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COMPUTER AIDED TOTAL SYSTEM FOR SHIP ELECTRICAL CABLES

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The market served by the shipbuilding industry sees many cyclic changes and the industry is vulnerable to every change of economic climate which occurs. Throughout all the demand for ships, new and different ships and possibly in reduced numbers, tends to continue and causes the industry to re-orientate its efforts, reconsider accepted ideas and methods both in design and production and explore different procedures with the object of retaining viability and improving competitiveness. Computers have been utilized for some time in the shipbuilding industry in various spheres of activity generally with some measure of success, principally in the scientific/technical application and also the accounting/data processing fields. More recently their use as a production tool has increased with the advent of numerically controlled equipment in shipyards. The present paper describes yet another application and deals with the work involved in developing a total logical system for the processing and control of electrical cables for ships, from drawing office to termination and discusses the benefits to be derived at each stage. The present situation in which the use of a Database computer system located in America, is linked to an I.C.L. 1903 in the U.K., is described. This system enables modern Database techniques to be integrated with established computer routines — in this case C.A.P.I.C.S., and provides for the shipyard user, who has no computer programming knowledge, direct access to a computer network. The lessons experienced as a result of using computer techniques for electrical cables for a ship are applicable to the use of computers elsewhere in the industry. These techniques could lead to a "step" change in the attitude of the industry in the use of computers as a production aid, for it can provide the small shipyard, as well as the large shipyard, with a tool which is not restricted in its scope and is applicable to nearly all shipyard systems embracing planning, material control, accounts, etc. In general, computers are not the universal solution to all problems and can introduce quite a few of their own. Often, the process of logical thinking through the problem, which is necessary when considering how to apply a computer, can produce an answer to a problem without actually resorting to the computer. Finally the industry, though often accused of being conservative, is receptive to ideas provided they follow a logical evolutionary, rather then revolutionary, pattern.

HISTORY

It is essential to know the background of the authors' company, so that the developments which they are about to describe can be seen in their correct context and an appreciation gained as to the motives/techniques employed.

In 1968, Cammel Laird were building *Polaris* nuclear submarines and recognized that, because of the lack of a declared future naval shipbuilding programme, the company's future lay in building merchant vessels.

Positive efforts were required to be made by all departments concerned with merchant shipbuilding to play their part in making this part of the company's activities profitable. The content of ship specification was closely examined and improved and Company Standards prepared, which defined procedures, practices and equipments. Competitors' methods, especially Japanese, were also studied in order to ensure that the types of ships offered were in line with those available on the market.

In so far as electrical equipment was concerned a series of Electrical Standards were prepared which specified in detail all the major cost items which were purchased from sub-contractors. Over a number of contracts these Standards were improved.

In parallel with these activities, the electrical installation department had developed various techniques for supporting cables, glanding, ducting etc, in an endeavour to reduce cost.

The work involved, in the electrical drawing office, of drawing, scheduling, routeing, together with the installation and capital cost of the cable, form the major cost of the electrical works in a modern merchant vessel. The shipbuilder, in exercising control in the system design, cable selection and routeing, can achieve economies which will have a direct bearing on the electrical installation cost.

Secondly, although the total electrical installation forms only a relatively small percentage of the total vessel cost, an efficient and effective control of electric cable and equipment can be used as an indirect method of monitoring the outfit progress on the vessel.

An examination of the processes involved in producing electrical drawing, cable size and type selection, methods of routeing, etc was carried out and the variables that occurred in the drawing office and installation department in 1968 are defined in Table I.

Despite the obvious shortcomings or lack of a system, merchant vessels were built and commissioned, but usually by a continuous fire brigade type action.

Because it was an old established company there were a large number of "experts" within the installation department and these people played a dominent role in outfitting the vessel. Often drawings and material were sacrificed in order to meet the short term production requirement.

Decisions were made without reference to the design or drawing office and deviated from the drawings. Possibly Sir Lenard Redshaw's comment that "drawings are a challenge to

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TABLE I—DRAWING OFFICE AND INSTALLATION VARIABLES

	Drawing Office Variables	Installation Variables
Drawings	a) Individual section leaders influenced whole method of drawing operation. b) Impossible to predict the total no. of drawings required for a vessel. c) No logic in the drawing numbering system. d) No standard method of presentation or even size of drawing.	a) The installation managers liked to influence the type of drawing that they required. b) Drawings required well ahead of the ship so that the installation department could route and sketch cable arrangements.
Cables selection and routeing	d) Cable selection criteria variable and dependent upon experience or lack of experience. e) Cable routes issued for guidance. f) Cable lengths were "guestimated" and cable ordered on a vessel by vessel basis.	c) By cable routeing, the installation managers learnt about the vessel and estimated their manning problems. Again depends upon experience. d) Cables routed to suit the production short term requirements. e) No accurate record kept of cable used.
Equipment information	g) Equipment ordered but scant information provided to the installation department.	f) Stores operated on a "go and find it" basis.

the ingenuity of the work force to find another solution" really sums up the situation.

In order to control costs it is essential that the plan for the installation department is sensible, achievable and supported by a drawing system in which even the company's installation "experts" had confidence. For many years these "experts" had built vessels, often by using their experience and drawings as guidance.

In 1970, the type of vessel being built changed from simple cargo vessels to chemical carriers and LPGS, etc, of which the installation department had no experience and different cable techniques and equipment were required.

Some of the senior draughtsman and installation managers left the company about this time and, as in other industries, experience was lost as people left the company. This provided the added incentive to use the drawings and other drawing office information as an instruction rather than guidance.

During the period of 1970 up to 1972 the company changed the format of its drawings and grouped them on a system basis. The main reasons for this were:

1) so that the drawing office work could be planned more effectively;
2) that the output from the drawing office to the installation department would have the same format, irrespective of which section leader or draughtsman prepared the drawings;
3) that some system drawings could be applied to a number of vessels, i.e., become standard systems;
4) improve the content of information on the drawings;
5) relate cable numbers to systems and standardize on a cable number system.

Situation in 1972

By the end of 1972, a logical drawing number system had been produced and had been applied and improved over three classes of vessels.

This system follows the format of the electrical specification and operates on a system basis.

The same numbering system is used for correspondence, drawings, order etc.

Shipyard Reconstruction

In 1972, the company put forward proposals for a major reconstruction of the shipyard and the intention was to change the methods of ship construction and this would lead to shorter outfitting times.

The reconstruction would be devoted mainly to improving the steel manufacturing facilities construction process and the speeding up of this process would only reveal bottlenecks elsewhere in production.

Review of Electrical Outfitting Methods

Obviously those involved with the electrical aspects of the company's work could not let the electrical outfitting be the bottleneck and began to review its present methods and techniques and see if these would be compatible with its future methods of building.

Installation

As far as cable installation is concerned, the application of new ideas and techniques since the mid-sixties (including cable hangers and catinery systems) have reduced installation costs or kept them relatively constant, despite increases in national wage levels, etc. Also the methods used were consistent with future building techniques.

Cable Cutting

It was decided that all cables, other then lighting cable should be cut to length in the stores and in this way reduce the time and effort, often in adverse conditions on an open quay or vessel, to cut cables to length.

To support this aim it was necessary to provide adequate information to the stores, so that the cables could be cut to length. A review of the drawing office practices was undertaken in order to determine how this information could be provided and aşcertain the changes in current practice that would be needed to support the aim of cutting cables to length.

Review of Drawing Office Methods

Design Aspects

The major cost of cable is for power distribution and the design of the system and selection of cable for specific applications is usually determined by the draughtsman using experience, cable rating tables and classification rules, etc.

The contingencies allowed in cable sizing are determined by the experience of the individual draughtsman and his estimate on how the system will expand between the initial design stage and the ship going to sea.

Changes in the power distribution, as the ship design develops, necessitates re-examination of the power cabling and possible re-sizing.

Routeing Aspects

Preliminary cable routes are established as soon as general arrangements are available for engine room and deck areas.

These basic routes and the siting of electrical equipment allow the drawing office to estimate the length of cable required between the various items of equipment which is summated in the form of a cable schedule. Obviously if the cable route is changed and the consequential affect on cable lengths not recognized, or if the installation department install cable on different routes, then the whole basis of the cable schedule is in jeopardy.

Cable Schedule Aspects

The cable schedule is the summation of the cables required for the various systems and this forms the basis of a cable order.

Obviously, as the system cable requirements change, equipment resited or routes modified then the cable schedule requires to be amended and in practice this calls for frequent and accurate updating.

The company tried various forms of cable schedules over a period of years in an attempt to provide the basis of a cable control system. This aspect demanded more attention because:

i) copper price was in the order of £1000 per tonne,
ii) the extended deliveries, in the order of 26 weeks are common, and this is further aggrevated when the vessels have a short build time.

Cable Usage

Thus there are a whole variety of reasons why there are deviations from the planned use of cable per vessel, as shown in Table II.

TABLE II — CABLE SHORTAGES

Shortages from Drawing Office Sources	Shortages from Installation Causes
1) Route modified and effect not related to cables already scheduled.	1) Inaccurate measurement of cable required and can give high scrap percentage.
2) Equipment resited and effect not related to cables already scheduled.	2) Cable cutting on quay and errors made on high side.
3) Incorrect summating of cable quantities.	3) Use cable available rather than wait for correct cable of specified size.
4) Systems modified and cables missed or forgotten.	4) Problem of identifying cable size when drum markings illegible and cable selected by inspection of C.S.A.
5) Individual cable lengths summated but not feasible to optimize cutting.	
6) No allowance for actual scrap percentage.	

Theft and Damage

There are two other causes.

Theft — for the price for scrap copper is attractive.

Damage — resulting from other processes without due regard to the protection of the cable e.g. welding, burning, or drilling in close proximity to cables.

Review of other Shipyard Cabling Practices

The next stage was to find out whether any other shipyard had a cable control system and if so could it be of value to the authors' company.

In January 1973, a party visited Verolme Elektra, at Rotterdam, who have been cutting cables to length in the stores, not only for their shipyard, but also for their yards in other companies.

a) Two main points emerged from that visit:

Detailed composite drawings are essential for accommodation areas and engine room, and where cable routes are defined then they must be adhered to. Also specified routes for cables must be complied with.

b) There was no magic in determining the cable length. At Verolme it was one man's assessment and he deliberately erred on the high side. As the various shipyards within the Verolme group return all scrap lengths of cable over 3 metre length this provides a feedback of cable length accuracy and if necessary the cable lengths for the next ship in the class can be amended. Thus the percentage contingency in estimating cable lengths is gradually reduced on successive vessels of the same class. Because Verolme have been operating this system for about 15 years, a degree of confidence has been established, but this does not mean that mistakes do not occur!

To support the stores cable cutting system, the drawing office:

1) manually routed all cables and calculated cableway widths, etc;
2) located every item of electrical equipment on the large general arrangements;
3) made wide use of standard drawings and procedures;
4) tabulated cable data for selective sorting and summation by an electro-mechanical sorting equipment.

It was concluded that, while the Verolme cable system worked, it was operating at its maximum capability and it was felt the company should investigate further and look into the possibility of using computers. As the basic problem was that of determining the individual cable lengths, the company began thinking of storing the cable routes available within the vessel in a matrix form within a computer.

In order to gain experience of computer techniques, the company began using a time sharing system and a terminal. Within six months of spare time activity, a programme for fault level calculations was developed.

About this time a library search was undertaken to establish how other industries had tackled this problem of controlling the use of cabling. It was this search that revealed the work of the Electrical Research Association and C.A.P.I.C.S. (Computer Aided Processing of Industrial Cable Systems), a suite of computer programs which can be used to assist in the design and installation of a cabling system. It has been developed and used in nuclear and conventional power stations, oil rig platforms, chemical and process plants.

C.A.P.I.C.S. processes data from plant layout drawings and equipment data, and carries out routeing, sizing and accommodation of power, instrumentation and control cables for various methods of installation.

A series of schedules are automatically produced by the system for use in the design/drawing office and the site office. The information provided not only defines the electrical parameters of the cabling system, but also quantities of material of cables, accessories, installation material requirements and planning targets together with cost control data.

Although C.A.P.I.C.S. was designed for land based installations, it could be foreseen how certain of the routines could be of assistance in shipbuilding.

Of immediate interest at this initial stage, was the routeing of cable and, hence, the method of determining the cable lengths, the sizing of the cable, which would be carried out on a logical and repetitive basis, and the accommodation which is a calculation of the space that the cables on a particular route will occupy.

The C.A.P.I.C.S. suite of programs comprises three modules as shown in Fig. 1. these being.

Design Module

This routes each cable along the shortest route available on the cable network, sizes the cable, using electrical data and consideration of the route length which it has calculated. It then calculates the space required to accommodate the cables along the route.

This process is carried out for the initial design and subsequent design amendment resulting in listing lengths of cables which have been consistently and accurately sized.

Material Take-off Module

This produces a material list, priced or unpriced, for cables, glands and installation material which can be used for requisitioning or ordering purposes.

The Planning Module

This produces planning schedules for the electrical equipment and cable installation and monitors the progress and cost of these activities.

First Reactions to C.A.P.I.C.S.

1) C.A.P.I.C.S. appeared to provide the basic features required for a cable control system these being:

a) it selects the shortest possible cable route available;
b) it uses a logical cable selection criteria;
c) it determines the space required for the cableways;
d) it provides installation information.

2) C.A.P.I.C.S. had been designed for land based installations and may need considerable modification before it could be applied to a ship installation.

3) The complete range of programs offered more than the company required to operate in the immediate future.

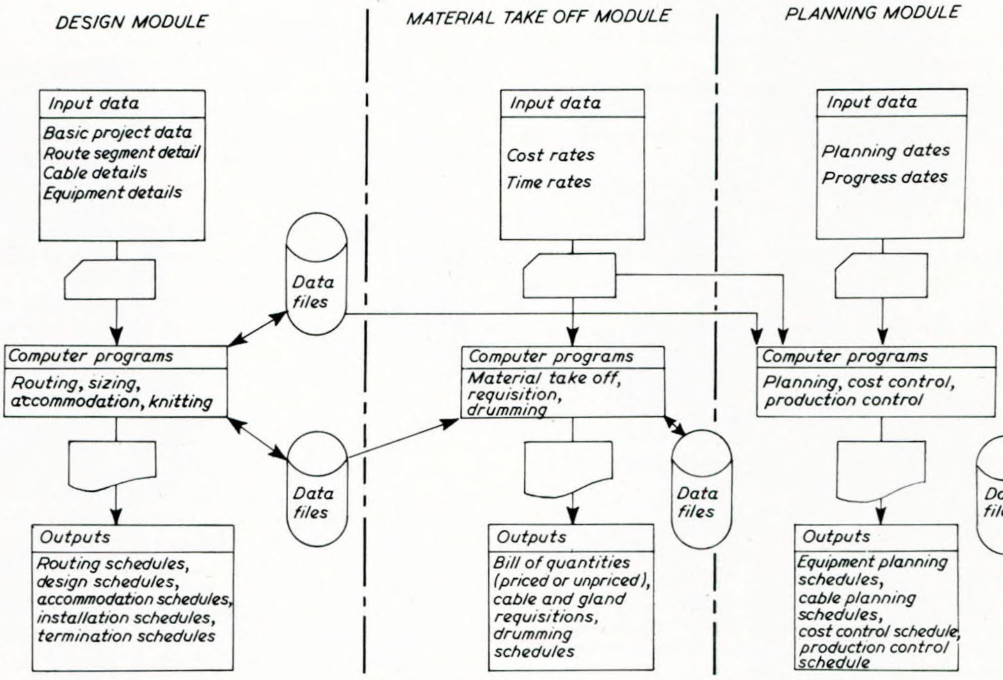


FIG. 1—*Block diagram of C.A.P.I.C.S. functions*

4) The number and variety of input data sheets and the terminology involved was confusing. Also the fixed format of the input data may be too restrictive and may require changes in the drawing office practices, especially in cable numbering systems.

