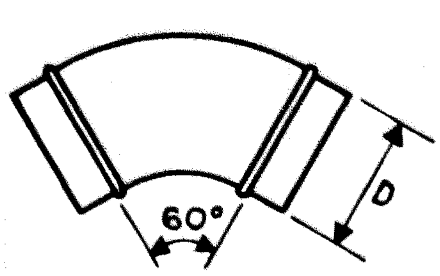


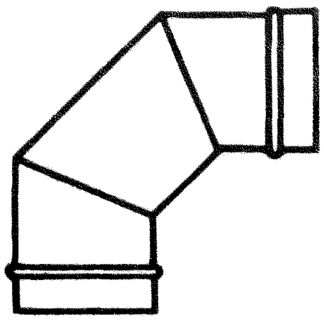
8. 6. 1 (2) Manipulation of Component Dimension Data



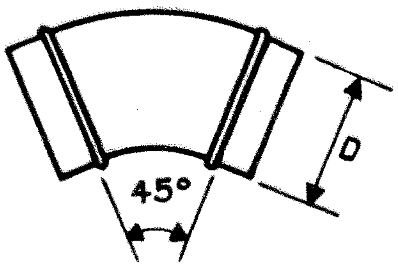


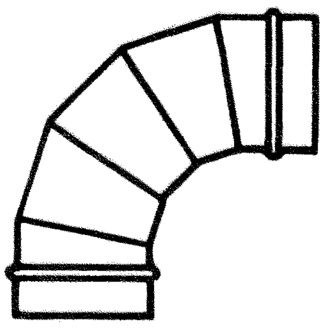
PRESSED BEND 90°	THROAT RADIUS 'R'			FABRICATED BEND 90°	MITRED
	½ D	1 D	1½ D		
		BB		DB	



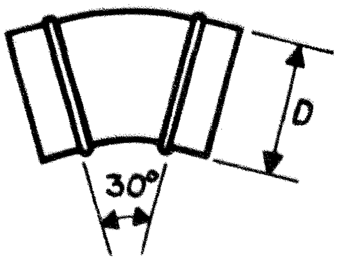


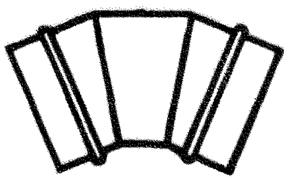
PRESSED BEND 60°	THROAT RADIUS 'R'			FABRICATED BEND 90°	3 SECTION
	½ D	1 D	1½ D		
		BD		DD	





PRESSED BEND 45°	THROAT RADIUS 'R'			FABRICATED BEND 90°	5 SECTION	
	½ D	1 D	1½ D		EQUAL	REDUCING.
		BF		DF		





PRESSED BEND 30°	THROAT RADIUS 'R'			FABRICATED BEND 45°	3 SECTION.
	½ D	1 D	1½ D		
		BH		DH	

S		2	9												**COMPONENT**

8.6.2 (1) Component Name Code and Illustration Data Sheet

Faber STANDARD
PHRASE LIBRARY

S29 DUCTING FITTINGS

S29L STEEL DUCTING FITTINGS - LOW VELOCITY (M=HIGH VELOCITY)

```
1    KK/ Extra over mild steel circular ducting for
1    KM/ Extra over flexible circular ducting for mild steel
1    KP/ Circular cross section mild steel

          2    BB/ bend,90 deg.
          2    BD/ bend,60 deg.
          2    BF/ bend,45 deg.
          2    BH/ bend,30 deg.
          2    BK/ bend,twin 90 deg.
          2    DD/ branch

                    3    BR/ angle radiused
                    3    BT/ main
                    3    BV/ outlet
                    3    DB/ shoe


          2    DF/ cap
          2    DH/ change section
          2    DK/ change shape
          2    DM/ coupling

                    3    DF/ reducing


          2    DP/ cross

                    3    DK/ angled branches


          2    DR/ cross,180 deg.

                    3    DV/ eccentric reducing


          2    DV/ plug
          2    FB/ spigot

                    3    FF/ diffuser
                    3    FD/ grille


          2    FF/ tee

                    3    FK/ branch,     45 deg.
                    3    FP/ straight,   90 deg.
                    3    FT/ reducing,   90 deg.

                              4    BH/ self flanged ends,drilled
                              4    BM/ slip joint ends

                                        5    DH  galvanised finish
                                        5    DM  g.a.m.
                                        5    FH  painted red oxide
```

