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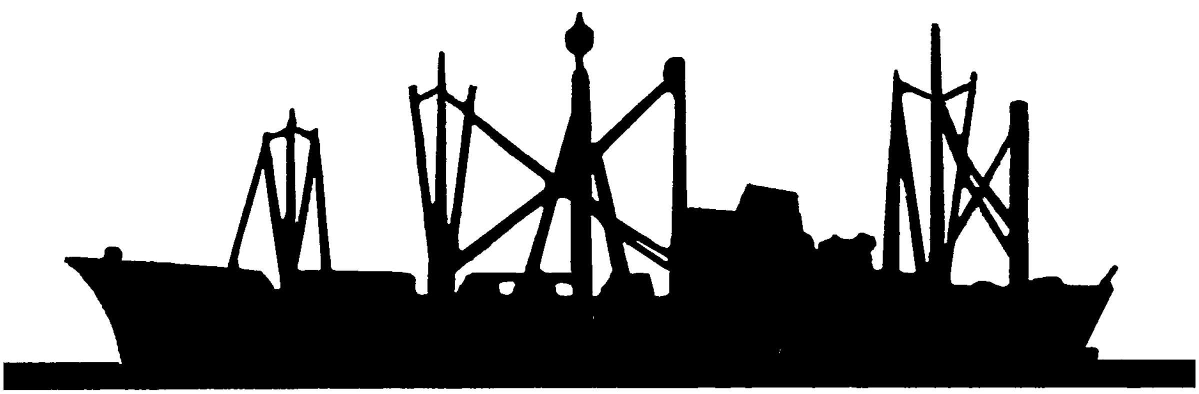

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

IREAPS

BRITISHIPS--SHIPBUILDING CAD/CAM IN PRODUCTIVE APPLICATION

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ABSTRACT

BRITSHIPS is the generic title for a computer system built from related ship design/production software created by the British Ship Research Association (BSRA). The integrated system has been the subject of continuous development since it first went into use in the late 196Os, and won a Queen's Award to Industry for technological innovation in 1974. BSRA is the central research and development agency for the British shipbuilding industry. BRITSHIPS has been developed in close consultation with the industry and is a reflection of the practical needs of the shipbuilders. The system is constantly updated in line with advances in design and production technology, advances in computing methods, and the developing requirements of the shipbuilding community.

This paper describes the structure and organization of the system, and the facilities it offers.

ABOUT BSRA

The British Ship Research Association (BSRA) is one of the largest research organisations in the world devoted to marine technology. Its staff of some 200 includes naval architects, marine engineers, mechanical engineers, physicists, chemists, mathematicians, computer specialists and economists all with specialist knowledge of the marine application of their subject.

Since its foundation in 1944, BSRA has conducted a planned programme of research to advance ship and shipbuilding technology. The knowledge and experience gained embraces virtually every aspect of marine technology: hydrodynamics, structures, engineering systems, automation, shipbuilding technology, vibration and noise reduction, anti-corrosion and anti-fouling techniques, computer applications and management aids.

BSRA's experience in the application of computers to routine ship design office calculations extends over a quarter of a century. In the 1960's BSRA pioneered interactive computing, using on-line terminals for these calculations. UK Shipbuilders were quick to appreciate the advantage of this method of working. Batch processing provides a means of validating a proposed design but interactive operation enables the programs to be used creatively while the design is being evolved and has resulted in a more rational approach to the design process.

A further development was the BRITSHIPS Suite which comprises a comprehensive set of computer programs for ship design and production. More recently a computer-based system for the design, detailing and generation of production information has been developed based on interactive computer graphics.

BSRA computing facilities include:

On-line access to a range of mainframe computers including a large IBM and an ICL 1904s on site providing dial-up service.

DEC PDP 11/45 and 11/40 minis with interactive graphics terminals.

A range of microcomputers, including Alpha LSI/2O, Ferranti FlOOL, Altos Series 8000.

Redifon Ci5000 hybrid digital/analogue system.

supported by:

Kongsberg DC 3OOF/1845 draughting system.

Applicon AGS 800 interactive design and draughting system.

In addition to the research departments there is also a large Technical Services department which offers a wide range of technical services, in support of marine technology, on a contract basis world wide. BSRA Technical Services support operators, builders and designers of ships and other marine structures in a number of ways:

Information services

Design support

Shipboard engineering and automation

Noise and vibration

Corrosion and fouling

Ship trials

Service performance

Shipyard methods

Measurement and instrumentation

Computing facilities, and

Computing packages.