5) Cost would be prohibitive.

6) The company's shipyard computer would be too small to handle the programs.

First Application of C.A.P.I.C.S. to Shipbuilding

After two meetings with engineers from the Electrical Research Association it was decided that the advantages that C.A.P.I.C.S. could offer outweighed some of the initial hesitation. Also that the cost of operating C.A.P.I.C.S., on a bureau basis, on the E.R.A. computer, together, with the support services from the engineers at E.R.A. was not prohibitive.

The first shipbuilding project on which the programs to be applied was the 20 000 dwt products tanker *Esso Severn.* This was the third vessel, for the Esso Petroleum Co. Ltd. and was similar to the previous vessels, *Esso Mersey* and *Esso Clyde* which had been built by the authors' company in 1970/72.

At the outset it was decided that the Design and Material take-off modules would be applied and the existing internal planning techniques used to produce installation dates etc. It was realized that the programs for these modules were more sophisticated than required, but it was decided to use the programs without modification, so that the company could learn of the full scope of the existing programs before deciding upon any program modifications, and hence develop a simplified package for use on future contracts.

Esso Severn

Although the steelwork and major portions of the vessel were a direct "repeat", the electrical distribution system was changed and now employed group starter boards. Other equipment changes were also required to satisfy the latest Lloyd's Register of Shipping Rules.

The power distribution system and the individual auxiliary system drawings had to be redrawn. This however, allowed the incorporation of the lessons learnt from building the previous vessels and the modification of the section and cable numbering systems which had been gradually improved on later vessels.

At this stage the company was confident that C.A.P.I.C.S. would be of benefit to it, but had the safeguard that if E.R.A. could not meet the programme or produce the appropriate output information to build the vessel, then resort could always be made to the drawings being prepared.

A timetable for the C.A.P.I.C.S. exercise was drafted out and time was allowed for the redrawing of certain systems.

Early in the exercise it was decided to send members of the drawing office and installation department to E.R.A. for a one week course on C.A.P.I.C.S.

The handbooks provided by E.R.A. were studied and typical data input sheets completed etc, so that staff became aware of the scope of the basic programs and the method of operation.

The exercise aimed at completion by the end of November 1973. The timetable was generally adhered to and outputs were available for the installation departments to commence work on *Esso Severn.*

Basic Time Scale of Project

February, 1973	Cammell Laird discussed with E.R.A. the possibility of applying C.A.P.I.C.S. to shipbuilding.
April, 1973	Contract placed with E.R.A. for the first vessel — *Esso Severn.*
June, 1973	Cammell Laird personnel attend a one week C.A.P.I.C.S. course at E.R.A.
December, 1973	Majority of inputs complete and outputs received.
March, 1974	Vessel launched.
October, 1974	Vessel scheduled to be handed over to her owners.

The timescale for producing the paperwork for vessel 1364 was longer than one would anticipate for similar vessels — this was mainly because the company experimented with different types of C.A.P.I.C.S. input sheets, methods of producing input data and made requests to E.R.A. to look into various types of output documents, program modifications and costs.

There was now a clear understanding of C.A.P.I.C.S. and its techniques and shortcomings and a knowledge of the type of useful outputs that could be derived and a belief that the input data process should be speeded up.

C.A.P.I.C.S. APPLIED TO SHIPBUILDING

Fig. 2 shows the sequence in which the input data is created and related to the design drawing timescale of the vessel. Each of these major tasks will be described in some detail.

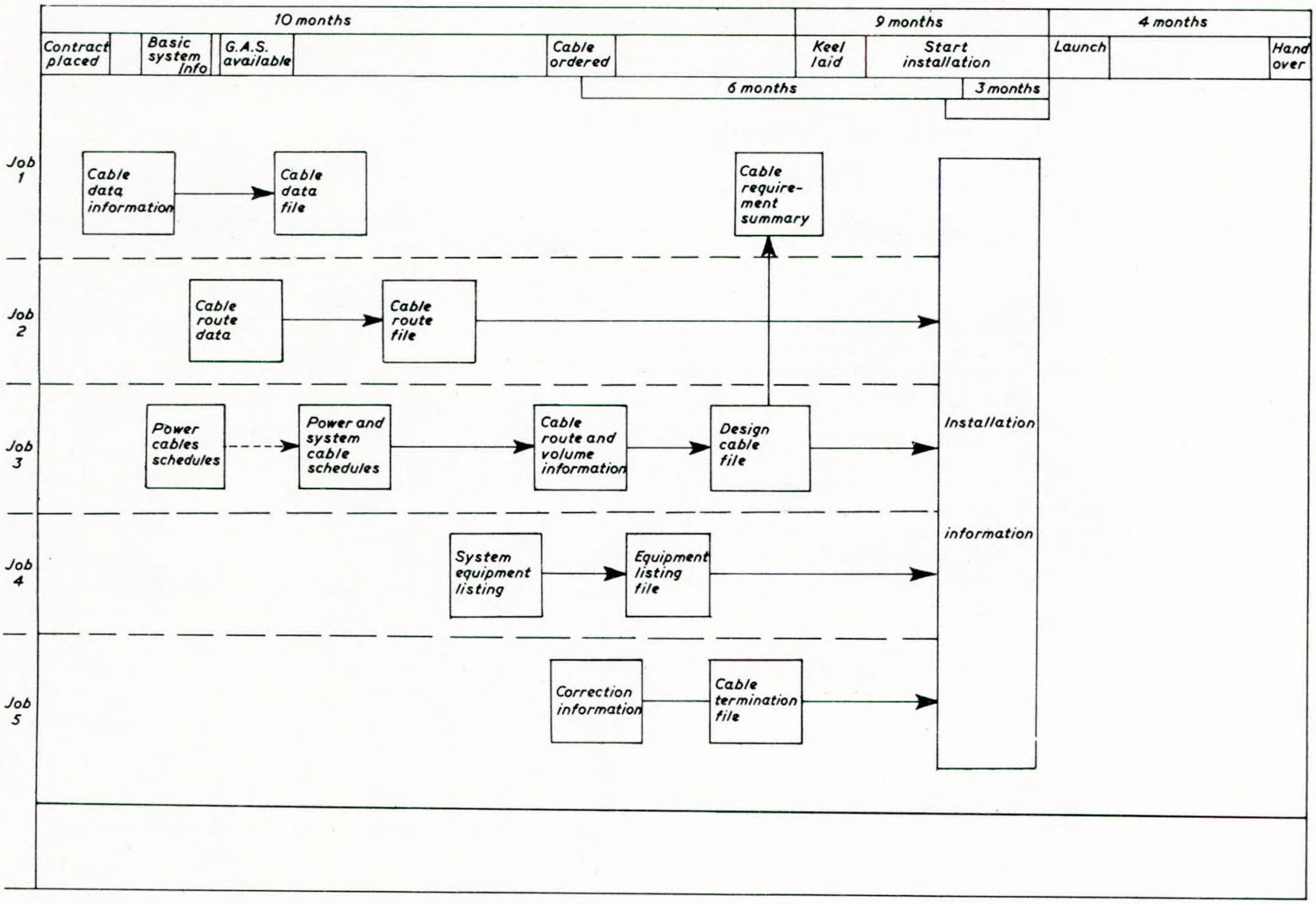


FIG. 2—*Data input sequence*

The timescale for the complete project is shown across the top of Fig. 2 and the job steps listed on the left hand side.

Fig. 3 shows the stages involved in data generation and transmission to E.R.A.

Job 1 — Cable Rating File

The cable rating file now holds information on ships' wiring, defining the electrical physical data for a wide range of cables specified in BS.6883.

Related to this file is a gland and lug (electrical termination) file which relates to cable overall diameter with a size of gland and the cable conductor with a lug size.

These tables were compiled with the valuable aid and assistance of B.I.C.C. and are now available for all C.A.P.I.C.S. users.

The first job of any new shipbuilding project is to check that the cable specified for this project is available within the file and that the cable current rating is in line with the particular Classification Society Rules for the project.

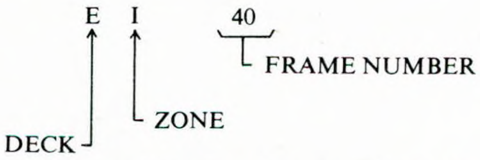
Job 2 — Cable Route File

As soon as the general arrangement of the engine room and accommodation are available, the position of the major items of electrical equipment and the cableways are indicated. At this stage the cableway width dimension is "guessed" and can only be taken as an indication of requirements.

The ship and machinery installation drawing offices compare this preliminary cableway requirement with other equipment, pipes, vents, and if it is acceptable, in principle, then a simplified cable network drawing is prepared as shown in Fig. 4.

The draughtsmen assign nodes to the cableway. A node is assigned at the origin and destination of each cable route and at every point of convergence or divergence of the route.

The program requires that the node be defined by four characters and the following number system has been adopted.



The cableways between nodes are defined as segments and, on an input data sheet, the draughtsman defines the distance between these nodes.

Thus a file of acceptable and approved cable routes are provided and held in the C.A.P.I.C.S. files.

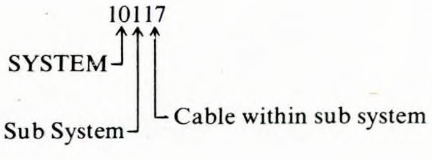
The route file can be modified, by producing the necessary input data and the effect of change, both from material and cost aspects, can be evaluated by the program.

Job 3 — Power and System Diagrams

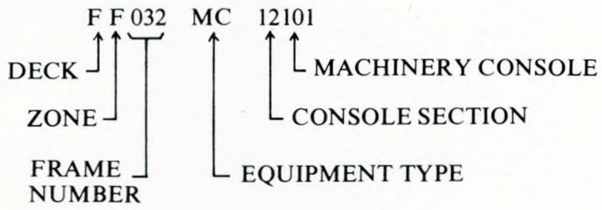
As the various power diagrams and system drawings are prepared, cable data sheets defining cable numbers and equipment numbering are prepared.

Fig. 5 is a simple system drawing and indicates how the cable and equipment number system operates.

The cable numbering system is defined by five digits as follows:



The equipment number is defined by 12 digits as follows:



The cable data input sheet defines the "start" node and "finish" node and the "to" and "from" equipments. The program routes the cable between the start and finish node along the available cableways and elects to use the route which gives minimum lengths.

A list of proposed cable routes is then produced as an output and if after checking these are acceptable then the programs proceed to carry out "sizing", having regard to voltage drop now that the length of run has been determined and the type of circuit protection device.

The design schedule is then produced and is checked by the drawing office. If it is accepted, a list of cable requirements is produced.

Again system modifications can override the data stored on file and the effect on the cable summary/order can be assessed, together with the cable volume in each segment.

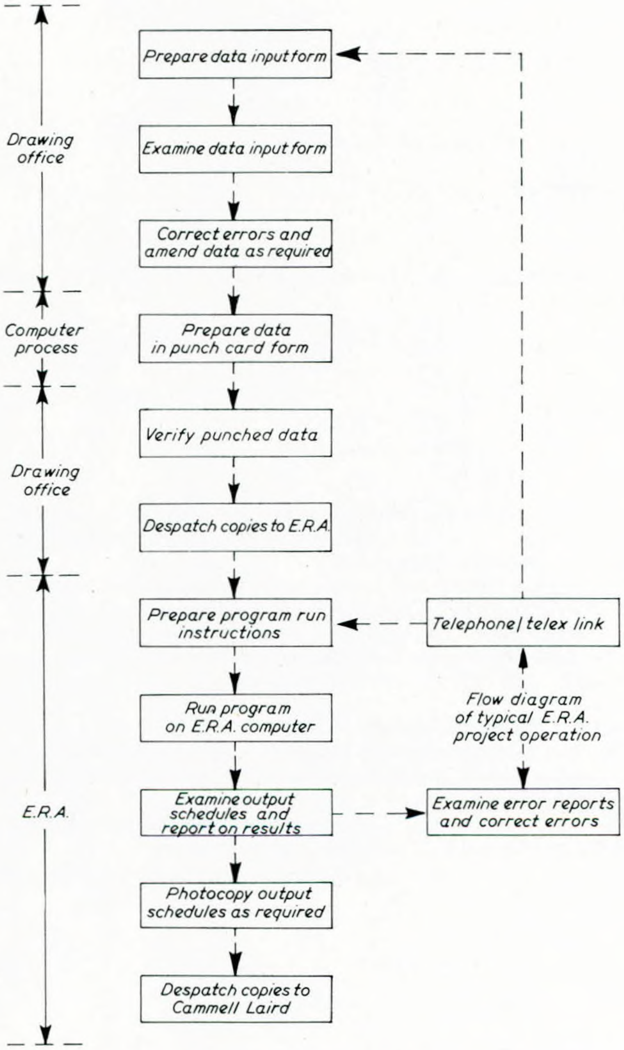


FIG. 3—*Information flow Cammell Laird/E.R.A. MK.II*

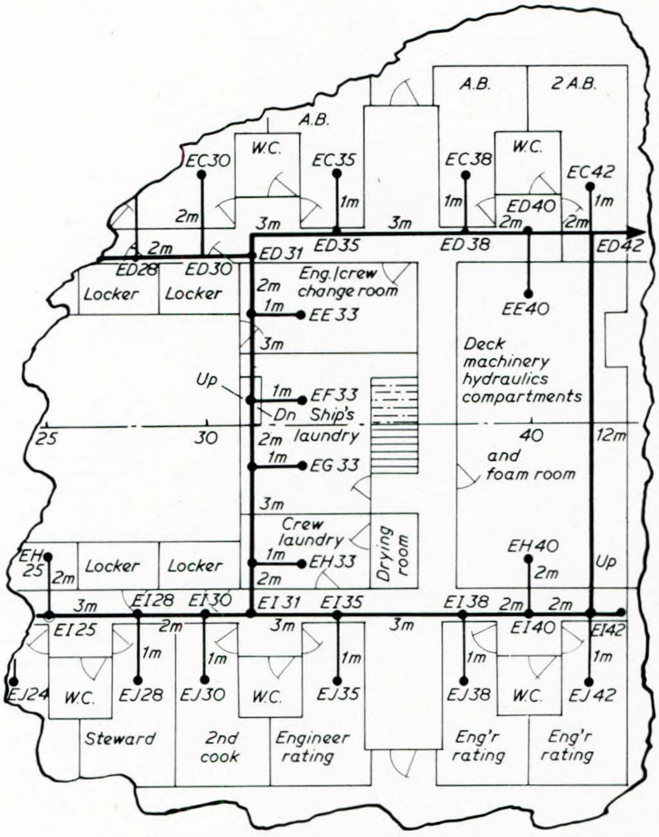


FIG. 4—*Cableway detail showing nodes and segment lengths*

Summarizing

The design module of the C.A.P.I.C.S. program will:

i) find the shortest route available for each cable, taking into account any restrictions imposed by the designer, e.g., port side cable run only;
ii) calculate the most economic cable size consistant with the circuit protection;
iii) calculate the space required to accommodate the cables on each route segment;
iv) determine the optimum array of cables to minimize cross-overs along the route (this is an optional facility);
v) produce all necessary schedules for cable installation within the vessel.

In the case of control circuits or presized cables, i.e., cable size determined for other reasons than electrical loads, then the system accepts the cable size and calculates lengths, etc.

Job 4 — Equipment Schedules

While the equipment number enables the computer to relate cables to items of equipments, it is essential that the installation departments are provided with clear English descriptions of equipment on all output documents.

The format of the equipment number allows the computer to produce listings sorted by location, equipment type and systems.

The natural extension of this schedule is the inclusion of order number, delivery etc, and hence the link with the material control and planning systems.

Job 5 — Connexion Information

A variety of methods of conveying connexion information to the installation department has been carried out and experience is being gained of the best methods.

One method recently tried was the connexion card, the format of which is shown later in Fig. 8.