8. 6. 3. (1) Component Description Sheet

Use of the full facility; to provide a detailed description of the component; its function, fixing size and location, results in a long code string, in excess of 80 alpha-numeric characters. Although this extent of information is necessary for costing, and useful at later Project Contract stages, much of the detail is irrelevant in other design routines and its repetition would be an annoyance in manual transactions and an unnecessary expense in data processing.

8. 6. 6 Component Specification

The description of a component is supplemented by a specification to provide more detailed instructions about material and workmanship. 8. 6. 6 (1) is a sample sheet of clauses and paragraphs which use the Name code followed by a numerically ordered sequence. Not all of the paragraphs are required and the computer routine which produces the final copy is able to re-number the paragraph sequence to provide consecutive numbers or a chapter/paragraph numbering.

8. 7 EXAMPLE OF USE BETWEEN PARTICIPANTS

The previous example illustrated the use of the proposed system within the design routines controlled by one participant. A similar structure would be used by each participant in the construction of a Detailed classification/code, using the responsibility matrix described in 8. 4.

8. 7 (1) is the responsibility matrix for a window assembly, which was studied in 2. 5. To show how the proposed system could handle information transactions between participants, the following examples examine two of the contacts between participants. It is assumed that the participants would use compatible computer systems, capable of addressing each other's Detailed data file and the Project file. The use of visual display units to display component data and the component-in-location would enhance the system.

```
SUPPLY NETWORK
ATMOSPHERIC PRESSURE 101600.015 N/SQ.M  SUPPLY AIR TEMP.  13.30 DEG.C
MAX. VEL. LIMIT IN MAIN DUCT   10.800 M/S  PERCENT LOSS THRU LEAKAGE
MIN. UNIT ST.P.  200.000 N/SQ.M  MAX. UNIT ST.P.  470.000 N/SQ.M
NETT RESISTANCE IN A/C EQUIPMENT ETC.    0.000N/SQ.M


METHOD OF DESIGN AND ANALYSIS - STATIC REGAIN - FACTOR =  75.00 PERCENT


SECTION INPUT DATA

DUCT    NODE  NODE   LENGTH   | JOINT  |NO.OF  OTHER RESISTANCES   MAX.VEL.   AMBIENT  U-VAL
TYPE    NEAR  FURTH  OF       | TYPE   |BENDS  K-FACTOR    P.D.    SPECIFIED  TEMP.    (WATT
        -EST  -EST   SECTION  |        |                (N/SQ.M)  (M/S)      (DEG.C)  SQ.M.
        FAN   FROM   (M.)     |        |                                              DEG.C


OVAL     11    12     1.500   |  /  /  |  0    -0.430     0.000     0.000     27.00   1.200
OVAL     12    13     3.000   |MM/HW/B |  2     0.000     0.000     0.000     27.00   1.200
ROUND    13    14     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     13    15     3.000   |SD/NH/T |  1     0.000     0.000     0.000     27.00   1.200
ROUND    15    16     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     15    17     4.000   |SD/NH/T |  0     0.000     0.000     0.000     27.00   1.200
ROUND    17    18     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     12    23     8.000   |MM/HW/T |  2     0.000     0.000     0.000     27.00   1.200
OVAL     23    21     3.000   |SD/ND/B |  0     0.000     0.000     0.000     27.00   1.200
ROUND    21    22     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     21    20     5.400   |SD/NH/T |  0     0.000     0.000     0.000     27.00   1.200
ROUND    20    19     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     23    24     3.000   |SD/ND/B |  0     0.000     0.000     0.000     27.00   1.200
ROUND    24    25     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     24    26     5.400   |SD/NH/T |  0     0.000     0.000     0.000     27.00   1.200
ROUND    26    27     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     12    31     2.000   |MM/HW/B |  2     0.000     0.000     0.000     27.00   1.200
ROUND    31    32     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
OVAL     31    29     5.400   |SD/NH/T |  0     0.000     0.000     0.000     27.00   1.200
ROUND    29    28     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200
ROUND    29    30     1.000   |SD/NH/B |  0     0.000     0.000     0.000     27.00   1.200

NUMBER OF SECTIONS IN NETWORK =   21
NUMBER OF TERMINAL UNITS IN NETWORK =     10
TOTAL ESTIMATED AIR FLOW IN NETWORK =       2.312 CU.M/S
```