In addition BSRA manufactures and supplies hull roughness analyser gauges for the quantitative assessment of hull surface condition. The SFOLDS, ship design analysis programs are supplied with an ALTOS micro-computer as a complete hardware/software package.

1 INTRODUCTION

BRITSHIPS has been used, as an integral part of their design and production procedures, by UK shipyards for a number of years, some of the BRITSHIPS modules are also used overseas. It consists of a comprehensive system of computer programs for ship design and the support of ship production using modern methods of manufacture with numerically controlled (NC) machine tools. BRITSHIPS has been developed with the practical assistance of shipbuilding managers and combines the expertise and experience of these people with up-to-date computer technology.

The BRITSHIPS system and the tasks performed by each of the major modules which it comprises are described in Section 2. In Section 3 the use of the system is traced through the development of a hull form design, the definition of the steelwork parts and the output of technical information required for manufacture and machine control data.

A list of the design analysis programs, known as SFOLDS, together with a short description of each program, is contained in Appendix 1.

2 BRITSHIPS - SYSTEM OUTLINE

2.1 The Modules

The system, see Fig.1, consists of six major modules linked through common data files which constitute the system data store. Each module may be run as a self contained sub-system. This means that it is not necessary to implement all the modules at the same time or in the same location although in practice certain groups of modules would normally be run together.

The shipyard may select the modules most relevant to its needs and may implement them progressively.

The modules are:

MODULE	MODULE NAME	TASKS PERFORMED
T100	SFOLDS (ship Form on-Line Design System)	Routine ship design calculations
T110	BRITFORM	Generation of hull form geometry
T200	BRITFAIR	Lines fairing, and production definition of hull form
T300	BRITSHELL	Shell arrangement, longitudinal definition and plate development
T400	GOLD (geometric on-Line Definition)	Interactive definition of steelwork piece parts and solution of design problems in geometry
T410	GOLDNEST	Interactive nesting of piece parts within a rectangular plate and defining of cutting sequence

2.2 SFOLDS

SFOLDS is a suite of programs for ship design office calculations which are arranged for use either in conventional batch processing mode or interactively on-line from a computer terminal.

Programs are provided for hydrostatics, stability, longitudinal strength, tank calibration, launching, grain calculations etc. Other programs enable preliminary offsets and lines drawings to be generated for forms conforming to the Revised-and Improved BSRA standard series. For these forms powering data can also be derived based on comprehensive model tests for the series.

SFOLDS programs use a common hull form definition to minimise data preparation. When the design has been finalised the offset data are transferred to the system data store for lofting by the BRITFAIR system.

The main SFOLDS programs offer the user a choice of output options at run time and there are programs for listing outputs in special formats e.g. HYTAB and KNTAB (Appendix 1). Any of the data stored on file may be selectively listed.

The SFOLDS programs which are now in regular daily use by over 50 organisations throughout the World are written in a highly portable version of FORTRAN IV and have been implemented on the following different computers:

IBM System 370
ICL 1900 series
ICL 2900 new range including 2903 and 2904
Honeywell 2000 series
Honeywell 6000 series
GE 400
Univac 1100
Prime
Hewlett Packard 2000
Control Data Cyber 170 Series

The SFOLDS module comprises the programs listed in Appendix 1. Additional programs dealing with seakeeping, vibration, propeller design etc., are also available.

2.3 BRITFORM

BRITFORM is based on the hull form design phase of the FORAN system and allows the rapid design of hull forms without the need for manual drawing and fairing of the ship's lines. By utilising the interface with BRITFAIR, production details can be readily incorporated into the design.

BRITFORM is an integrated suite of programs allowing designers:

- to create entirely new mathematically smooth hull forms from a basic description of the geometry of the ship,
- to alter a previous design to incorporate modified design criteria,
- to obtain a mathematically smooth hull definition from a sketch design,
- to check the hydrostatic particulars,
- to define the deck arrangement.

The results are presented graphically where appropriate and, because of the mathematical nature of the surface definition, the hull definition at frame sections can be obtained immediately the design is acceptable.

Figure 2 shows the building frames and Fig.3 the outline general arrangement for a design generated by BRITFORM.

The interface with BRITFAIR can be used to introduce, more flexibly, production details and is a necessary link to the BRITSHELL and GOLD Modules.