C.A.P.I.C.S. Outputs

Throughout the drawing preparation stages and up to the time of producing installation information, a copy of all data

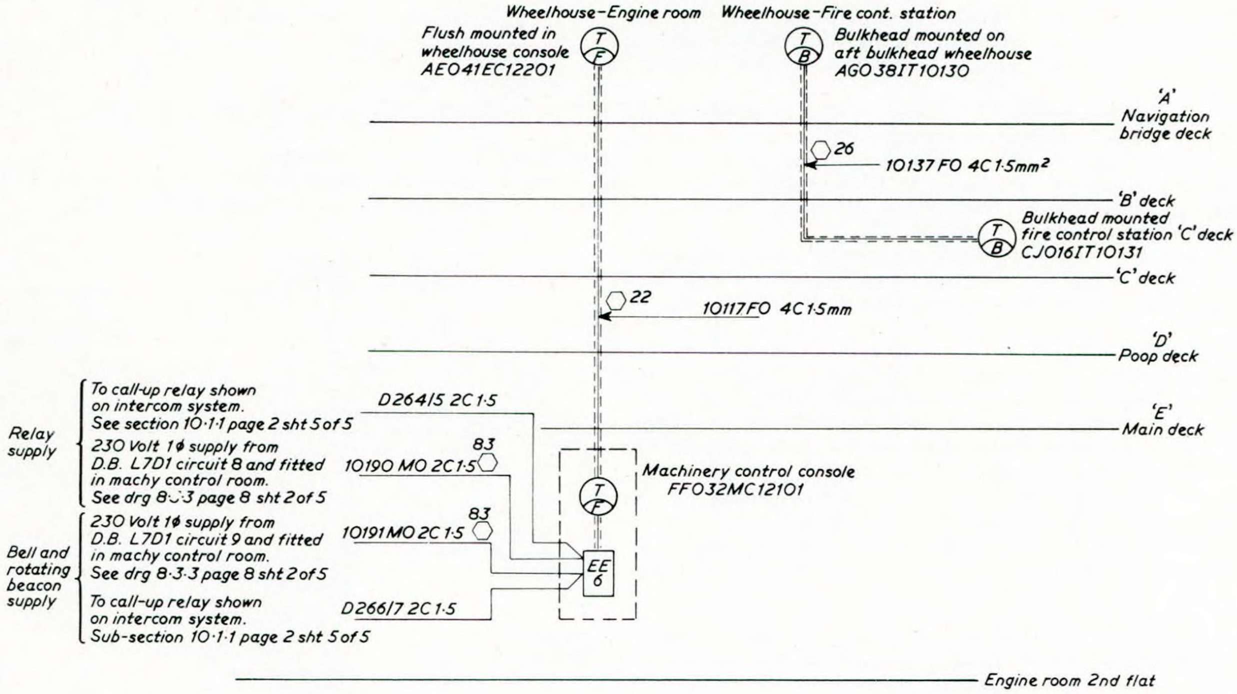


FIG. 5—*Typical system diagram*

held in the computer is available within the drawing office and the C.A.P.I.C.S. system is arranged so that all inputs and outputs are dated.

The responsibility of checking these documents must lie with the draughtsman, but this task can be simplified by checking on a ship system basis.

When information is required for the installation departments, the latest current information is used to produce installation data.

The block diagram in Fig. 6 shows the types of output data produced.

The format of data produced for the installation department has been improved as a result of experience gained on two types of vessels and the system currently in use and how it is derived will be described.

Cables Through Route Data — in Knitted Order

When a specific cable is routed and the route is accepted, the computer records the passage of the cable through the various nodes. This is a similar process to the manual method termed "flagging". The computer then produces a list of cables passing through a specific node and this data is used to determine the volume of cable on cableways and inside ducts. Thus the cableway and cable duct dimensions can be

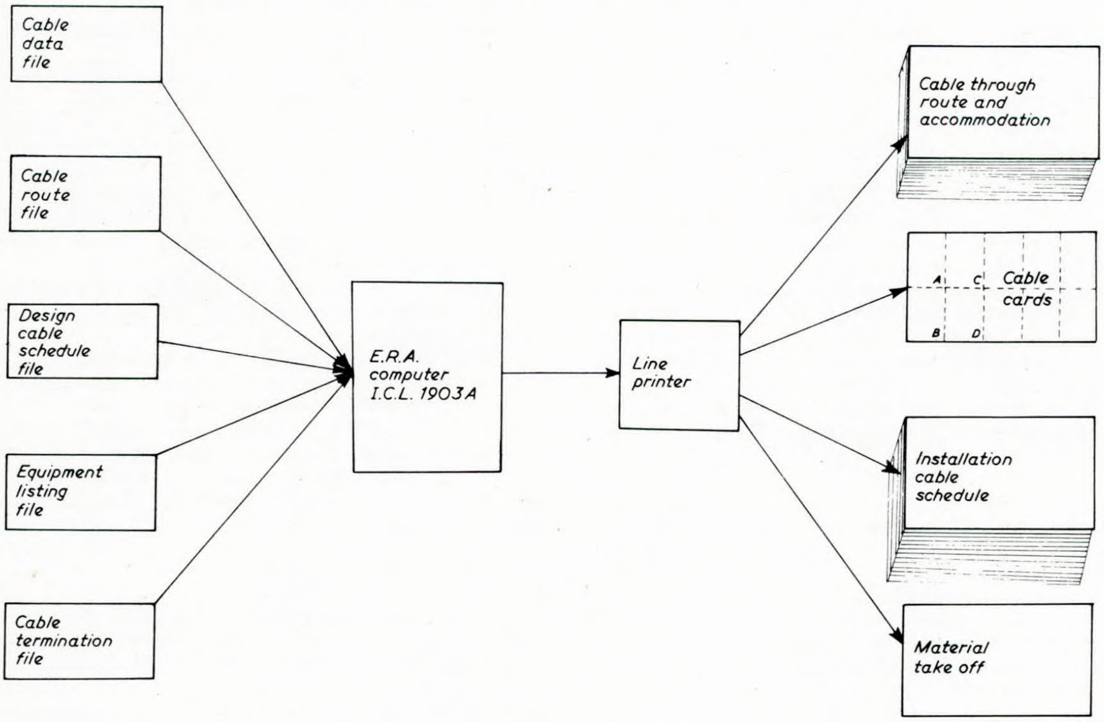


FIG. 6—*Output data information*

determined. This output data is required at an early stage in the contract so that the cableway widths, which were estimated on the preliminary general arrangements, can be confirmed.

It is appreciated that the final width may be greater than the initial width as a result of system modification or merely because some system data was not available at the early stages. The sizing of cableways or ducts is not however a precise art and is only carried out to assess the nearest standard which should be applied.

When the width and duct dimensions are confirmed, they can be used as the parameters against which the cableway volumes can be checked as the design progresses.

Cables from Equipments

The C.A.P.I.C.S. system provides a list of cables from equipments and this is one of the essential features of the installation output data. Because all drawings etc. are prepared on a system basis, then all the data supplied to C.A.P.I.C.S. is checked and held on file on a ship system basis. This data was to be merged with other files to produce the essential output data related to installation.

Installation is performed on an equipment and location basis, not on a system basis.

Transit Drum

A transit drum is the means of conveying the cut lengths of cable to the vessel. A drum may hold up to 40 cables of various cross-sections and cores. The contents of the transit drum are:

1) cables running along a common route with similar destinations;
2) cables local to a particular area on the vessel;
3) segregated cables.

Generally, each drum will form a separate group on a cableway. By this means the contents of a cable drum can be clipped and banded as soon as it has been "pulled in" thus making it more difficult for cable thieves. The print-outs of "cables from equipment" and "cables through route" in knitted order form the basic information from which the contents of the transit drums are derived.

This method of using transit drums has been operated on three vessels to date and has been a definite aid to the electrical installation department allowing them to cable the vessel in a short time. It overcomes some of the cable handling problems as the transit drum can often be sited in the engine room or compartment near the equipment and this facilitates the pulling in activities. Monitoring of transit drum movements will also provide basic planning information.

Connexion Information

Over a number of vessels, a variety of methods of conveying connexion data to the installation department has been tried.

The company has tried using the C.A.P.I.C.S. suite of programs to produce installation cards for each cable and list on the card the connexions required at the items of equipment to which the cable is connected.

This system has not operated very satisfactorily, mainly because the connexion data taken from sub-contractors' drawings does not line up with the equipment markings when it arrives. Also the time taken to input the data and up-date the information in C.A.P.I.C.S. is excessive. However, the card installation method has taught some valuable lessons which can be applied to the next stage in system development.

Equipment Listings

The equipment coding system developed by the company allows the use of C.A.P.I.C.S. to sort the equipment by:

a) its location on the vessel;
b) its type or specification;
c) the system to which it is to be applied.

This information forms the basis of a stores control system and by additional information can be used for equipment expediting etc.

Material Take-off

This module produces bills of quantity without additional manual inputs and these include:

1) cable requirements;
2) gland requirements;
3) lug requirements;

which can include pricing information.

Review of C.A.P.I.C.S. Operation

Fig. 7. shows the timescale of the operation for the first merchant vessel and the major points that emerge are:

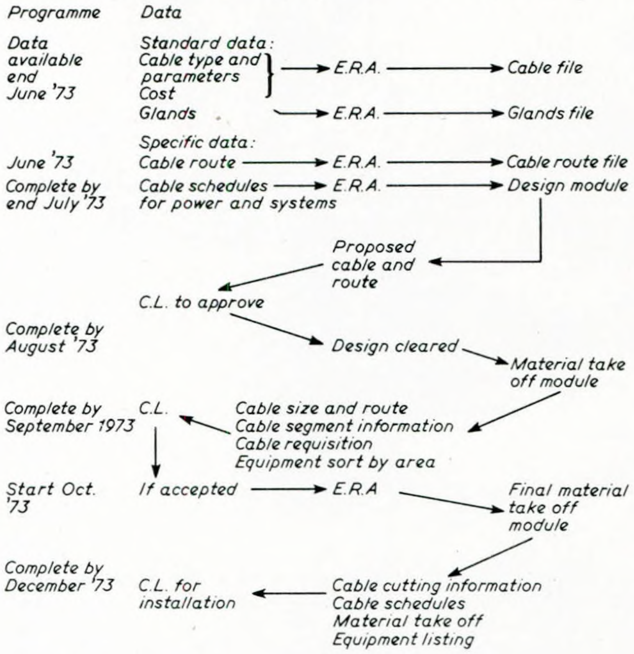


FIG. 7—*Actual information flow diagram and timescale*

i) the systems can be tackled piecemeal in a form acceptable by the drawing office and loaded onto the computer in reasonably sized data blocks, thus using the computer efficiently;
ii) that selected outputs can be requested and examined and the system operates in a series of logical steps;
iii) that the memory system is dynamic and the implication of a system change is carried out through the whole system;
iv) material take-off, together with prices, could provide a basis for comparing different designs.

All output at the drawing office is on computer line-printer stationery and as a first priority the company discussed with E.R.A. how a preprinted stationery, similar to that used at a power station, could be used.

This led to the introduction of the cable card as shown in Fig. 8. This card has been designed so that it divides along perforated lines with four portions.

The "A" portion was intended for the stores and defines all the information required for cutting and identifying the cable at the stores.

The "B" portion was destined for the installation department and includes the route that the individual cable will follow together with the cable identification.

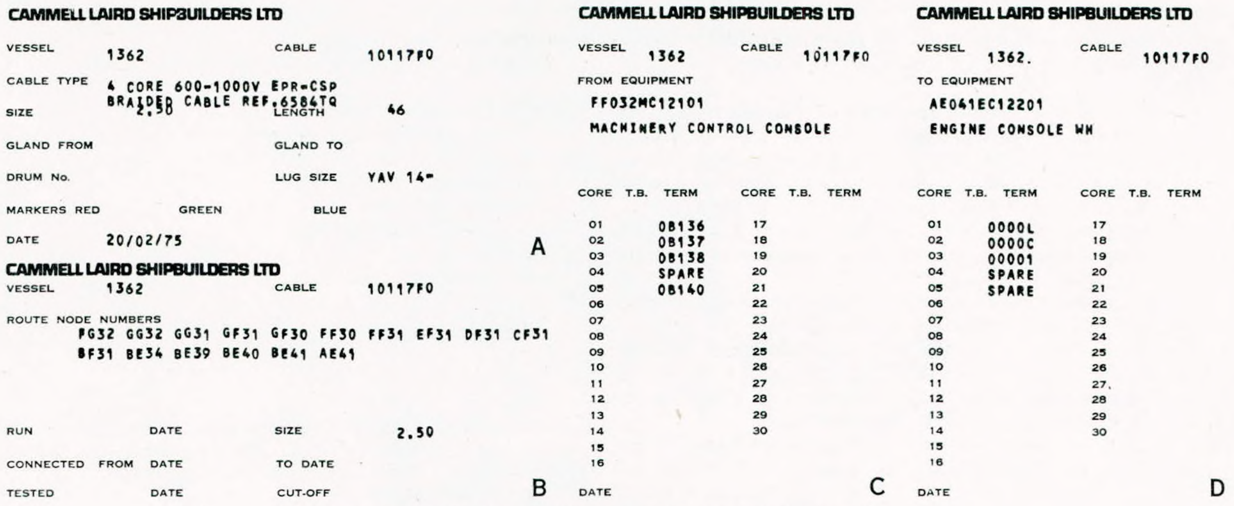
The "C" and "D" portions were intended to be used for connecting the cable at the "to" and "from" equipments.

Having used this idea for one vessel, the company has since progressed to a more acceptable system for the installation department.

ADVANTAGES OF APPLYING C.A.P.I.C.S.

General

The knowledge and experience of the drawing office and installation staff enabled the previous "system" to operate, and when cable supplies were readily available and costs relatively constant, the previous "system" could cope and support the then type of shipbuilding programme times and practices. Often urgent ordering of cables or equipment was required to ensure that the programme was maintained.



CAMMELL LAIRD SHIPBUILDERS LTD

VESSEL 1362 CABLE 10117F0

CABLE TYPE 4 CORE 600-1000V EPR-CSP BRAIDED CABLE REF.6584TQ

SIZE 2.50 LENGTH 46

GLAND FROM GLAND TO

DRUM No. LUG SIZE YAV 14-

MARKERS RED GREEN BLUE

DATE 20/02/75

A

CAMMELL LAIRD SHIPBUILDERS LTD

VESSEL 1362 CABLE 10117F0

ROUTE NODE NUMBERS
FG32 GG32 GG31 GF31 GF30 FF30 FF31 EF31 DF31 CF31
BF31 BE34 BE39 BE40 BE41 AE41

RUN DATE SIZE 2.50

CONNECTED FROM DATE TO DATE

TESTED DATE CUT-OFF

B

CAMMELL LAIRD SHIPBUILDERS LTD

VESSEL 1362 CABLE 10117F0

FROM EQUIPMENT
FF032MC12101
MACHINERY CONTROL CONSOLE

CORE	T.B.	TERM	CORE	T.B.	TERM
01		0B136	17		
02		0B137	18		
03		0B138	19		
04		SPARE	20		
05		0B140	21		
06			22		
07			23		
08			24		
09			25		
10			26		
11			27		
12			28		
13			29		
14			30		
15					
16					

DATE

C

CAMMELL LAIRD SHIPBUILDERS LTD

VESSEL 1362. CABLE 10117F0

TO EQUIPMENT
AE041EC12201
ENGINE CONSOLE WH

CORE	T.B.	TERM	CORE	T.B.	TERM
01		0000L	17		
02		0000C	18		
03		00001	19		
04		SPARE	20		
05		SPARE	21		
06			22		
07			23		
08			24		
09			25		
10			26		
11			27.		
12			28		
13			29		
14			30		
15					
16					

DATE

D

FIG. 8—*Typical cable connexion installation card*

This is no longer acceptable, for cost and delivery situations change rapidly and the type of support the new building method requires will necessitate a change in the methods of cable processing.