8. 6. 4 (1) Computer Coded Input Sheet

```
                                                              LIST OF PARTS

ROUND DUCTWORK
  DUCT          NETT           BENDS
  DIAMETER      LENGTH     90DEG    45DEG
  (M.)          (M.)

     0.150        2.00        0        0
     0.175        2.00        0        0
     0.200        2.00        0        0
     0.225        2.00        0        0
     0.275        2.00        0        0


RECTANGULAR DUCTWORK
  LARGEST    SMALLEST   NETT    BENDS IN PLANE OF       BENDS IN PLANE OF
  DIMENSION  DIMENSION  LENGTH  LARGEST  DIMENSION      SMALLEST DIMENSION
  (M.)       (M.)       (M.)      90DEG    45DEG          90DEG    45DEG

  NONE


FLAT-OVAL DUCTWORK
  SIDE        DIAMETER    NETT        HARD  BENDS           EASY  BENDS
  (M.)        (M.)        LENGTH     90DEG    45DEG        90DEG    45DEG
                          (M.)

     0.550       0.150   34.19        1        4            0        0
     0.680       0.200    8.00        0        2            0        0
     0.810       0.250    1.50        0        0            0        0


DUCT FITTINGS

  ROUND/ROUND FITTINGS

  NONE


  RECTANGULAR/RECTANGULAR FITTINGS                           LARGEST    SMALLEST
                                                             DIMENSION  DIMENSION
                                                             (M.)       (M.)

  NONE


  FLAT-OVAL/FLAT-OVAL FITTINGS                               SIDE       DIAMETER
                                                             (M.)       (M.)

    FITTING TYPE   MM/MW/        CONNECTION NEAREST FAN      0.810       0.250
                             CONNECTION FURTHEST FROM FAN    0.550       0.150

    FITTING TYPE   SD/ND/        CONNECTION NEAREST FAN      0.680       0.200
                             CONNECTION FURTHEST FROM FAN    0.000       0.000
                                 CONNECTION   3             0.550       0.150
                                 CONNECTION   4             0.550       0.150
```

8. 6. 4 (2) Computer Output of Listed Codes

JOB NO:
SHEET NO:
ELEMENT NO:
DRAWING NO:

SERVICE:
INSTALLATION:
DEPT:
BLOCK:
FLOOR:
WORK PORTION:
OTHER:
ROOM:

UPDATE:
DESCRIPTION NUMBER: XK

BOX	PRIMARY CODE	SECONDARY CODE	SIZE STATE	SIZE STRING	FIXING	QUANTITY	OPTIONAL MTRL. RATE	OPTIONAL LAB. RATE
A C 1	S27L	FK/DB/-/DK/DD	BBR	500	C	3		
A C 2	S30L	C/ES/E/N/L		500x200	CBC	1		
A C 3	S29L	KP/BB/-/BM/DH	BBR	500	C	1		
A C 4	S98E	B/A/BA/CA/E	BBR	500	C	3		
A C 5								
A C 6								
A C 7								
A C 8								
A C 9								

ROGUES 10 20 30 40

SEQ. CODE:

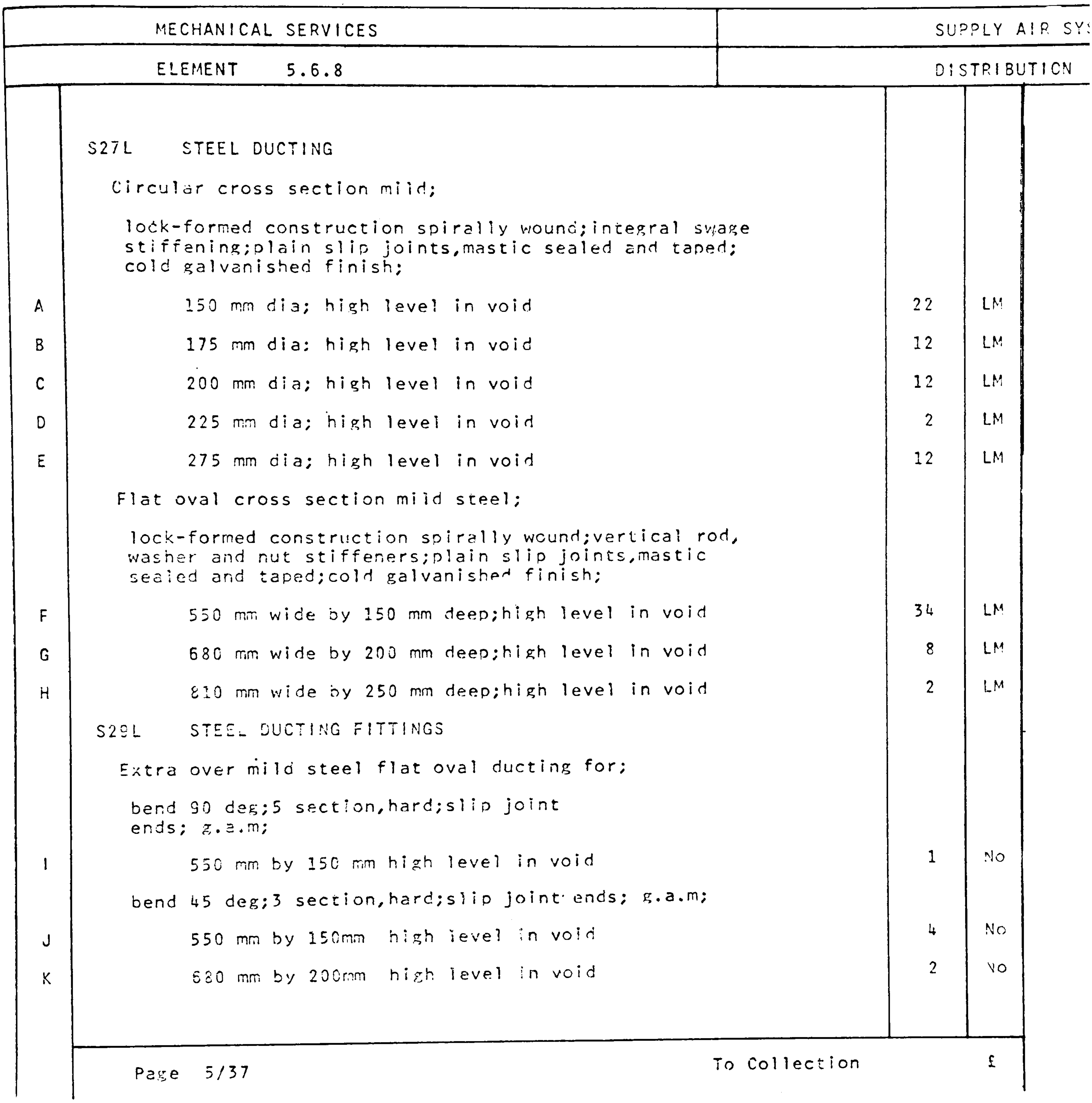
1

2

3

4

8. 6. 5 (1) Typical Coded Take-off Sheet



```
          MECHANICAL SERVICES                                    SUPPLY AIR SY
          ELEMENT    5.6.8                                       DISTRIBUTION

      S27L    STEEL DUCTING

        Circular cross section mild;

         lock-formed construction spirally wound;integral swage
         stiffening;plain slip joints,mastic sealed and taped;
         cold galvanished finish;

A              150 mm dia; high level in void                    22     LM

B              175 mm dia: high level in void                    12     LM

C              200 mm dia; high level in void                    12     LM

D              225 mm dia; high level in void                     2     LM

E              275 mm dia; high level in void                    12     LM

        Flat oval cross section mild steel;

         lock-formed construction spirally wound;vertical rod,
         washer and nut stiffeners;plain slip joints,mastic
         sealed and taped;cold galvanished finish;

F              550 mm wide by 150 mm deep;high level in void     34     LM

G              680 mm wide by 200 mm deep;high level in void      8     LM

H              810 mm wide by 250 mm deep;high level in void      2     LM

      S29L    STEEL DUCTING FITTINGS

        Extra over mild steel flat oval ducting for;

         bend 90 deg;5 section,hard;slip joint
         ends; g.a.m;

I              550 mm by 150 mm high level in void                1     No

         bend 45 deg;3 section,hard;slip joint ends; g.a.m;

J              550 mm by 150mm  high level in void                4     No

K              680 mm by 200mm  high level in void                2     No

          Page  5/37                              To Collection         £
```

8. 6. 5 (2) Sample of Bill Output

8. 7. 1 Component Selection

Responsibility for the initial selection of the window; its appearance position and dimensions, has been shown to lie with the Architect, who therefore has file responsibility for these features. In the Study of Practice the selection routine was found to be both inter-active, between participants, and iterative.

Initial information about the selection would be conveyed from the Architect to the Engineer through the Project File buffer-store as a type/location schedule or drawing. The Engineer would use the Name code, plus perhaps part of the high-level Detailed code, to access his Detailed data file for the required physical features, or he may request from the Architect the Identification code and use it to obtain data from the component manufacturer. In the latter case the manufacturer would need to maintain a 'reflected' Name code and Detailed data file.