2.4 BRITFAIR

BRITFAIR is the lines fairing, hull surface definition and interpolation module, and performs the lofting functions of:

fairing the lines,

adjustment of the form to accommodate constructional details at stem and stern,

incorporation of production engineering requirements such as flat areas and knuckles,

definition of decks, flats, stringers, hopper tanks and other intersections with the moulded surface,

interpolation of building frames,

deformation of an existing hull form.

The module is preferably used interactively from a terminal since this gives the user maximum control over the processes.

Figure 4 is an example of the production level definition created for a bulk carrier using BRITFAIR.

BRITFAIR takes in offset data defining the hull form at the normal design level of detail (e.g. as used for making the tank model) and outputs a complete production definition. BRITFAIR creates a series of structured data files which are subsequently accessed by the BRITSHELL and GOLD modules.

Processing by BRITFAIR to create these files in the data store is essential to the application of BRITSHELL and the optimum use of GOLD in piece-part definition.

The data on file may be displayed graphically in various forms of drawing, on any required scale and the detailed numerical information available in the 'loft books' is output by the system.

2.5 BRITSHELL

BRITSHELL is the Shell and Longitudinal Definition Module and is used to:

- define and verify the seams, butts, longitudinals or any general line on the hull surface,
- describe the straking arrangement, and
- develop the shell plates and produce the NC tapes and listings for plate cutting,
- generate manufacturing statistics such as length of profile, percent scrap,
- generate shell jig setting information.

Typically the procedure for using BRITSHELL is for the positions of the seams and longitudinals to be obtained from the plate edge body plan and shell expansion drawing. These lines are adjusted and verified by use of the BRITSHELL facilities and then the individual plates which constitute each strake are identified to the system using the simple user language which minimises the amount of numerical data that has to be supplied.

Typical output for the shell arrangement, longitudinals and deck-at-side lines is shown in Fig.5.

The shell arrangement already defined will be used as a basis for the development of the shell plates and the generation of plate marking information through a further application of the BRITSHELL input language. A plate may have up to seven sides. There is also provision for specifying the plate thickness and the grade of steel to be used. A margin of additional material which can be trimmed during erection may be specified on one or more sides. The cutting margin is also specified for each batch of plates. This is the amount by which the nominal length and breadth of the ordered plate should exceed the theoretical dimensions of the minimum circumscribing rectangle. It provides for the width of the cut and allows for any mal-alignment of the plate on the burning table and for departures from the nominal dimensions. A marking statement specifies which of the lines already defined on the moulded surface should be transferred to the developed plate. Figure 6 shows a check drawing of a developed plate (produced on the screen of a display terminal with annotations indicating the significance of the various lines shown). Steel/ordering information and plate preparation statistics (Fig.7) will be generated for each developed plate. Depending on the method of flame cutting used in the shipyard the actual manufacturing data output will consist of either an NC machine control tape, an optical template drawing, or a tabular statement of co-ordinates for manual marking. The same procedures will be used for the development of any longitudinals which do not lie in one plane.

Rolling set information can be drawn on the plate itself from the NC tape. Alternatively this information can be output in tabular form.

BRITSHELL also generates the Longitudinal Information Files necessary for the automatic notching facility of the GOLD processor.

2.6 GOLD

GOLD is the piece parts definition, nesting and general geometric problem solving module.

GOLD (Geometrical On-Line Definition) forms the parts definition module of the system, and takes advantage of the latest developments in language processing techniques to provide a system which may be used either in conventional batch mode or on-line from an interactive graphics terminal.

There are two approaches to part programming, the first requires detailed information for each part in the form of working drawings. This information is then coded as a set of unique instructions which result in the replication of the original information in the form of a drawing or control tape. The other approach is to use a system for defining the part geometry in algorithmic form, i.e. it is the method of constructing the geometry which is defined to the computer rather than the actual shape of the individual part. Most practical systems contain elements of both methods. The first is of course simplest to comprehend, but can become tedious and there will be no saving in time compared with graphical methods, but there may be an improvement in accuracy. The advantage of the second approach is that instructions can be prepared for standard configurations, and used again and again with different dimensional data. These may be at various levels ranging from standard details for cutouts and brackets, to repetitive arrangements that may occur in several ships or components that simply change in shape at different stations within one ship.

GOLD allows a gradual progression from the first approach to the algorithmic mode. Initially, part-programmers coding individual parts from fully dimensioned drawings need only be instructed in a few simple statements defining points, circles and contours. These enable quite complex shapes to be defined by terse statements which specify dimensional data for the key features of the outline. As they progress to more general

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The development of algorithmic definitions for standard arrangements has close analogies with the writing of simple computer programs and the work is greatly facilitated through the use of an interactive on-line system which provides immediate validation of each line of instructions as it is input. GOLD may be used on-line from a remote access terminal when complex standard definitions are to be created while processing the main volume of work in batch mode.