Although C.A.P.I.C.S. demands more drawing office effort and time than that employed in the company's previous building practices it has enabled the drawing office to produce more and better information, for the new shipbuilding techniques, with existing manpower.

If C.A.P.I.C.S., or a similar system, were not available, or not used, the demands on the drawing office to produce better and more detailed information would necessitate an increase in staff with no assurance that the system could function any better.

Initially allowance has to be made for re-training the draughtsman, so that he can appreciate that the long term objectives will enhance his job security, and that the computer exists as an aid in his work and is incapable of replacing him.

Advantages at the Drawing Office Level

The necessity for a C.A.P.I.C.S. system becomes more apparent when cable deliveries are in the order of 20 to 26 weeks and cable costs are high, for the system calculates the individual lengths of each cable to within a metre and highlights any descrepancies or material shortages.

The major advantage in the drawing office is that the system demands a systematic input which will lead to standard drawing office procedure and output presentation. This will simplify the operation of the drawing office in that all draughtsmen will become familiar with one system.

Standardization of systems and format of presentation should enable the draughtsmen to spend more time in system design and, thereby, increase his scope and knowledge and, therefore, job satisfaction.

The system does require certain repetitive input data, but this occupies a relatively small percentage of the overall drawing office activity and, having completed the C.A.P.I.C.S. input, the computer system provides the instant memory and performs a wide range of mundane tasks which will be essential for supporting future building techniques.

The system provides a "tool" that can be used by the drawing office for more detailed analysis of the cost of cabling systems for power distribution etc, and can also be used for rapidly calculating the cost of cableway re-routeing and specification changes.

These facilities are impractical with the previous methods and timescale of operation.

The main advantage that can be derived is by using it at the earliest possible opportunity in designing the basic power distribution system, and using C.A.P.I.C.S. to generate cable quantities required for that system. Changes in the basic system can readily be made and C.A.P.I.C.S. will provide the relevant information to support this change.

The cable sizing aspects of C.A.P.I.C.S. have caused the company to re-assess some of its basic ideas on cable sizing and has allowed it to develop a logical range of standard cable sizes.

Discussions have also taken place with Lloyd's Register of Shipping who have agreed, in principle, that they could give approval to a power distribution system whose information had been derived from an "approved" computer program.

The design capability of C.A.P.I.C.S. has been examined by Lloyd's Register of Shipping and, providing certain additional functions are performed, they are receptive to giving "approval" to its programs.

This would simplify the "approval" procedure in both Lloyd's Register of Shipping and the drawing office.

Advantages at the Installation Level

Previously the electrical manager and foremen for a particular vessel spent about 3 to 4 months planning detailed cable routeing etc, from the various system drawings produced by the drawing office.

An overnight change to new system was not anticipated and obviously there will be a learning factor involved, but because C.A.P.I.C.S. carries out the routeing work, it is anticipated reducing this period by about 50 per cent.

The cutting of the cable at the stores and the grouping of the cables into appropriate groups for pulling in is also a major factor in increasing the efficiency of the department.

A major part of the installation department involvement for a vessel relates to the "stores chase" and the future changes in the store system should reduce this aspect of electrical installation work.

Advantages at the Cable Stores

C.A.P.I.C.S. underlined the need for re-organizing the cable store and removing the responsibility from individual storekeepers of operating and devising their own "systems".

The use of standard cables and the forward planning of cable cutting further simplify the stores operation and efficiency.

DISADVANTAGES OF APPLYING C.A.P.I.C.S.

General

C.A.P.I.C.S. demanded changing some of the existing practices; all changes which involve people are normally met with some form of opposition because they are forced to learn new ideas and techniques and C.A.P.I.C.S. is no exception.

To simplify this learning phase the company has tried to make both the drawing office and the installation department aware of the ultimate scope that C.A.P.I.C.S. can offer, but when problems occur in either areas they tend to revert to familiar, past practices. This has been recognized and allowances have been made to allow the C.A.P.I.C.S. system to progress in stages — this however places demands upon the few people who are actively engaged in developing it.

At the Drawing Office Level

Continuous effort was required throughout the building of the first vessel on which these new techniques were being developed.

More effort and time is required at the drawing office stage in order to provide the input data. The cable data sheet is a more elaborate form of the cable schedule used previously and the equipment listing, which is an essential part of C.A.P.I.C.S., demands a logical and consistent approach.

Although the equipment list provides a C.A.P.I.C.S. input, it can also be used as basic data for a stores information system.

As with all computer systems all inputs and outputs have to be checked and updated where necessary.

After experience is gained and the techniques become more acceptable across the whole drawing office, then it is estimated that about 1000/1500 manhours of effort is required for input data for the first ship of a class.

The number of hours involved on repeat vessels is dependent upon the "identicallity"or similarity between the vessels.

At Installation Department Level

As with the drawing office C.A.P.I.C.S. will call for a change in the attitude to and the method of working. The intention being that it will provide the installation department with a new tool enabling them to carry out their primary role of supervising and planning the installation. Thus freeing the installation department from their mundane activities such as cable routeing, stores chasing, etc.

Close liaison was required, during the building of the first vessel, to monitor and assess the effectiveness of the application of C.A.P.I.C.S. to actual installation and the feedback was used to modify the techniques for next class of vessels.

Cable Stores Level

A completely new approach was developed for organization of these stores and supporting documentation. This demanded drawing office and installation department effort to develop and implement a stores procedure.

C.A.P.I.C.S. EVALUATION

The savings that result from applying C.A.P.I.C.S. are difficult to assess for it is just one cornerstone of an overall system which, in the long term, requires to be integrated. It is not possible to predict accurately the cost of a manual system that could carry out the C.A.P.I.C.S. function, with the same degree of efficiency, but a conservative estimate could be based upon the table showing time required for a manual version of C.A.P.I.C.S.

Costs

It was essential to monitor the cost of this trial of C.A.P.I.C.S. because, unless it was cost effective, a solution would be sought elsewhere.

The cost for the evaluation on the first vessel comprises:

a) drawing office time to provide input data and checking output data;
b) E.R.A. cost for computer time and engineering assistance;
c) program modifications.

Drawing Office Costs

At the beginning of the evaluation, a separate job number was raised so that drawing office time spent on C.A.P.I.C.S. could be recorded. The total spent was 1913 manhours which also includes checking output data.

As this also includes time for learning the method of compiling input data sheets it is difficult to assess how these hours would be reduced as experience is gained.

A realistic estimate would be about 1000 hours.

E.R.A. Costs

Because of the company's limited computer capacity the E.R.A. computer was used on a bureau basis and input data sheets despatched to E.R.A. for card punching and processing.

This also afforded, the reassurance that E.R.A. checked the format before inputting to the computer and carried out first line vetting of the output.

Cost for this service — £3500 (1973 prices).

Program Modifications

Three modifications were agreed and cost about £3000; they are now available to all C.A.P.I.C.S. users.

Total cost:	
Drawing office work	
1913 hours at £1·25	£2500
E.R.A.	£3500
Miscellaneous travel etc.	500
	£6500
Program modifications	£3000
	£9500

As a result of this evaluation and the type of control it brings, the company has now applied or is applying C.A.P.I.C.S. to all its future vessels. These are:

4—32 000 dwt products tankers
5—55 000 dwt products tankers
2—55 000 dwt products tankers
(different electrical system)

Savings

The cost of applying C.A.P.I.C.S. to a class of four vessels would be about £8000 and therefore it is necessary to save about £2000 to £2500 per vessel in order to cover this cost.

The major saving areas are:

Cable: Other shipyards who have extensive cable control systems accept that the cable loss is in the order of 3 per cent per vessel. Currently the authors' company does not know what its scrap and loss percentages are but it is estimated that they are greater than 10 per cent per vessel. It would be required to make a 5 per cent saving per vessel on cable cost alone to cover the cost of C.A.P.I.C.S. for a four-vessel contract.

Drawing office time saved: The company looks to C.A.P.I.C.S. to carry out a lot of repetitive work that would otherwise be carried out by the drawing office. The drawing office time recording system does not allow accurate assessment of the time spent on individual tasks. However, Verolme Elektra data has assisted in making an assessment of the manhours required to produce a C.A.P.I.C.S. type of output.

Time required for C.A.P.I.C.S.		Time required for manual version of C.A.P.I.C.S.	
Input	hours	Output	hours
1) Identifying nodes on cable route and producing input data.	200	1) Detailed cable routeing and flagging	700
2) Complete more elaborate cable schedule	400	3) Parts listing	400
3) Prepare basic equipment list	200	2) Determinable length to be cut	1050
4) Check output data	400	4) Documents in form suitable for installation dept.	400
	1200		2550

It is, therefore, considered that C.A.P.I.C.S. saves the difference in time between input and manual output, say 1000 hours, but as this is an estimate no savings on drawing office activity can be claimed.

Similarly, it is known that there is time saved at the installation level, both in planning cable routes and cutting cable but this aspect has been ignored, as the manhours saved cannot be proved.

Also there is a saving of effort at the stores level.

Finally, it has been possible to reduce the numbers of drawings issued to the installation department, which is a significant amount of time and money, not only for the actual printing, but also in the subsequent modification/updating.

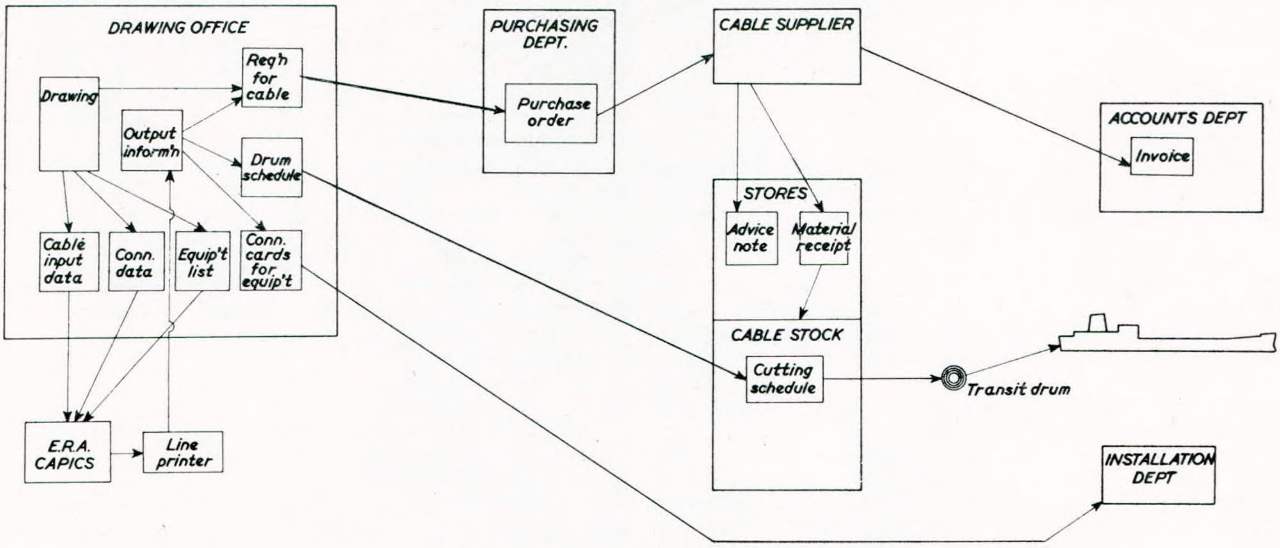


FIG. 9—*Block diagram showing functions carried out by Cammell Laird departments in cable processing and interface with E.R.A.*

EXPERIENCE OF USING C.A.P.I.C.S.

Having operated this system for a number of vessels the company can assess its strengths and weaknesses.

At the outset, a cable control system was required, starting at the drawing board and ending upon completion of the installation. C.A.P.I.C.S. has helped to create and develop a basic cable system and Fig. 9 shows the relationship of E.R.A. with the various departments involved in cable processing.

Checking Data Input

This is one of the major problems that has also been experienced with other computer systems, some of which are being developed on the company's "in house" computer. Because the user is remote for the computer, the data input is translated to punch cards and hence additional errors can be introduced. The first run through the computer often produces an error listing amounting to about 10–25 per cent of the contents of the input data. If this error listing is produced some days or weeks after the input was prepared, the draughtsman has to revert back to the drawings he previously used to create the data and this can be frustrating and time consuming.

Updating information can again result in error lists and another check against the basic drawing is required.

A variety of methods has been tried of producing input data and reducing the "turn round" time from creating input data to producing a useful computer output, but it was found that two weeks was the best that could be managed and four weeks was the norm. During the initial stages of system design, this turn around time is acceptable, but is unacceptable when modifications are required during the installation stage.

Ideally the input data should be fed directly to the computer system, by the user, and the data checked at the time of transmission.

Program Modifications

Although the software for C.A.P.I.C.S. is extensive, some of the techniques are not applicable in shipbuilding and require to be simplified or improved.

If this involves re-programming, the cost is usually prohibitive and other methods have been found of obtaining the data required from the existing suite of programs. The authors will consider the various stages of the C.A.P.I.C.S. operation and indicate current developments.

Cable Data Table

The complete range of shipbuilding cables is now held in this file and discussion has taken place with E.R.A. as to how restrictions could be placed on certain cables within this file, so that the computer will select from within the company's standard range of cables. A technique is currently being developed in conjunction with E.R.A.

Cable Routeing

The method of defining a logical system of nodes has been developed. The next stage is to try and define the length between nodes to better than the nearest metre.

Cable Accommodation

Because the cable installation techniques in land practice, especially power stations, is different from that used in shipbuilding, the methods of calculating the space occupied by the cables is also incorrect.

It has been possible to use the C.A.P.I.C.S. outputs and a simple formula to calculate the cable volume and hence cableway width.

Currently, the company is providing E.R.A. with a definition of its installation techniques and proposes using the C.A.P.I.C.S. programs to calculate cableway width and frequency of support, related to cable volume and cable weight.

Design

There are changes required in the design programs to cater for:

1) system voltage drop and fault level;
2) system discrimination;
3) system stability.

Currently the programs calculate the voltage drop for an individual feeder cable and consider this data when determining the cable size. Unfortunately, it does not print out the voltage drop value or summate the total voltage at the end point of a feeder system. Although the program contains the impedance values of the cables, it does not calculate the fault level at the various points in the system.

Similarly, although C.A.P.I.C.S. checks on the type of protection device and that the device discriminates with the cable characteristics on each feeder during the sizing routine, it does not consider discrimination between feeders.

These design program changes would also make the programs more acceptable to Lloyd's Register of Shipping and could possibly lead to an "approved" program.

In most vessels today, the size of motors for pumps has increased and there is constant pressure to use smaller generating plants. The problems of starting large auxiliaries on relatively small generating plants are well known. The C.A.P.I.C.S. system contains nearly all the parameters required to calculate system stability and even make an assessment of whether the generating plant is adequately sized.

Equipment Listing

Generally acceptable.

Connexion Data

Because of difficulties in obtaining the correct connexion information at an early stage in the contract, the company believes this is best handled outside the C.A.P.I.C.S. system.

Situation — Beginning of 1975

In parallel with the C.A.P.I.C.S. work, a "cable stock" file had been developed which was held on the in house computer and various methods were tried of up-dating this file as cable was cut for the various vessels.

Unfortunately, this computer was also to be used to develop other programs for the shipyard and difficulty was experienced in obtaining computing time.

Investigations into time sharing computer systems were put in hand and a brief survey disclosed the existence of D.M.S. MK. III, marketed by the Honeywell Computer Timesharing Company. A contract to use this facility was signed in March 1975 and after a short initial learning period the company is developing programs for cable stores; invoices, etc, which are all vital supporting activities in an overall integrated or "total" cable control system.