After completing the assessment calculations on the initial selection, the Engineer would, when working interactively through visual display units, approve or suggest modifications to the proposed window assembly. Other participants may be involved in the selection until a solution is agreed. At this stage the window assembly Name code and selected Detailed codes would be placed in the 'confirmed' Project Data file.

Whilst most components would be of standard manufacture, some such as windows may be purpose made for the project. In this case the component information also may be held on the Project File.

8. 7. 2 Component Specification, Measurement and Description

It is the duty of the Architect to prepare the specification for a project and of the Quantity Surveyor to use this specification to produce a brief description for the Bill of Quantities. The Surveyor also has to measure the quantity of each component included in the project.

For frequently used components the specification and description would

S26.10000.1. DUCTWORK GENERALLY.

S26.11000.1. Definition.
Materials, apparatus and methods detailed throughout the Ductwork Compon Schedules and specification clauses,apply to all enclosures for convey air, and their ancillaries,whether as ducting runs or casings for equipm and accessories.

S26.12000.1. Design.
Ensure that the design velocities and pressure conditions comply with values and tests specified.

S26.13000.1. System Classification.
For the purpose of ductwork detail,classify systems by fan static pressu or by the air velocity in a particular section of ducting,or other enclos for conveying air,using whichever factor requires the heavier constructi or thickness of material.
Where the system is described as 'High Velocity' or 'High Pressure' use specification for that classification throughout.
Classification Factors.

	Low Pressure	High Pressure
Fan Static Pressure (positive)	up to 500 pa	500 pa - 2500 pa
Fan Static Pressure (negative)	up to 500 pa	up to 500 pa
Air Velocity in Duct	up to 10 m/s	10 m/s - 40 m/s

Velocity ranges also define the terms 'Low Velocity' and 'High Velocity'.

S26.14000.1. Routes.
As set out on the drawings, allowance being made for the diagrammat presentation where used.

S26.20000.2. Materials.
As called for in the component schedules,specification clauses and drawing Ensure materials are free from all defects and,where ferrous materials used,free from rust or scale.

S26.31100.1. Joints.
Make transverse joints on site similar to those detailed in the compone fabrication schedules.

S26.32000.1. Workmanship.
Ensure compliance with the current accepted standards and practice.
Arrange all exposed ducting runs to present a neat appearance,parallel w other ducting or services runs and the building structure.
Plumb all vertical ducting.

S26.41000.1. Erection.
On site, from manufactured or fabricated components and sections to make the required systems.
Align ducting, prior to connection to other components,allowance being m for all clearances,insulation,and adjacent services.