The geometry of the faired hull form and structural arrangement defined by BRITFAIR and BRITSHELL is accessible to GOLD. Elements of this geometry may be referenced by name when writing parts descriptions and require no further definition. Frame shapes and the points at which each longitudinal intersects a transverse frame may be referenced in this way. The stored longitudinal scantling information enables the appropriate 'notch' profile to be generated automatically where transverse webs are penetrated by longitudinal stiffeners. The dimensions of the notch will be adjusted by the system to allow for the obliquity of the bar at the point where it passes through the transverse material.

A further development has been to reduce the extent of part programing instructions needed to define large steelwork components with many detail cutouts. Often-used cutouts required for drainage, passage of stiffening members etc. are described in part programming language by the use of macros. In normal circumstances, these are called as required each time the detail occurs, and obviate the need to part program the cutout each time.

Common practice is to build the description of a new component calling the system macros as necessary, and describe the remaining outline in part programing language by reference to the hull file, or by defining the boundaries.

The Structural Part Macros (SPM) development is in effect a suite of large macro programs, defining items such as floors or longitudinal girders in double bottom structure. Programs have been created, whereby the parts programmer can call the relevant SPM full description, and by defining a small number of parameters create the complete part description. The computer program is used interactively with the hull file, GOLD system, and existing low complexity macros. The output from the SPM is produced directly on a punched paper tape for the numerical-control profiling machines, or as optical l/10 scale templates as defined by the user.

Further work is continuing in this concept, and it is proposed that more major components will be added to the parts library of this broader application of the BRITSHIPS System.

The power of the GOLD system extends its use beyond parts definition to general design problems involving complicated geometry geometry.

2.7 GOLDNEST

GOLDNEST is the module for the interactive nesting of piece parts. Parts may be nested as they are programmed or they may be stored and the nesting done later using a separate interactive nesting facility GOLDNEST. This operates as a post processor and does not require the reprocessing of the original part programs.

Certain properties of the parts such as the length of profile and weight are calculated and stored along with the grade of material, thickness and the completed definition of the part. These are used by GOLDNEST to generate manufacturing statistics.

GOLDNEST is operated from an interactive terminal equipped with either a display screen or an A3 size plotter. The outlines of parts to be nested together are displayed and by means of simple instructions input at the keyboard and the use of a cursor on the screen or plotter table, the required positions of the parts are indicated. Parts may then be repositioned until a satisfactory nesting has been achieved. Parts may be replicated or mirrored as required in the course of nesting. Finally the order in which the parts are to be cut is indicated. Figure 8 shows the result of a nesting as it appears on the plotter. The broken lines represent rapid movement of the cutting head between marking and burning operations. The output from GOLDNEST is a file of cutter location data for the nested arrangement. This is then post-processed to produce machine control instructions for either an NC machine or a drafting machine on which an optical template is to be drawn.

Various auxiliary programs may also be brought into use for example, to generate the marking information required for the bending of frames by the inverse line method or to provide the data required for setting pillar jigs for curved assemblies.

3 BRITSHIPS IN APPLICATION

The BRITSHIPS Modules are used in various ways in the development of a ship design from initial concept to the output of the detailed information required for manufacture. The process is conveniently considered in four main phases:

Concept Design - the development of the initial concept and assessment of its feasibility.

Contract Design - complete specification of the design in all its functional aspects.

Production Definition - including the specification of fabrication details.

Preparation of Manufacturing Information - drawings, tabulated data, NC tapes.

3.1 Concept Design

In this phase the main hull form parameters are established and use is made of various programs in the SFOLDS module.

Using the BSRA Standard Series program MSHF a basis form may be created having the proposed dimensions and form coefficients. This form will then be evaluated using the various design analysis programs hydrostatics, stability, powering etc.

If the form does not satisfy all of the design requirements it may be modified by use of the form distortion program DEFORM which applies the classical form distortion procedures such as 'one-minus-prismatic'. The design analysis programs may then be used to re-evaluate the modified form and the process continued until a satisfactory solution is reached.

The whole process is carried out within the computer but under the control of the designer using a remote access terminal. Computer files are used to transfer data between programs but tabular listings and drawings may be output for assessment at any stage.