CAMMELL LAIRD CABLE CONTROL SYSTEM

General Description

The Cammell Laird Cable Control System (C.L.C.C.S.) makes use of the E.R.A./C.A.P.I.C.S. suite of programs and the G.E. D.M.S. package via the Honeywell Time Share Link in this country. Using the overall system concept, C.L.C.C.S. covers the ordering, delivery invoicing and stock recording and the allocation of cable to various vessels in the form of Transit Schedules. Also included in the system is cable termination information, glands, and lug requirements. Fig. 10 shows the relationship of the company's departments and E.R.A. to the D.M.S. system.

The main advantage, to the company, of the combined C.A.P.I.C.S./D.M.S. package is of flexibility and timescale. The basic cable information requires only one input and this is then used by both computer systems for data manipulation and calculation.

The output data can be tailored to meet the specific user requirement. Modifications in the format can be carried out speedily and with minimum effort on behalf of the user.

Data Management System (D.M.S.)

The General Electric (U.S.A.) Data Management System is marketed in this country by the "Time-Sharing Division" of Honeywell. The system can be accessed throughout the United States and Europe and other parts of the world. The link to Europe is by satellite, but often the user needs only call the local telephone exchange. The combined C.A.P.I.C.S./D.M.S. package being described can be applied almost anywhere in the world. Fig. 11 shows the basic communications system.

D.M.S. is a Database System and since most of the company's requirements are for manipulation of given data, it forms the basis of the C.L.C.C.S. Information is held in the computer on interrelated "Files" containing dependent "Records" having individual "Items".

The link between files is via "Key" items, Cammell Laird files, as shown in Fig. 10, hold data relating to:

i) cables ordered;
ii) cables in stock;
iii) cables delivered;
iv) cables invoiced;
v) cables allocated to various vessels in the form of Transit Schedules;
vi) termination data;
vii) equipment data.

The system can be extended to cover equipment ordering, parts listing and planning.

The files and their data are directly related to the present manual systems that are in current use within the authors' company, but as little information is required by the Database system to change the file format, they can be readily modified to suit another shipyard.

The whole aim of this system is to integrate the various activities so as to monitor and control the use of cable from the ordering stage through to the termination stage.

The data held within the database will be checked automatically, i.e., cable delivery notes will be checked against the cable order and deviations will print out for action.

Method of Input into the Database

The method of input can be varied to suit particular customers e.g. punched cards, paper tape, magnetic tape etc. The company has used punched cards for some data input, but most of the data has been prepared on punched paper tape. The input medium has been a normal teletypewriter with paper tape attachments, via a G.P.O. modem unit.

The restrictions concerned with teletypewriters are on outputs rather than inputs and, where necessary, the Hi-speed Service which Honeywell offer covers this aspect. This service provides remote production of reports or listings on full size computer stationery, or on punched cards, and can be accessed from normal terminals. The style of input for Database is free-format, but simple programs have been written to convert the fixed-format type of punched card.

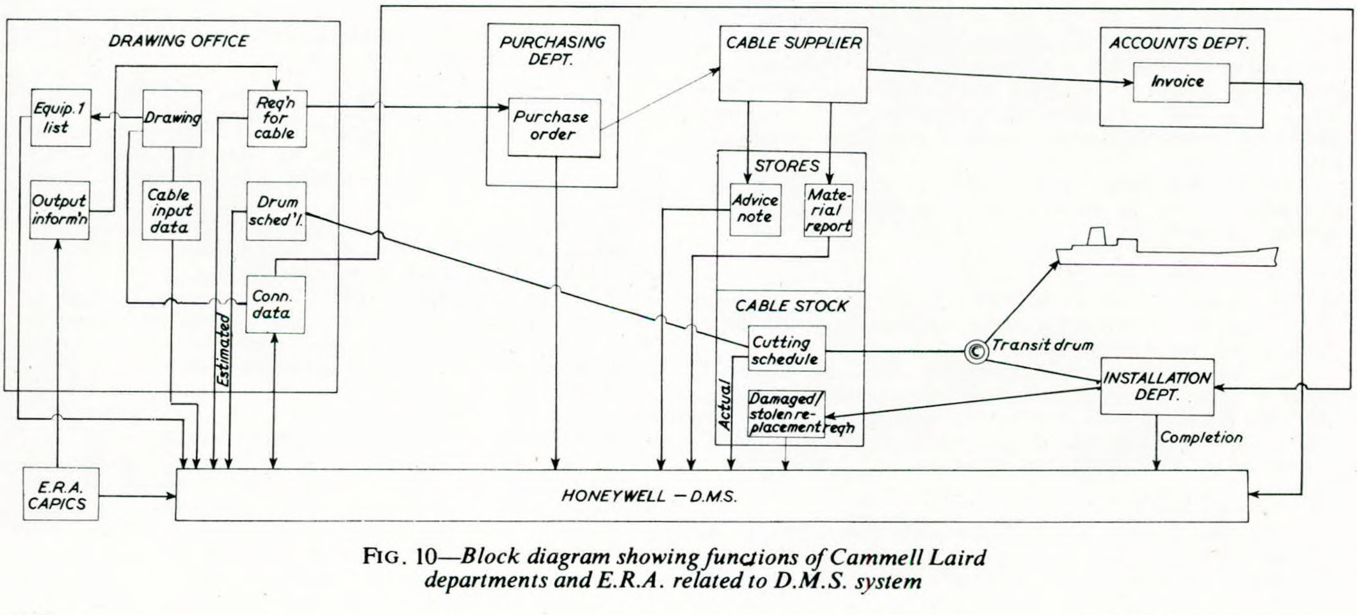


FIG. 10—*Block diagram showing functions of Cammell Laird departments and E.R.A. related to D.M.S. system*

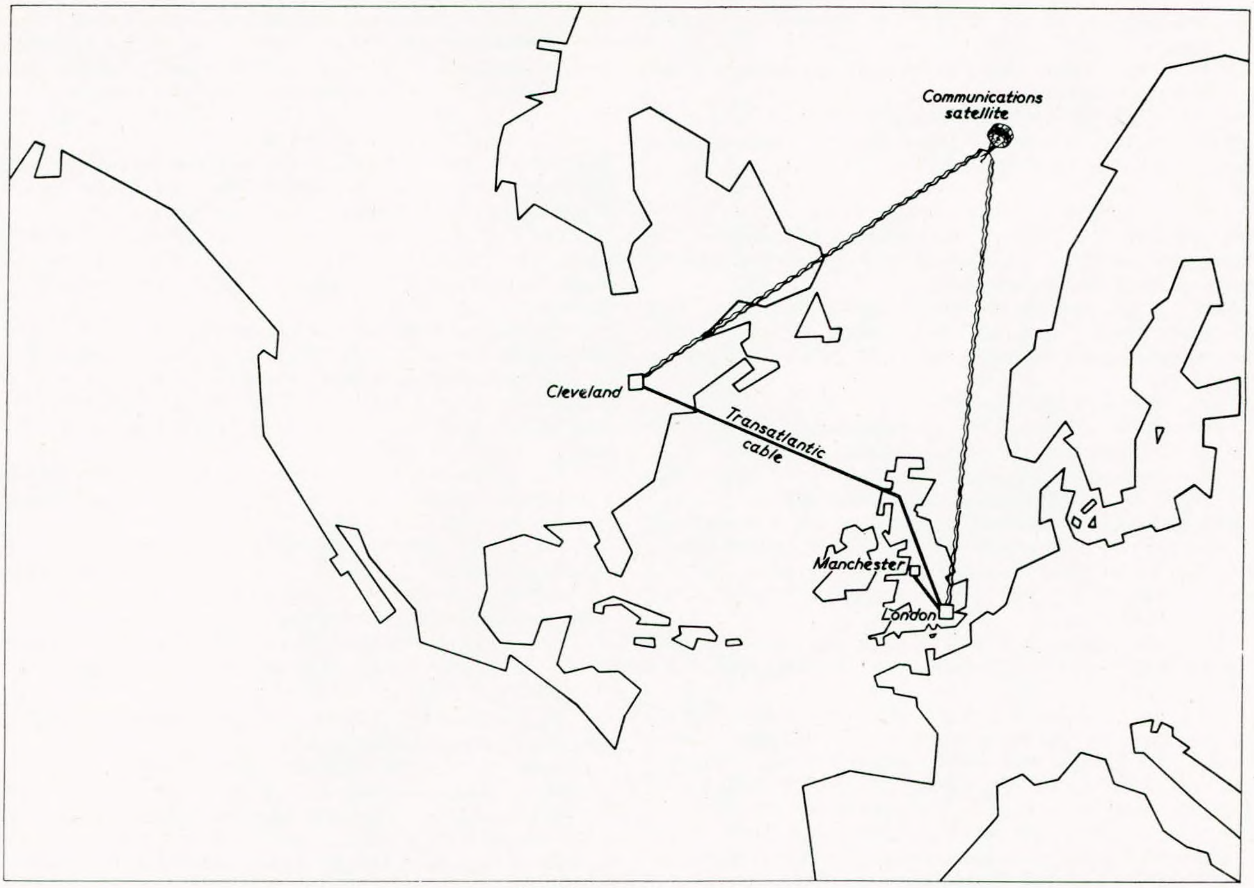


FIG. 11—*Satellite communications system*

Updating Information in the Databases

As well as the retrieval of information from the various databases, it is necessary to add new and update existing information. This is a vital aspect of database organization for, if the information is not kept in line with the changes in the physical system, conclusions based on information extracted from the databases must be treated with caution.

Maintenance of information in the various databases is achieved by using the loading end updating modules of the D.M.S. system. Using these modules, new records can be inserted, records deleted or replaced, or individual items on existing records can be changed.

Data Transfer to E.R.A.

The cable input data and equipment listing required by C.A.P.I.C.S. is also required to produce the Transit Drum Schedule. The cable input data is fed into the database as the various system drawings are completed and, when data defining a substantial number of cables is available, i.e., about 500 cables, a block data transfer to E.R.A. takes place.

The data is processed by the I.C.L. 1903 Computer, based at Leatherhead, and the various cables routed and sized as required, and the output data regarding the calculated cable length and cross-sectional area is transmitted back to the database.

In the initial stages the usual line printer output from the C.A.P.I.C.S. program would be sent to Cammell Laird and checked before E.R.A. is allowed to transmit data directly into the database.

Output Data from the Database

The prime object for setting up the database for the cable control system is to produce a Transit Drum Schedule which is a cable cutting instruction to the stores.

However, D.M.S. also allows English language enquiries to be made on to the database and some of the typical enquiries that can be made of the individual and composite databases are listed below.

Cable Purchasing

Apart from the simple listing of information contained in the databases on cables ordered, delivered and invoiced, the following questions can be asked:

1) Which items of an order have been delivered?
2) Which items of an order have not been delivered?
3) Which cables were delivered after the required date?
4) Have the cables on a particular invoice been delivered? (So that payment can be made).
5) Has an order been correctly fulfilled?
6) List all cables delivered on a particular day or delivery.

The output from the last enquiry can be used as an update document for the cable stock file.

Cable Stock

Some of the enquiries that can be made of the stock file are:

1) Total value of stock or of a particular cable at bought prices.
2) How much cable of a particular type do we have in stock?
3) Which drums contain cable less than a certain length. (So they can be deleted from stock).

Cable Cut File

Related to the cable cut file typical enquiries are:

1) Total amount of a particular size and type of cable required in a ship.
2) Produce a total cost of cable for a vessel.
3) What is the variation between planned and actual cut length?
4) How many cables were cut to compensate for the damage?

Cable Stock File

Related to the stock file:

1) Produce a list of equipment related to specific systems.
2) Produce a connexion schedule for a particular piece of equipment.
3) List all cables connected to a piece of equipment.

Using the enquiry module of the D.M.S. system, all these different reports can be produced.

BENEFITS OF THE C.L.C.C. SYSTEM

Before applying C.A.P.I.C.S., the company had reviewed its methods of producing drawings and, in particular, introduced a logical method of cable numbering.

This review led to sectionalizing all drawings into recognizable systems and then constructing a cable number system which related to the system and hence the drawing number.

The section number also related to:

a) the electrical specification for the vessel;
b) the filing system for correspondence;
c) the method of filing drawings;
d) the method of filing requisitions and orders.

The idea of sectionalized drawings has in turn enabled the production of drawings to be planned and more closely related to Installation Department requirements. It also identifies more clearly where delays occur and what is the true cause of the delay.

Thus even without applying C.A.P.I.C.S. a direct benefit was gained and a degree of control of the drawing production obtained.

Applying C.A.P.I.C.S. has provided the basis for a more disciplined approach to the control of a cable usage. This is because C.A.P.I.C.S. cable input data is of one type and irrespective of the complexity of the system each cable has to be identified with certain electrical parameters. C.A.P.I.C.S. will not exercise discretion in sizing cables and works strictly in accord with the program, assessing length, effect on voltage drop and circuit protection discrimination.

This first output showed that the company regularly oversized cable and caused it to re-examine its policy on feeder cables and basic cable routeing.

It also revealed the wide range and variety of cables being applied to a vessel and an assessment of reducing this variety can now be made. In turn this had led to the definition of a policy for a standard cables range.

The work of determining cable routes and cable groupings previously performed by certain people within the Installation Department is now an integral function of the drawing office and cables are cut to length at the store.

This saves cable, which is estimated to be in the order of £5000 per vessel (i.e. about 10 per cent).

The introduction of a database/E.R.A. link will, it is anticipated speed up the processing time of the system and allow more system configuration to be assessed during the design development stages.

The integration of the total system within a database will, it is anticipated, lead to self-checking routines and even closer control of the cabling system.

The last phase will be the merging of a planning system with the database and will complete the total system.

Finally the Honeywell Database package has complemented the C.A.P.I.C.S. suite of programs and comparatively large amounts of data can now be prepared and set up in temporary files, these file contents being vetted before the computer processes the information.

In practice this means that the average engineer, draughtsman, electrician, storekeeper, clerk, typist, can all play their direct part in the overall system, recording information primarily for their own systems and purposes, but in essence providing the database with vital information.

SUMMARY

The introduction of database systems and the accompanying software now make it possible for the "user" without programming experience to use a computer system.

The use of a time-sharing system offers further advantages for it places at the disposal of the user as much computing power as he requires and he only pays for the amount he uses.

The use of high level languages and especially D.M.S. means that the computer storage and speed of response will be "less efficient" than that attainable by a program written specifically around the subject, but the advantages of direct user participation in developing the system far outweigh the alleged "inefficiencies".

The "Cammell Laird Cable Control System" shows how a database system has been developed and linked with a calculation program run on an I.C.L. 1903 computer.

While the subject described relates specifically to an integrated system for cables, the same techniques can be applied to other areas of shipbuilding where there is a requirement to exercise "control".

The main aim of data processing, in aiding production, should be to provide the right material to the right place at the right time.

This implies that a material control system, linked to a planning system is required.

Finally, one can see that the application of database systems to data handling, within the shipbuilding industry, can introduce a "step" charge in the attitude of the industry to the use of computers as a real production aid and, in this way, keep pace with the progress made with more sophisticated software.

ACKNOWLEDGEMENTS

The authors wish to thank the directors of Cammell Laird Shipbuilders Limited, for permission to present this paper, and express appreciation of their agreement at the outset to fund and support the development.

Thanks are also due to Mr. T. Cooper, manager of the Ship Electric Department of the company who, throughout the various development stages, has given encouragement and support, having always advocated that information provided at the ship installation stages should be in the form of schedules rather than drawings. His departmental managers have also been a source of inspiration and borne the brunt of implementing the new ideas.

As always, much depended on the efforts of the drawing office, in this case in the generation of the information in the required form and, despite a natural reluctance to change, support was provided to develop the system.

While certain aspects of the C.A.P.I.C.S. programs were modified by E.R.A. in order to provide us with the specific outputs that we required, we would have liked to implement other program changes, but the cost would have been prohibitive. However, individual experts within E.R.A. were most helpful in indicating alternate means of achieving the type of output required within the existing programs.