Issue

8. 6. 6 (1) Computer Generated Specification

ASSEMBLY : Window
COMPONENT: Frame (CIB List 3)
MATERIAL : Glass (CIB List 4)

FEATURE			PARTICIPANT				
			Arch.	Envir. Engr.	Q. S.	Struct. Engr.	Manuf.
Physical Features Specification	1. 01	Name/Identification	✱	□	□	0	X
	1. 02	Description	✱	□	□		X
	2. 05	Dimensions	✱	0	0	0	X
	2. 07	Appearance	✱				X
	4. 03:01	Leakage (Air)	□	✱			X
	4. 04:03	Leakage (Water)	✱				X
	4. 07. 01	Thermal insulation	□	✱			
	4. 08. 01	Daylight trahs.	□	✱			
	4. 09	Acoustic;	✱	□			
	4. 14	Durability	✱				
Performance/ Cost	5. 02	Suitability (Economic)	□		✱		X
	5. 03	Suitability (Statutory)	✱				
	6	Sitework	□		✱		X
	7	Operation & Maintenance	✱				
	8	Prices & Conditions of Sale	0		✱		X

X	Source of information
✱	File responsibility
□	Prime user
0	Secondary user

8. 7 (1) Responsibility Matrix for Window Assembly

be standards in the respective participant's office. The quantity of the component would vary with the project. Therefore the specification and description belong to the Detailed data file whilst the quantity listing is part of the project file.

To compile the Bill of Quantities, the components would be listed in an order determined by the Name code sequence. Most of the descriptions would be drawn from the Surveyor's Detailed data file but the specific project component descriptions would be inserted in the listing from the Project File. Component quantities would be available also from the Project File.

The computer program used to process the data would have to follow an agreed procedure to access the files but there would be no necessity to have standard routines for document presentation.

8. 8 IMPACT ON PRESENT PRACTICE

It has been argued earlier, 7. 1., that an initial acceptance of traditional practice is a desirable feature of an information system. By dividing information into small parcels and giving responsibility for them to the participant most concerned, the proposed system allows great flexibility in practice whilst providing uniformity in and control over, the information itself.

There is some impact, however, on traditional practice, the most obvious of which is that the participants need to adopt a formal attitude to information.

8. 8. 1 Variable Design Teams

Although the functions of the participants may not vary, the grouping of individuals, or firms, making up the design team may vary between projects. Associated with these changes would be differences in computer systems and design programs. The existence of a common information data-based should assist in establishing communication links

8. 8. 2 Responsibility for the File Data

In traditional practice it is the responsibility of the individual participant to ask the question, obtain and store the information and attest its accuracy. By giving the most-concerned participant responsibility for the relevant part of the Detailed data file, most of this responsibility is retained but there is an additional responsibility in contributing to the Project File. Any change in the confirmed project data would have to be notified to the other participants, and some proposed changes would have to be agreed.

8. 9 FURTHER STUDY AND DEVELOPMENT

The development of a data-base system for communication of component information between computer aided design systems is currently lagging behind the development of computer hardware and data-base technology. Following the collapse of the CACCI study programme, little concerted effort has been made by the British construction industry to develop collaborative systems.

Since advance on a broad front is not possible, except on a national scale, the industry must make intermittent progress by the efforts of individuals in the sectors of the industry. To avoid duplication and wasted effort this progress should be mapped-out on an overall plan such as the proposed system.

Areas of further study include:

a. The preparation of a responsibility matrix for the Detailed data file, based on the CIB Master Lists.

b. An evaluation of the ability of the existing classification systems, such as CI/SfB, SMM or BTN, to provide a compact Name code, with sufficient definition to uniquely identify a component to the Detailed data file and group items-of-supply from the Identification code.

c. A reconciliation of the analyses of the building; its type, constructional elements and components, made by the several information systems used in the construction industry.

d. An extension of the study to consider those information needs of the construction stage which could be met during the assembly of the Project File.

e. An appraisal of the function and form of the Sector Authority for classification, as proposed in the Draft BS, and the Trade Association proposed for the control of Name codes.

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