3.2 Contract Design

The Standard Series form is a satisfactory basis for all the preliminary calculations but a standard form can rarely be used in the final design without local modification. Such features as propeller aperture, bow form and flare may need to be adjusted to the particular requirements of the design. The BRITFORM module provides the flexibility required for such adjustments. A particularised version of the form is therefore generated using BRITFORM.

The design analysis programs will again be used to evaluate the new form and the calculations will be carried out in a greater depth of detail. A model cutting drawing will then be generated for use by the experiment tank. If, as a result of tank model tests, further modifications are required, these can be made quickly by a further application of BRITFORM.

When a fully acceptable hull form design has been achieved an outline general arrangement, profile and decks, Fig.3 will be produced and a preliminary building frame body plan, Fig.2, usually on 1/25th scale, will be generated as a basis form steelwork design and engine room arrangement.

GOLD may also be used during this phase to solve such problems as the establishment of stern frame geometry in relation to the required propeller clearances.

3.3 Production Definition

Hull forms designed using BRITFORM are defined mathematically and are therefore completely fair. However, local modification is invariably required to incorporate the engineering details of stern frame and bow construction. Control at this level of detail is achieved through the BRITFAIR module. At the same time more subtle changes may be introduced to ease production, for example, framing which is nearly straight in the mathematical definition may be made completely straight where this can be done without detriment to the hydrodynamic characteristics.

Where the design has been prepared manually for some reason, BRITFAIR is used to fair the whole surface and create a definition at the level of precision required for production.

The shell plating arrangement will be defined precisely using the BRITSHELL system and definition language.

The arrangement of longitudinals, stringers and girders on the moulded form will also be defined using BRITSHELL. A schedule of scantlings of longitudinals will be created and stored for subsequent access by the GOLD processor when generating the appropriate notch forms for penetrations by longitudinals in transverse components.

GOLD will be used to define the detailed geometry of structural components and in particular to prepare macros or standard definitions for components for which the same basic design is to be used at several points in the structure.

3.4 Manufacturing Information

The shell arrangement already defined will be used as a basis for the development of the shell plates and the generation of plate marking information through a further application of the BRITSHELL input language.

The main application of GOLD will be in this phase. The geometry of the individual piece parts and their cutting sequences will be defined and processed to create standard APT cutter location data. For parts that are to be nested these data will be called from the data store for processing by GOLDNEST.

The output from GOLDNEST is a file of cutter location data for the nested arrangement. This is then post-processed to produce machine control instructions for either an NC machine or a drafting machine on which an optical template is to be drawn.

Various auxiliary programs may also be brought into use for example, to generate the marking information required for the bending of frames by the inverse line method or to provide the data required for setting pillar jigs for curved assemblies.

4, FUTURE DEVELOPMENTS IN BRITSHIPS

Since 1968 a major portion of the UK Shipbuilding Industry has been using BRITSHIPS with its numerical methods to assist in the definition of the hull form and the definition of piece-parts. A logical extension of the system is to integrate the steelwork design and drawing office functions with the lofting activities using interactive draughting techniques. A development along these lines has been jointly carried out by Swan Hunter Shipbuilders and BSRA, under the sponsorship of British Shipbuilders. This new development is to be known as BRITSHIPS II to distinguish it from the earlier system.

BRITSHIPS II will incorporate an interactive draughting module and this will be the designer's principal means of comnunicating with the system. For the implementation at Swan Hunter Shipbuilders the CADAM interactive draughting package will be used..

Computer graphics can significantly improve productivity in the production and modification of the several hundred drawings required to communicate design information to the customer, regulatory authorities and the shipyard's own production departments. A more important benefit from a shipbuilder's point of view derives from the fact that drawings created using a graphics system are stored in a machine-readable form as computer files: geometrical, numerical and text data once created in a drawing may therefore be used in other computer processes. BRITSHIPS II provides a software system which enables the drawing data, produced by the draughting module, to be used directly for technical and administrative purposes.

The interfaces between BRITSHIPS II and BRITSHIPS I and other systems are shown in the schematic information flow diagram, Fig.9. Figure 10 presents an overview of the BRITSHIPS II software together with the interactive graphics data base and the BRITSHIPS II data store.

In the preliminary design phase the 3-dimensional geometry of the hull form and the moulded lines of the primary structure will be created using an extension of BRITSHIPS I techniques. Interface programs will make.it possible to incorporate data relevant to the hull form definition and compartmentation generated during the preliminary design phase.