Finally our especial thanks are accorded to Honeywell, whose attentive personal service had enabled us to develop the total system in a short time.

Discussion

Mr. J. K. Robinson, M.I.Mar.E., opened the discussion by saying that much of the background described in the paper presented a familiar picture to those engaged in shipbuilding. The contributor's company had considered using computer aids (C.A.P.I.C.S. included) in 1973, but unfortunately did not have the staff to introduce systems in parallel with traditional methods, nor had a series of similar vessels to spread the investment over and, as the E.R.A. system was designed primarily for land installations, this method was rejected and instead they concentrated on improving manual techniques. From the authors' experiences with C.A.P.I.C.S., the contributor's company concluded they made the correct decision at that time.

For the future, however, the company intended using computers as an aid to cabling complex or series ships. Computers provided a fast means of handling data and of presenting up-dated information for production control (an area where British shipbuilding had shown some weaknesses by long fitting out times), and the resulting increase in drawing office expenditure would be more than amply compensated by better stock control and improved installation efficiency.

What should the ideal program include? Obviously in the design module the fixed data should be based on marine cabling. Searching for the shortest route was seldom necessary on ships' systems: cable routeing on space allocation being more important. Classification societies and owners would naturally be interested in a facility whereby systems could be routed so that damage on a route would not hazard the vessel (one could envisage naval vessels doing this on-line for damage control). An additional useful feature might be load analysis as a check on generation and distribution equipment sizes. The authors suggested the incorporation of voltage drop summation and system discrimination, and the contributor's company would agree, as these were needed on every vessel, and would also suggest that circuit breaker and M.C.C.B. discrimination be included as well as fuses. For fault level and stability calculations, Mr. Robinson would recommend these to be very simple, in the form of a check that margins appeared adequate, as there were seldom problems. Any special cases could then be investigated in detail outside the cabling program suite.

Regarding the print out, it might be necessary to modify this from yard to yard to take account of the different restrictive practices of the work force. Were the authors looking for better methods of connexion information using computers? Would it be possible to extend the system to output "as fitted" drawings?

Mr. M. J. Bolton, F.I.Mar.E., thought the paper was excellent, and had learnt a lot from it. It seemed to him that the use of C.A.P.I.C.S. would result in a further saving which did not appear to have been mentioned. This was the elimination of the draughtsman's "fudge factor". Examination of typical ships' high power books had shown a number of circuits with cables which were a size larger than necessary. Presumably this had occurred either because with the smaller size the circuit current had approached the rated current or the voltage drop had approached that permitted and, "to be on the safe side", the draughtsman had selected the larger cable. Thus increased expenditure was incurred not only on account of the increased cable size but also because of the more substantial cable supports and the associated increase in labour.

In item ii) of the summary associated with Job 3 described in the paper, it was said that the program would calculate cable size consistent with protection. For this to be done effectively, the program would have to be used to calculate fault currents iteratively, i.e., taking account of cable size in the calculation, but later on in the paper, this was evidently not so. Obviously a factor in fault current calculation was the size of all of the associated cabling, including the cable under consideration. The subsequent increase in the size of some cables to cater for extensions to the network during the design process would increase the fault current at certain nodes and this must be covered also. At the contributor's company, standardized programs had been produced for the rapid calculation and updating of system fault currents, and the method of network reference was similar. There might be scope for running such a program in parallel with a C.A.P.I.C.S. program.

The paper stated that C.A.P.I.C.S. contained nearly all of the parameters required to calculate system stability. It was difficult to see how this could to so, as the present program did not appear to cater for machine, regulator or prime-mover governor transfer functions. Would the authors provide further information upon this?

Provided that, as at Cammell Laird, an individual shipyard management and staff showed some degree of dedication in application, C.A.P.I.C.S. evidently could be made to work. Did the authors foresee problems in its application by a leading shipyard in the construction of a class of ships in several shipyards?

The authors said that the system could be applied in a warship such as a destroyer. Did this cover all cabling throughout the ship, including weapons and communications, or just the electrical power installation? How well could the drumming of measured and cut cables be applied in such a ship where, of necessity, extensive modifications were sometimes made to the network during construction?

Considering the drumming of selected and cut cables generally, Mr. Bolton wondered if this was always economic as every cable had to be handled twice. For the more common sizes, would a cheaper alternative be to take the drums of new cable to the ship and to reel the required lengths off through a meter on the spot? This practice appeared to work in one European shipyard.

Would the authors please comment on the possible application of computer routeing to piping and trunking?

In winding up their presentation, the authors asked if ship-owners could see advantages in the application of C.A.P.I.C.S. In one respect the answer appeared to be a firm yes. Shipowners were normally provided with plans of simplified main cable routes which sometimes showed risers and down drops but rarely identified the cables themselves.

When the system network had to be modified or extended, the shipowner had, to some degree, to guess the actual route taken by a particular cable and to estimate which runs had space in them for more cable. With ships returning to the UK this was relatively easy: a check could be made, but for those which returned only for refit or had turn round times of only a few hours, reliance had to be placed on estimates. These estimates were sometimes very wrong, the modification work was more extensive than at first thought and plant had to be shutdown for access, all of which led to delay in completion. C.A.P.I.C.S. information would certainly improve work planning in some cases.

Mr. F. E. Hutchins, F.I.Mar.E., said that this was an excellent paper, and most useful at this time when the electrical capacity of shipyards was a particularly governing factor in the ability to build ships. From his experience at Devenport Dockyard, the contributor supported this. In fact the diagrams shown at the meeting emanated from MoD in 1966, for recabling both a major aircraft carrier and in building a new construction frigate. Many of these features were possible and desirable for warships as well as other ships. The Ministry had a standard drawing system with cable numbering, and a cable issuing system very similar in appearance to that shown. They did not use a computer to plan the routes. It was done by hand, but the numbering and lengths of cables were taken off for ordering purposes in planning the drawings at an early stage.

Cables cut to lengths were issued on drums related to routes or compartments, and there were negotiations with the trade unions for standard times for running cables: certain drums carried a number of predetermined cables, and the work force was given so many hours in which to do this work. This was helpful in planning the amount of labour required on the ship with minimum of congestion. Performance was monitored, with related planning for compartment completions which gave good yardsticks with which to measure the overall general program for the ship, utilizing the dockyard's own computer.

Mr. Hutchins was not sure that using a computer was completely possible for cable route planning for warships, because there were so many problems to deal with in connexion with action damage, routeing cables from the point of view of separating them for electrical interference general congestion in routes and so on. Many of the problems seemed to be more difficult. Flexibility also had to be built in, as weapon systems were often still very much under development when ships were well into their building stage. But this direction should be looked into, coupled with meaningful monitoring of working time, labour loading etc, which would be in the best interests of this business.

Mr. Howlett noted in the paper that the authors said that in the early stages they had to safeguard against the chance that if the program could not be met, or the output information produced, they could always revert to the drawings which were being prepared. This was what was done in the first of the class. Had they now sufficient confidence not to do this parallel manual working with a new class of ship?

Secondly, the authors had made much of cables being cut to length. The contributor would have thought that this had been standard practice in shipyards for a number of years. To quote it as a claimed advantage for this particular system was going a bit far, particularly as the basic data for this was prepared by the draughtsman from a drawing, fed into a database, and the sums done on a computer when the draughtsman could have done it equally well with a simple pocket calculator. So the contributor stated it was not such an advantage for the computer system as the authors would appear to claim.

Mr. J. A. Wilson, F.I.Mar.E., said he thanked the authors for their excellent paper. Mr. McIver had told him of C.A.P.I.C.S. and the contributor's company was pleased to have a visit from E.R.A. some time ago when they were tempted to adopt the system for a very large warship which they were building. However, they had decided it would be prudent to get initial experience on a smaller surface ship, and they might well have this opportunity with a new design which they had in hand.

One of the main interests of the contributor's company was the building of submarines, and they had, of course, given consideration to cable management and routeing but present needs were being met by C.O.D.E.M. (Computerized Drawings Fron Engineering Models) equipment, which was based on the L.U.R.G.I. system for producing information and drawings from scale models. In submarine work, there was benefit from the requirement that a full ship, 1/5 scale models of designs down to very fine detail must be made, for then cable routeing information could be satisfactorily handled.

The system employed two telescopes which could traverse vertically and horizontally in two planes and were linked to a computer to trace and pick-off piping and cable runs. The data could then be used to produce production information and drawings by means of a plotter linked to the computer.

Mr. J. E. Chadbund congratulated the authors on their paper having qualities of honesty in describing the difficulties which they met. If it was considered that C.A.P.I.C.S. was originally intended for cable installations in power stations, Mr. Chadbund wondered how much time and effort were needed to adapt it to a ship's installation, where often there was ventilation trunking and pipes following the same routes.

Shipbuilders needed two things. The first was a very rapid assessment of the cable needed, at the earliest possible stage, because the delivery was at least six months, and general arrangement drawings were unlikely to be completed.

Secondly, there was a need for automatic routeing, not only of cables but also pipes and ventilation trunking. C.A.P.I.C.S. seemed to fall in between these two requirements.

Also there was the question of the electromagnetic compatibility of the control cables. Presumably this had to be programmed manually into the data base, as it did not occur in power stations.

There was no assessment of the benefits obtained by Cammell Laird from C.A.P.I.C.S.: as the re-organization of the electrical drawing office, the drawing numbering system, and the stock-keeping system, plus the cutting up of cables to length in the stores, could have been carried out without the application of C.A.P.I.C.S.

Mr. E. Levings, said the presented paper illustrated the considerable effort and time involved in learning and successfully adapting only partly related computer programs to suit the particular requirements of the shipbuilding industry.

The construction of oil and gas platforms for the North Sea had many similarities to the shipbuilding activities described. These platforms were truly complex and the large ones having concentrated, high fault level distribution systems with typically 20 to 75 MW of generation power. It was obviously extremely important to ensure that the power system including generation, distribution switchgear and cabling was correctly designed and rated to provide an adequate, secure and safe system, while utilizing limited space effectively.

Proven expertise and techniques which rigorously treated the overall accuracy and excellence of design ultimately saving time and money by reducing to a minimum those modifications invariably found necessary during installation and finally commissioning offshore, were valuable and very necessary commodities.

As with the computer aided cabling programs, programs for studying power systems were available from various sources. However, these programs tended to cater for large land based utilities type systems with the virtually infinite busbar concept. Ship and offshore power systems, despite their sometimes large power rating, were small, isolated systems. They were characterized by disproportionately large induction motor loads which seriously affected the dynamic response and contributed significantly to fault level.

A power system study had been carried out on his company's Hutton Platform by A.C.S./E.R.A. The original computer program was designed for large systems, and produced unrealistic dynamic response results for the Hutton system. A satisfactory theoretical result was eventually produced only after the program was remodelled to take detailed account of governor, excitation and rotating mass parameters.

Unfortunately it was not yet possible to determine how accurate the theoretical predictions of performance for the Hutton project was, but no doubt there were other operators in the North Sea who could or would soon be able to verify the accuracy of this type of study. However, there was no doubt about the value of this type of study which predicted load flows fault levels, voltage and frequency response by helping the designers to achieve an optimum match between components on small systems.

The possibility of successfully adapting and extending computer aided techniques into the field of cable system design, materials and installation control for offshore platforms, which could probably be considered closely akin to the shipbuilding industry was very interesting and deserved further study.

Mr. G. E. Woodliff, F.I.Mar.E., said the paper emphasized that a systematic approach to a problem could produce a useful answer without necessarily using a computer.

The actual saving in cable could be attributed to this approach but it would appear a further saving could be effected if the cable lengths could be written into the program more precisely. He understood that the "start and finish" nodes were only defined to an accuracy of 1 m and since a ship was a high cable density type of installation, the use of cable lengths to this accuracy of definition must be wasteful. A change to the C.A.P.I.C.S. program enabling the cable lengths to be defined to greater accuracy would be useful.

With many custom built items such as consoles, a manufacturer probably had considerable freedom in positioning terminal boards etc. Could the authors please indicate whether they had considered any optimization in this respect which would effect a useful saving in cabling and installation costs.

Mr. P. T. R. Brown, in his written contribution, said he congratulated E.R.A. and their various members for pioneering C.A.P.I.C.S., and the authors for really making it work in the shipbuilding environment.

The transition to the more interactive version was particularly welcome: he was sure that the new approach not only very significantly enhanced the package but also would show the way towards future extensions and application of similar techniques to other areas of design activity. He felt one could not over-emphasize the importance of interaction as the principal key to successful design mechanization. The fact that C.A.P.I.C.S. had proved economic despite its original card-fed basis said a lot for its inherent capabilities: in its interactive form it could only go from strength to strength.

Mr. Priborski in an earlier presentation touched on possible future roles for graphic data capture systems. The comments of those who regretted the passing of the 1/5 scale model evidently confirmed that there was still a visualization problem. On this front Mr. Brown was sure that there was scope for linking output from ship-structure design programs such as those provided by B.S.R.A. to the input end of C.A.P.I.C.S., via an interactive graphics visualization and manipulation process in which tentative cable runs would be superimposed on a basic display derived from full-form co-ordinates, adjusted by the designer, and finally accepted as C.A.P.I.C.S. input geometry.

Mr. Brown was sure, therefore, that in addition to promoting exchanges of techniques between rival shipbuilding interests, this presentation would have served a further useful purpose in highlighting ways in which complementary activities of separate research organizations could usefully be made to converge onto future extensions of the work described.

Mr. J. E. Perry, wrote that it was encouraging to read of the successful application of the C.A.P.I.C.S. suite of programs. His company had provided specifications of their operational A.C.E. and C.O.P.P.I.C.E. computer cabling systems programs currently being used for the Hartlepool and Heysham nuclear power stations, while under its former title, Mr. Perry's company gave considerable assistance to E.R.A. when the system specification for C.A.P.I.C.S. were being developed.

From experience with A.C.E. and C.O.P.P.I.C.E. cabling programs, the contributor's company would emphasize the need to thoroughly educate staff on the aims, use and operations of the system before it was used on a contract.