In the scantling phase 'designers and draughtsmen will use the draughting system in conjunction with the moulded outlines for the construction of scantling plans. Programs will also be available to perform the various calculations required to be made in the course of preparing scantling drawings. Information extracted from drawings produced by the graphics system will be processed to create and add to the 3-dimensional model in the BRITSHIPS II data store, a representation of the shell seams and butts, and the moulded lines of longitudinals, stringers and girders. Facilities will be available for extracting steel requisition data from the scantling drawings.

The draughting system will enable the drawings produced during the scantling phase to be developed as detail steelwork drawings, avoiding the re-drawing necessary in manual systems. A library of standard details will be available which will encourage the use of properly engineered details throughout the design. Existing software (GOLD) will enable standard longitudinal notches to be generated and automatically sized positioned and orientated on the drawing. The output from the detail design phase will consist of detailed steelwork and production drawings for each unit, assembly and sub-assembly.

The interactive draughting system will be used to extract the piece-part geometry from the detail drawings and add other necessary information, e.g. edge preparation details. Nesting will be accomplished using the interactive version of GOLD and the part-programming operation will be reduced to the specification of cutting sequences and burning machine functions. Control tapes will be generated by the available BRITSHIPS I software.

Technical and planning information for production will be derived from the output of the detail design and piece-part separation phases. It will include structured lists of assemblies, sub-assemblies and piece-parts and additionally, isometric drawings showing clearly the relationship between the various components.