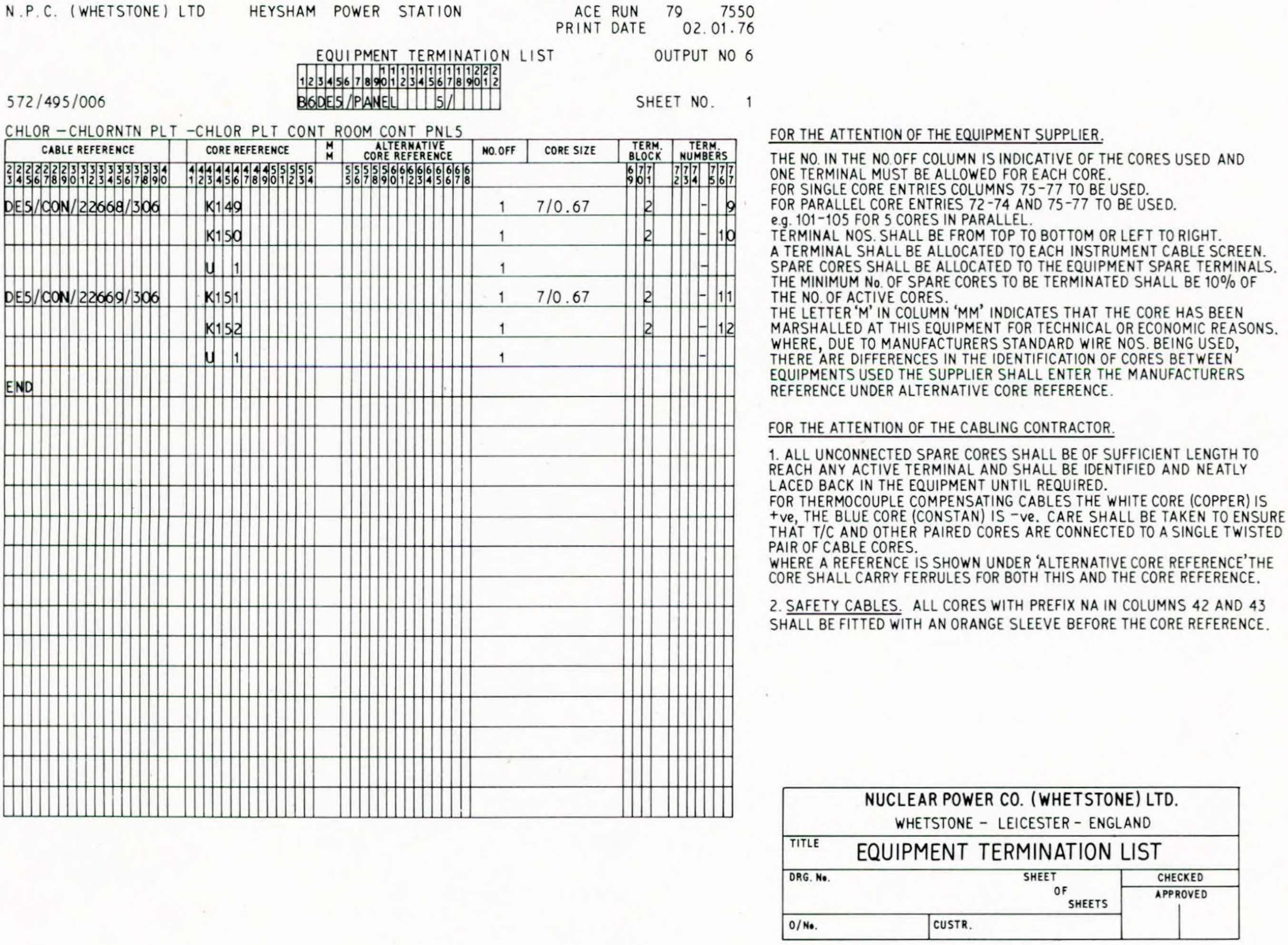
The application of C.A.P.I.C.S. would mean many changes to existing practices and staff having to learn new ideas and techniques, all of which would engender some opposition. Mr. Perry would emphasize the comments of the authors, that these must be taken into consideration.

His company was interested to read of the system for pre-cutting cables and drumming cut cables ready for installation on a common route or for installation in a common area. This was a system which did not seem to have been applied to power station cable installations but would seem to be an attractive proposition for all industrial installations where large numbers of cables were involved.

For expensive cables, e.g. H.V. power cables, were the derived cable lengths used or were the actual physical routes measured before the cables were cut?

Did the application of C.A.P.I.C.S. so far, encourage Cammell Laird to consider the system for future contracts? Would the authors please comment.

The contributor's company had used computer produced equipment termination lists (E.T.L.) for the termination of cables on the Hartlepool and Heysham contracts (Figs. 12



N.P.C. (WHETSTONE) LTD   HEYSHAM POWER STATION   ACE RUN 79 7550
PRINT DATE 02.01.76

EQUIPMENT TERMINATION LIST   OUTPUT NO 6

572/495/006   B6DES/PANEL 5/   SHEET NO. 1

CHLOR –CHLORNTN PLT –CHLOR PLT CONT ROOM CONT PNL5

CABLE REFERENCE	CORE REFERENCE	MM	ALTERNATIVE CORE REFERENCE	NO.OFF	CORE SIZE	TERM. BLOCK	TERM. NUMBERS
23–40	41–54		55–68			69–71	72–74 75–77
DE5/CON/22668/306	K149			1	7/0.67	2	- 9
	K150			1		2	- 10
	U 1			1			-
DE5/CON/22669/306	K151			1	7/0.67	2	- 11
	K152			1		2	- 12
	U 1			1			-
END							

FOR THE ATTENTION OF THE EQUIPMENT SUPPLIER.

THE NO. IN THE NO.OFF COLUMN IS INDICATIVE OF THE CORES USED AND ONE TERMINAL MUST BE ALLOWED FOR EACH CORE.
FOR SINGLE CORE ENTRIES COLUMNS 75–77 TO BE USED.
FOR PARALLEL CORE ENTRIES 72–74 AND 75–77 TO BE USED.
e.g. 101–105 FOR 5 CORES IN PARALLEL.
TERMINAL NOS. SHALL BE FROM TOP TO BOTTOM OR LEFT TO RIGHT.
A TERMINAL SHALL BE ALLOCATED TO EACH INSTRUMENT CABLE SCREEN.
SPARE CORES SHALL BE ALLOCATED TO THE EQUIPMENT SPARE TERMINALS.
THE MINIMUM No. OF SPARE CORES TO BE TERMINATED SHALL BE 10% OF THE NO. OF ACTIVE CORES.
THE LETTER 'M' IN COLUMN 'MM' INDICATES THAT THE CORE HAS BEEN MARSHALLED AT THIS EQUIPMENT FOR TECHNICAL OR ECONOMIC REASONS.
WHERE, DUE TO MANUFACTURERS STANDARD WIRE NOS. BEING USED, THERE ARE DIFFERENCES IN THE IDENTIFICATION OF CORES BETWEEN EQUIPMENTS USED THE SUPPLIER SHALL ENTER THE MANUFACTURERS REFERENCE UNDER ALTERNATIVE CORE REFERENCE.

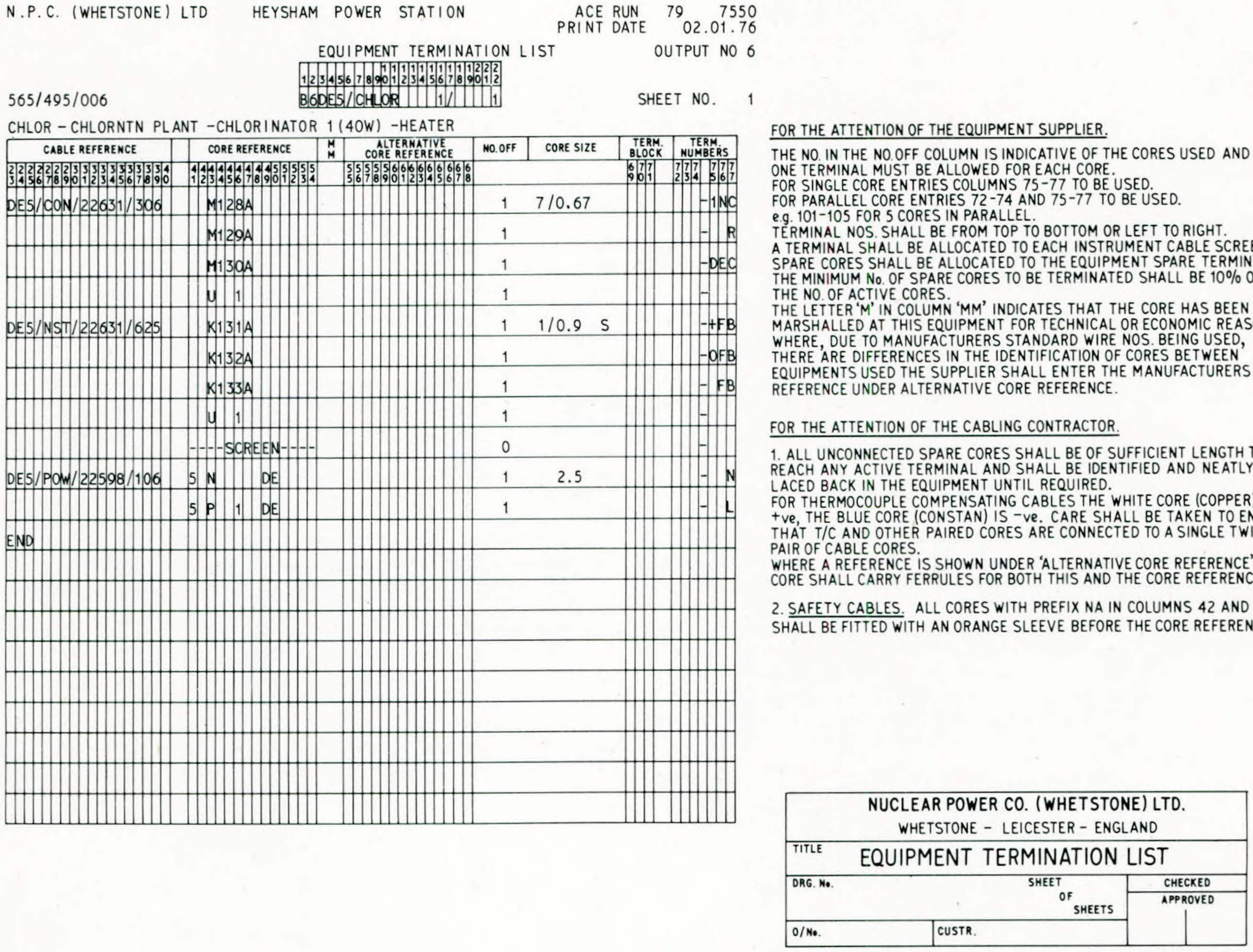
FOR THE ATTENTION OF THE CABLING CONTRACTOR.

1. ALL UNCONNECTED SPARE CORES SHALL BE OF SUFFICIENT LENGTH TO REACH ANY ACTIVE TERMINAL AND SHALL BE IDENTIFIED AND NEATLY LACED BACK IN THE EQUIPMENT UNTIL REQUIRED.
FOR THERMOCOUPLE COMPENSATING CABLES THE WHITE CORE (COPPER) IS +ve, THE BLUE CORE (CONSTAN) IS –ve. CARE SHALL BE TAKEN TO ENSURE THAT T/C AND OTHER PAIRED CORES ARE CONNECTED TO A SINGLE TWISTED PAIR OF CABLE CORES.
WHERE A REFERENCE IS SHOWN UNDER 'ALTERNATIVE CORE REFERENCE' THE CORE SHALL CARRY FERRULES FOR BOTH THIS AND THE CORE REFERENCE.

2. SAFETY CABLES. ALL CORES WITH PREFIX NA IN COLUMNS 42 AND 43 SHALL BE FITTED WITH AN ORANGE SLEEVE BEFORE THE CORE REFERENCE.

NUCLEAR POWER CO. (WHETSTONE) LTD.
WHETSTONE – LEICESTER – ENGLAND
TITLE EQUIPMENT TERMINATION LIST
DRG. No.   SHEET OF SHEETS   CHECKED   APPROVED
O/No.   CUSTR.

Fig. 12



N.P.C. (WHETSTONE) LTD   HEYSHAM POWER STATION   ACE RUN 79 7550
PRINT DATE 02.01.76

EQUIPMENT TERMINATION LIST   OUTPUT NO 6

565/495/006   B6DE5/CHLOR 1/ 1   SHEET NO. 1

CHLOR - CHLORNTN PLANT -CHLORINATOR 1(40W) -HEATER

CABLE REFERENCE	CORE REFERENCE	MM	ALTERNATIVE CORE REFERENCE	NO.OFF	CORE SIZE	TERM. BLOCK	TERM. NUMBERS
23–40	41–54		55–68			69–71	72–74 75–77
DE5/CON/22631/306	M128A			1	7/0.67		-1NC
	M129A			1			- R
	M130A			1			-DEC
	U 1			1			-
DE5/NST/22631/625	K131A			1	1/0.9 S		-+FB
	K132A			1			-OFB
	K133A			1			- FB
	U 1			1			-
	----SCREEN----			0			-
DE5/POW/22598/106	5 N DE			1	2.5		- N
	5 P 1 DE			1			- L
END							

FOR THE ATTENTION OF THE EQUIPMENT SUPPLIER.

THE NO. IN THE NO.OFF COLUMN IS INDICATIVE OF THE CORES USED AND ONE TERMINAL MUST BE ALLOWED FOR EACH CORE.
FOR SINGLE CORE ENTRIES COLUMNS 75-77 TO BE USED.
FOR PARALLEL CORE ENTRIES 72-74 AND 75-77 TO BE USED.
e.g. 101-105 FOR 5 CORES IN PARALLEL.
TERMINAL NOS. SHALL BE FROM TOP TO BOTTOM OR LEFT TO RIGHT.
A TERMINAL SHALL BE ALLOCATED TO EACH INSTRUMENT CABLE SCREEN.
SPARE CORES SHALL BE ALLOCATED TO THE EQUIPMENT SPARE TERMINALS.
THE MINIMUM No. OF SPARE CORES TO BE TERMINATED SHALL BE 10% OF THE NO. OF ACTIVE CORES.
THE LETTER 'M' IN COLUMN 'MM' INDICATES THAT THE CORE HAS BEEN MARSHALLED AT THIS EQUIPMENT FOR TECHNICAL OR ECONOMIC REASONS.
WHERE, DUE TO MANUFACTURERS STANDARD WIRE NOS. BEING USED, THERE ARE DIFFERENCES IN THE IDENTIFICATION OF CORES BETWEEN EQUIPMENTS USED THE SUPPLIER SHALL ENTER THE MANUFACTURERS REFERENCE UNDER ALTERNATIVE CORE REFERENCE.

FOR THE ATTENTION OF THE CABLING CONTRACTOR.

1. ALL UNCONNECTED SPARE CORES SHALL BE OF SUFFICIENT LENGTH TO REACH ANY ACTIVE TERMINAL AND SHALL BE IDENTIFIED AND NEATLY LACED BACK IN THE EQUIPMENT UNTIL REQUIRED.
FOR THERMOCOUPLE COMPENSATING CABLES THE WHITE CORE (COPPER) IS +ve, THE BLUE CORE (CONSTAN) IS -ve. CARE SHALL BE TAKEN TO ENSURE THAT T/C AND OTHER PAIRED CORES ARE CONNECTED TO A SINGLE TWISTED PAIR OF CABLE CORES.
WHERE A REFERENCE IS SHOWN UNDER 'ALTERNATIVE CORE REFERENCE' THE CORE SHALL CARRY FERRULES FOR BOTH THIS AND THE CORE REFERENCE.

2. SAFETY CABLES. ALL CORES WITH PREFIX NA IN COLUMNS 42 AND 43 SHALL BE FITTED WITH AN ORANGE SLEEVE BEFORE THE CORE REFERENCE.

NUCLEAR POWER CO. (WHETSTONE) LTD.
WHETSTONE - LEICESTER - ENGLAND
TITLE EQUIPMENT TERMINATION LIST
DRG. No.   SHEET OF SHEETS   CHECKED   APPROVED
O/No.   CUSTR.

FIG. 13

and 13). With the A.C.E. cabling programs, the core identification ferrule references were stored and printed out for each equipment in cable number — core number order.

These core lists for each equipment were issued to the equipment manufacturer for him to enter the terminal block data for each core. This document, completed by the manufacturer, was used as an input document to the A.C.E. program. Stored within the A.C.E. program was the terminal data for each core ready to be printed as a core running list for site when required.

The completed E.T.L. was issued as termination information to the cabling contractor who now had to handle one standard format only.

This cable core list was additionally of use to the equipment manufacturer. It provided the number and identity of cables to be terminated, plus the size and number of cores to be accommodated. This information would be used by the equipment manufacturer to determine the number and location of gland plates when allocating terminal blocks, particularly when parallel cores and cable to cable connexions had be accommodated.

It was also necessary to inform the equipment manufacturer of the size and type of large power cables terminating at his equipment. All of this information was on the E.T.L.

The authors stated that core terminal data could not be obtained in time, or if obtained, would be incorrect, and some other means than a computer produced core and connexion list was used. But this data must be made available in some form to meet completion dates. It might be possible to dictate to the equipment manufacturer, before manufacture commenced, how the core terminal for external cores were to be identified.

It was noted that the identity of cores contained in each system cable was not included in the information prepared in Job 3. It had been found that by recording this information in A.C.E., as soon as basic system information was available, and used as described above, it was possible to overcome most of the difficulties mentioned under the heading "Connexion Information".