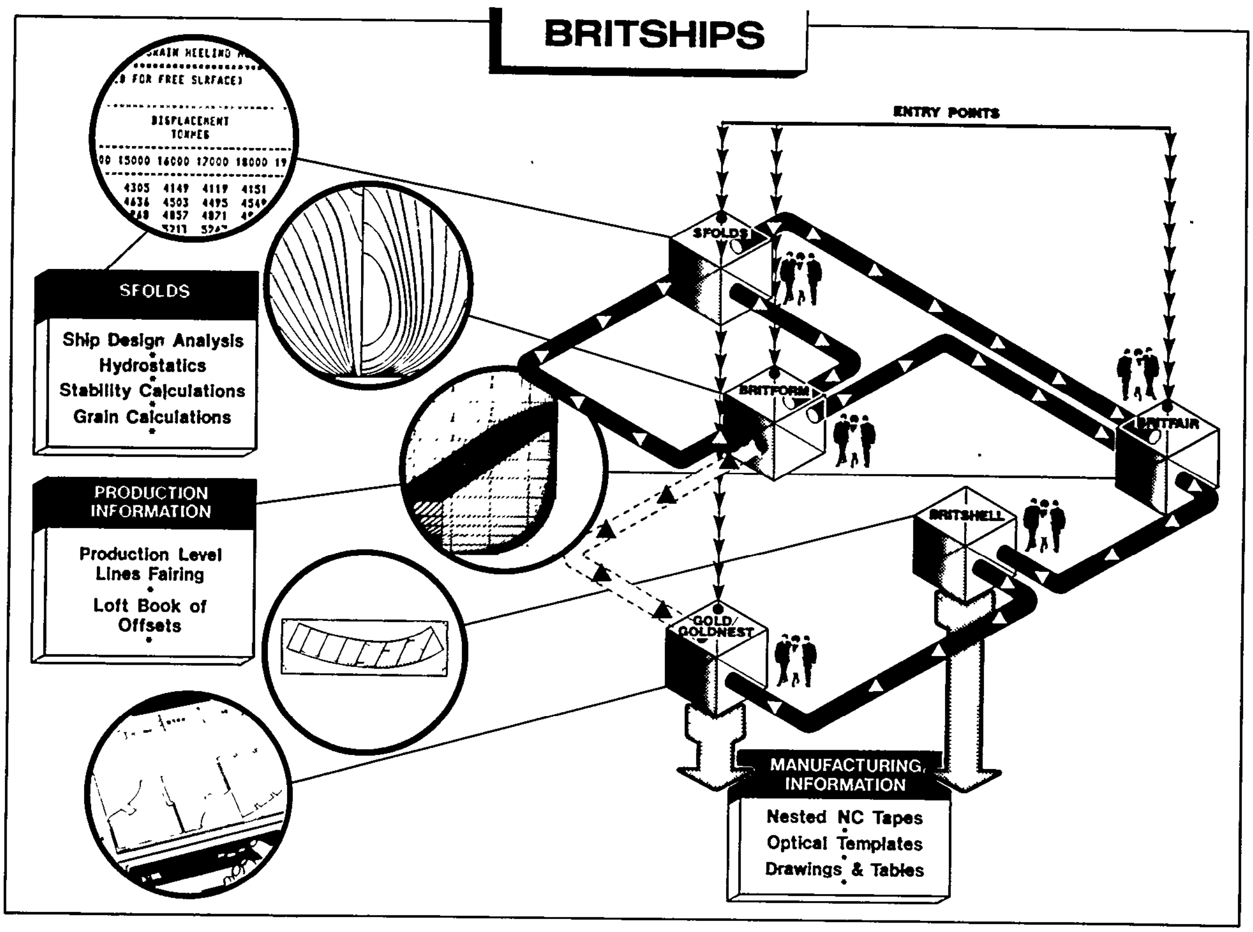

FIG.1

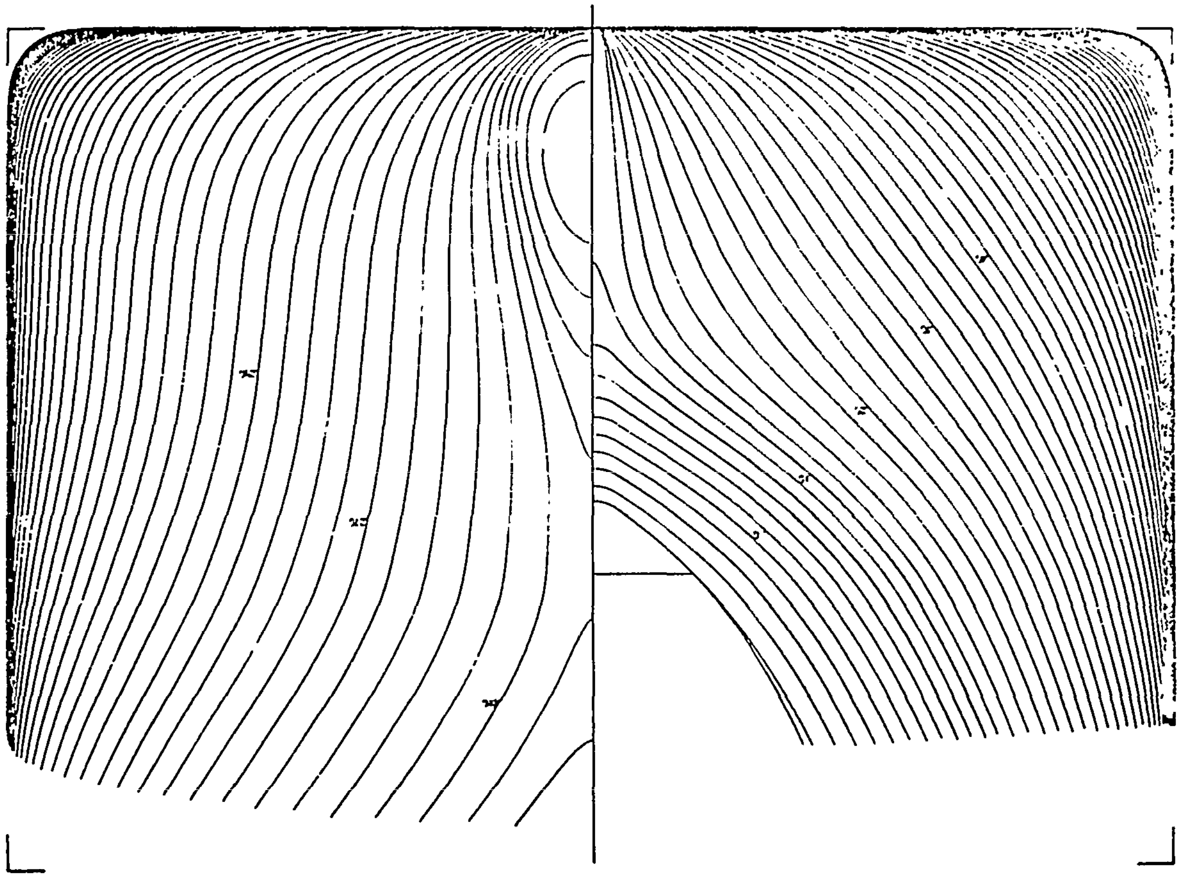

FIG.2 BUILDING FRAMES FROM BRITFORM

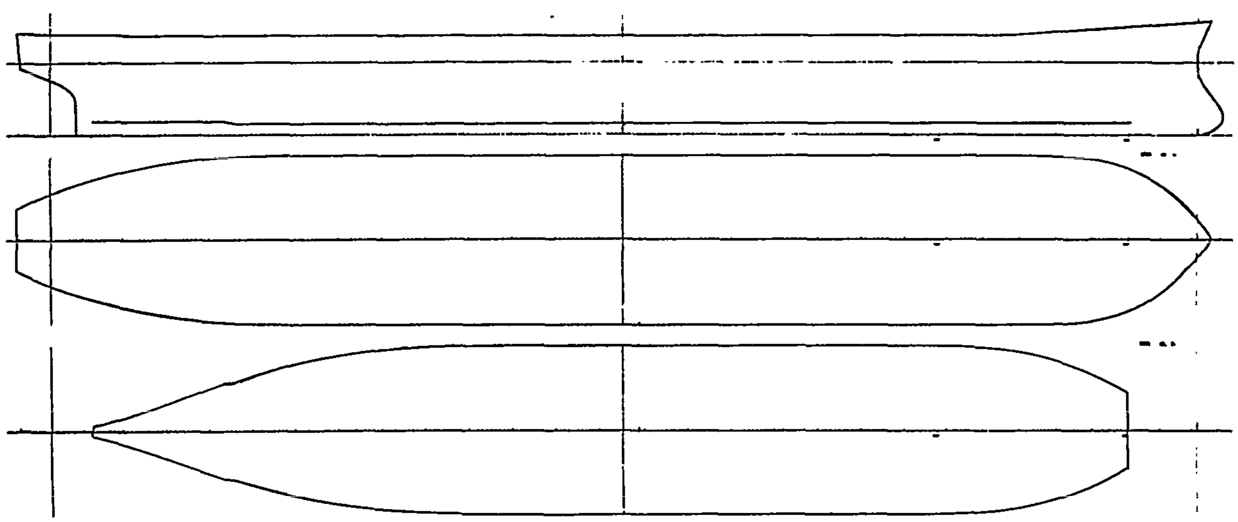