One of the problems in cable design was to know at any stage whether the cabling incorporated a particular modification. With the A.C.E. cabling program the core data for each cable was stored and an output existed listing the cores in each cable and the design parameters.

A similar facility existed in C.A.P.I.C.S. The cores used to size a particular cable could be listed on the cable input sheet and the data stored, and printed out as a core running list.

It was not clear if this facility had been used, or even if core identification ferrules were used. Would the authors please comment on the method used to determine if a particular modification to a circuit diagram had been incorporated into the cabling, and whether cable cores were identified.

It would be interesting to know how many late modifications were incorporated into the system and what inconvenience this caused. When assessing computer systems for cabling, one criterion should be the ability of that system to accommodate late modifications satisfactorily.

It was not clear how much, if any, of the planning and progressing module of C.A.P.I.C.S. had been used. Once the cable file and equipment file had been constructed the base for planning was established.

The "plan" module required the delivery, erection, and setting to work dates for equipment to be entered. With these dates fixed the program could list for each equipment connexion the limits within which the cable must be laid, terminated and tested.

Once the use of a computer had been accepted in the management of large cabling installations its application in the "planning mode" should, it was suggested, be considered.

On past contracts, difficulties had arisen when individual engineers have selected different cable make-ups and types for use in similar situations, with the result that more cable types have been specified than were strictly necessary.

To overcome this, the A.C.E. program selected from a predetermined range a suitable type of cable based on its voltage, function and environment. As B.S. 6883 covered a range of cable make-ups and types, could the authors explain how they ensured that the correct cable was selected.

Authors' Reply

In response to Mr. J. K. Robinson, the authors said that their company did not have an over-capacity of staff at the time of testing C.A.P.I.C.S., but had the opportunity of applying some new ideas to the third ship of the class. As pointed out in the paper, the third vessel was not electrically a repeat of the previous vessels and very little manpower was available for the conventional drawing work on this vessel, let alone for operating with E.R.A. in applying C.A.P.I.C.S. for the first time to a marine installation. But mainly because of co-operation received from the production departments, who were actively involved at the outset, it was possible to use the available effort in the best way.

In the summary section of the paper, it was stressed that the manual drawing system had been improved over three classes of vessels (i.e., eight ships), and it was agreed with Mr. Robinson, that this area should be tackled first and could yield good results for little expenditure. Mr. Robinson's rhetorical question of what should the program include was discussed in the paper in the section entitled "Experience of Using C.A.P.I.C.S." However, the authors did not think that there should be one all-embracing computer program, but, rather a series of sub-routines which could be linked together to provide the total system and that each sub-routine should be capable of being operated as separate free standing program.

For example, they agreed with Mr. Robinson that for some ships, fault level calculations were not complex or extensive and therefore the sub-routine, which dealt with this aspect, should be capable of being by-passed. Referring to the shortest cable route selection routine carried out by C.A.P.I.C.S., it was agreed that this was not strictly necessary on a marine installation. However, it was the selection parameter currently available within the standard program. The major benefit of C.A.P.I.C.S. was the allocation of cables to a specific cableway and the space required to accommodate the cables — this was possible because the cables had their route selected.

Regarding the format of print out, the point raised was valid and for this reason methods had been looked into by which selected outputs from C.A.P.I.C.S. could be used to provide an input into the Honeywell MK. III system which then allowed the ultimate user to define the format of the output he required. This could overcome the problems of accepting the rigid output format produced by C.A.P.I.C.S.

The whole aspect of connexion data, its presentation and accuracy, together with electrical system schematics (not wiring installation drawings produced in block diagram form) had been considered. The authors had attempted to use C.A.P.I.C.S. but they did not think that this was the answer, and believed that the connexion data, related to a cable number, could be handled better by a separate system.

Mr. M. J. Bolton raised the very basic aspect of the draughtsman "fudge factor" in assessing cable sizes. Voltage drop was often used by draughtsmen as a common excuse for increasing the size of the cables over and above the size which was adequately rated for the duty. This was one of the variables that could be eliminated by using C.A.P.I.C.S. to determine the cable size, for in determining the cable size the parameters of current loading, voltage drop, protection and discrimination, were utilized by the program.

C.A.P.I.C.S. program, automatically checking the cable, could withstand this "let through" energy of the circuit protection device. Please note that this was the rated value, not necessarily the actual value and therefore the result erred on the safe side.

If another program was available which could produce a more refined fault current calculation and hence an optimum cable size routine, then this might be worthwhile adding to the overall C.A.P.I.C.S. type of package for marine installation.

Regarding system stability, the existing program contained nearly all the information required, defining the electrical characteristics of the cabling, etc. The mechanical aspects of the generating system, i.e. prime mover governor characteristics, etc, had been considered by A.C.S./E.R.A. (See Mr. E. Levings contribution) for oil rig application and it might be worthwhile assessing and adapting aspects of these programs to ship installations.

At the authors' company, C.A.P.I.C.S. had been applied not at the design stage but more as an aid at the drawing office and production stages, and as such produced information regarding cable size, route, and length. This was considered as basic production information and acceptable to production departments in other yards and could be used by fellow yards if necessary.

The presentation of this cabling as information would not be on computer line printer output, but on preprinted stationery.

Although the company had applied C.A.P.I.C.S. to merchant vessels, there were larger gains or advantages to be made from applying it to a destroyer or any vessel which contained a large amount of cabling as this provided more scope to save money. The only systems not considered by C.A.P.I.C.S. on current contract were:

a) lighting cables from lighting distribution boxes to fittings:
b) fire detector cabling which usually looped from fitting to fitting:
c) co-axial cables for commercial aerials which were looped from cabin to cabin.

All other circuits including control, navigation aids, communications, power and low voltage and intrinsically safe circuits were entered into C.A.P.I.C.S. The authors did not see any differences in these circuits compared with those used in a destroyer or warship.

The advantage that the total system offered, i.e. Honeywell time sharing system linked to C.A.P.I.C.S., was that it could provide a method of quickly setting up and modifying system input data and assessing the results quickly. The implication of changing systems and the consequential effect on cable space required on cableways, through water tight glands, etc, could be made available far faster than by normal manual methods.

It was true that the cables were physically handled twice, but the production advantages that the transit drum system offered outweighed the disadvantages. Lighting cables, and cables for some other circuits whose data was not provided to C.A.P.I.C.S. were sent to the ship on non-returnable reels and used as required.

The major disadvantage with the method described by Mr. Bolton, i.e. sending drums of cable down to the ship, was that the cable usage varied considerably and it was impossible to control. Also the facilities in the stores were usually better than the quay wall or ship for measuring and re-coiling cables.

The authors did not believe that C.A.P.I.C.S. was suitable for vent trunking or pipe routeing, just as they did not believe that computer routeing piping packages were capable of being applied to cables without modifications, etc. The main basic differences were that piping and vent trunking required a three dimensional system of an "acceptable" order of accuracy while the position of an individual cable did not need to be geometrically determined. Similarly there was more scope in changing the cross-section of cable banks to suit the available space without detailed consideration of how changing cross-sectional area would affect system parameters and performance — which was a pipe and vent problem.

The authors said it was interesting to hear from Mr. F. E. Hutchins of MoD(N) experience, and to see that their manual drawing system had developed broadly along the lines that the authors' company had subsequently undertaken — i.e. drawings standardized and a cable number system established.

For many years the number and length of cables were obtained by scaling from the drawings and this formed the basis of an estimate. While this information formed the basis of cable demand schedule it required considerable effort before it could be used to cut cable in the stores to length. The latter function was carried out by C.A.P.I.C.S. and checked by the drawing office.

On current naval contracts, cable schedules were used by the production departments to define cable size and types, but the tradesman or supervisor determined by measurement at the vessel the cable length required. But this was one man's assessment and it was difficult to check the accuracy of the length actually required.

The idea of negotiation with the union for standard times for cable running, etc, and the subsequent planning and monitoring was something the authors would like to arrive at but was not possible with the present industrial climate.

Regarding the merits of computer cable routeing as opposed to manual methods, the advantage was the computer offered a possibility of assessing quickly the implication of system modifications.

One of the standard features available was that defined cables could be allocated a special code which meant that these cables were kept together and physically spaced away from all other cables.

It was standard land practice that remote monitoring or intrinsically safe cables were installed some distance away from power cables, and this facility had been used for ship cables.

In response to Mr. Howlett, the authors said it was foolhardy in testing or applying a new system not to have a fall back position and on the first ship the authors could have resorted to sending complete cable drums down to the vessel and allow the tradesman to cut the cables as required to install a system.

As a result of using C.A.P.I.C.S. on this first ship, it was now yard practice to cut nearly all cables in the stores (lighting and other cables excluded), to measurement derived by C.A.P.I.C.S. in the case of merchant vessels and by tradesmen in the case of the destroyer.

It was not common practice in the authors' shipyard and they suspected in most other shipyards, to cut cable in stores to length predetermined by a drawing office from drawings. The practice in some yards was that the tradesman, on board the vessel, measured the cable required for a specific system and either issued an order for the cables length(s) to be supplied or cut the cable from cable drums at the ship.

It would appear that Mr. Howlett had missed a very basic point — that the cableways on most vessels were modified and changed during the design development of the vessel. What was required was a method by which all cables passing along a cableway which had been modified would *automatically* have their lengths or route modified to suit the amendment. Also that the total cable requirements would be adjusted and potential shortage identified.

Obviously these jobs could be done manually but at a cost both in effort and time. This latter aspect was the more important, for on a recent naval contract cableway information lagged by about six months behind system or cableway changes. This was mainly because the changes were occurring during the building of the lead vessel and there were considerable difficulties in assessing manually the best solution, which would take into account glands through bulkheads and space available within existing cableways.

The authors could appreciate Mr. J. A. Wilson's reluctance to try a system like C.A.P.I.C.S. on a large warship and would agree that it was often best to carry out a pilot scheme on a smaller project. There was one other alternative and that was to apply it to one system only on the large warships and in this way gain operational experience.

The use of the C.O.D.E.M. system for cable routeing was interesting and if this was linked to C.A.P.I.C.S. then it would appear to simplify the cable route input data. (Job 2). The authors could only assume that the dimensions of the cableways on the 1/5 scale model were estimated initially and that all re-routeing and consequent changes in space requirements were determined by manual methods.

The authors agreed with Mr. G. E. Woodliff that the systematic approach to the problem did improve the manual system without use of a computer, but cable savings did not occur until C.A.P.I.C.S. was applied to the routeing of cables.

Mr. Woodliff was correct in his statement that cableway nodes could only be defined to the nearest 1 m, and that further cable savings were possible by increasing the accuracy of definition. Methods of improving the length accuracy had been discussed with E.R.A. and the cost of the program modification calculated. But this program change was only one aspect of many program changes that were needed to refine C.A.P.I.C.S.

Regarding the layout of terminal bars, etc, within consoles, the major saving that could occur was in installation time and not necessarily in cabling.

One of the biggest problems in cabling consoles was that external circuits were usually cabled in multicore cable and often a considerable length of cable had to be stripped within the console in order that the various cores could be wired to the appropriate connexion points which might occur at different areas of the termination chamber.

The other concerned accessibility to the terminal bars which was usually accomplished by lying or kneeling down, whereas a termination chamber, or a number of chambers built to the full height of the console would make accessibility for terminating and checking ship's wiring considerably easier and result in saving installation time but not necessarily cabling.

Cable cost savings could result from the use of appropriately rated control cabling, i.e. where the electrical requirements defined cable conductor size and that the cable was adequately sheathed to provide mechanical strength, required during "pulling in".

In response to Mr. J. E. Chadbund's contribution, the authors replied that although C.A.P.I.C.S. originated for land based industry it required no specific modifications before it could be applied to a marine application. The authors found that the power station applications were more sophisticated than that of a vessel, and necessitated that E.R.A. redefined some of the instructions so making the computer accept a reduced amount of data.

Mr. Chadbund raised again the relationship of cable pipe and vent routeing, and the authors could only repeat that they found C.A.P.I.C.S. route data input adequate for cabling system, but that it was totally inadequate for pipes and vents. This did not mean that the converse was applicable, i.e. that a system and route definition of pipes was applicable to cables.

When the transit drum content and hence the space required for a specific bank of cables had been determined then it was agreed that the cable space requirements could be treated in a similar manner to pipes and vents.

The problems of electromagnetic interference between power and control cables had been recognized for a long time in power station design, etc. The problem was usually overcome by specifying a segregated route alternatively keeping a specific distance from other cables. Both these features were available within C.A.P.I.C.S.

The paper provided a benefit summary and stated that the re-organization of the electrical drawing office work, the drawing and cable numbering system were carried out before C.A.P.I.C.S. was applied. It did not, however, enable the cable to be cut at the stores, or save cable by re-assessing sizing or length. This was where, the authors claimed, a financial saving occurred.

It was interesting for the authors to hear Mr. E. Levings present the electrical similarities between offshore oil and gas platforms, and shipbuilding, and they noted the power study that had recently been performed on the Hutton platform. In the paper, the authors had indicated that this type of development was necessary for ship systems and it now appeared that a basis was available.

The authors agreed that some of the techniques used in shipbuilding were directly applicable to platforms and would welcome an exchange of information on this topic.

The authors agreed with Mr. T. R. Brown that there were considerable advantages in developing the interactive aspects of the system and this work was continuing.

The work currently being undertaken by B.S.R.A. which defined the basic ship structure and hence provided the back cloth on which the cableways could be defined was still somewhat in the future but it was recognized that there would be advantages if this type of information could be passed to a C.A.P.I.C.S. program direct without the need to create a separate cable route data file.

Mr. J. E. Perry's written contribution was very interesting and it was obvious that he had a wealth of practical experience of applying a system similar to C.A.P.I.C.S. to power stations.

Regarding specific questions raised in the contribution, the authors answered:

a) The calculated lengths of all cables for the first vessel were surveyed to see if the lengths were "reasonable", cables were then cut and out of 1600 cables about 22 cable lengths were short. This was because equipment had been resited but the computer data had not been amended. Some cable lengths were longer than strictly necessary and these lengths have been corrected for the following vessels. Some short runs of large copper cross-sections were double checked by measurement at the ship prior to cutting but this was not practicable for all cables.

b) The experience of operating C.A.P.I.C.S. was being gained by more electrical drawing office staff as it was applied to present and future shipbuilding contracts. The authors were now in a position to define, clearly, the requirements for a computer aided cable package for shipbuilding and a number of shipbuilders have expressed interest in participating in the development.

c) The major difference between ship's equipment and a power station was that the ship's equipment was often standard equipment applied by the shipbuilder within an overall electrical system. The terminals and circuit requirements were defined by the supplier although he would be willing to change these for a price. Therefore the situation was that terminal markings could not be dictated. Often a cable would be connected between two items of equipment whose terminal markings would be completely different. This aspect gave some difficulty when it was attempted to apply the C.A.P.I.C.S. ferrule information and a card system was developed. (See Fig. 8). Practical operation had shown that the cost of revising the terminal information and the time required by the system to accept modification was unacceptable.

But the advantages that the system offered was that it automatically recorded the date for each change or amendment. This should also be standard practice for drawing issue but was not always the case.

The authors concluded that termination information was best dealt with outside C.A.P.I.C.S. and a later stage as it tended to delay the progressing of Job 3. (See Fig. 2).

d) Planning and processing module of C.A.P.I.C.S. was not used as on overall planning system operated within the authors' company, but they agreed that a natural stage in many applications would be the planning aspect.

e) Within B.S. 6883 there was a wide range of cables and selection was left largely to the individual draughtsman. Now a range of standard cable had been determined within the company, and this restricted the freedom of choice.

C.A.P.I.C.S., however, still held the complete range of B.S. 6883 cables, and would select the appropriate cable for the required duty. This was then used in order to select the nearest standard cable. By this method the cost of standardization could be readily identified and assessed.