FIG.3 OUTLINE GENERAL ARRANGEMENT

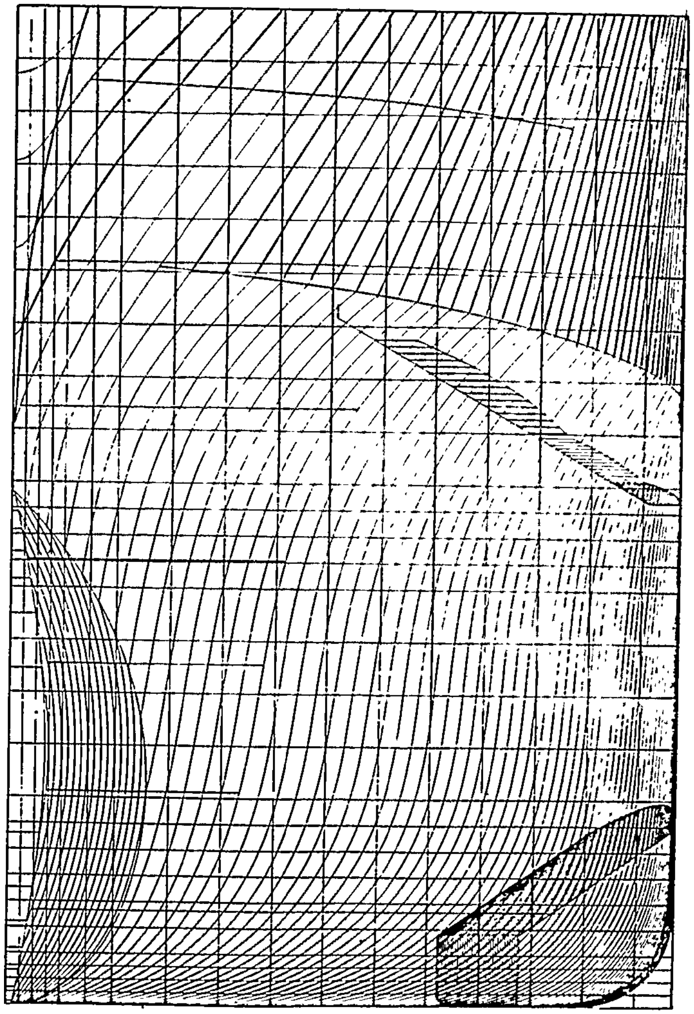

FIG. 4 BRITFAIR-EXAMPLE OF BOW ENGINEERED FOR PRODUCTION

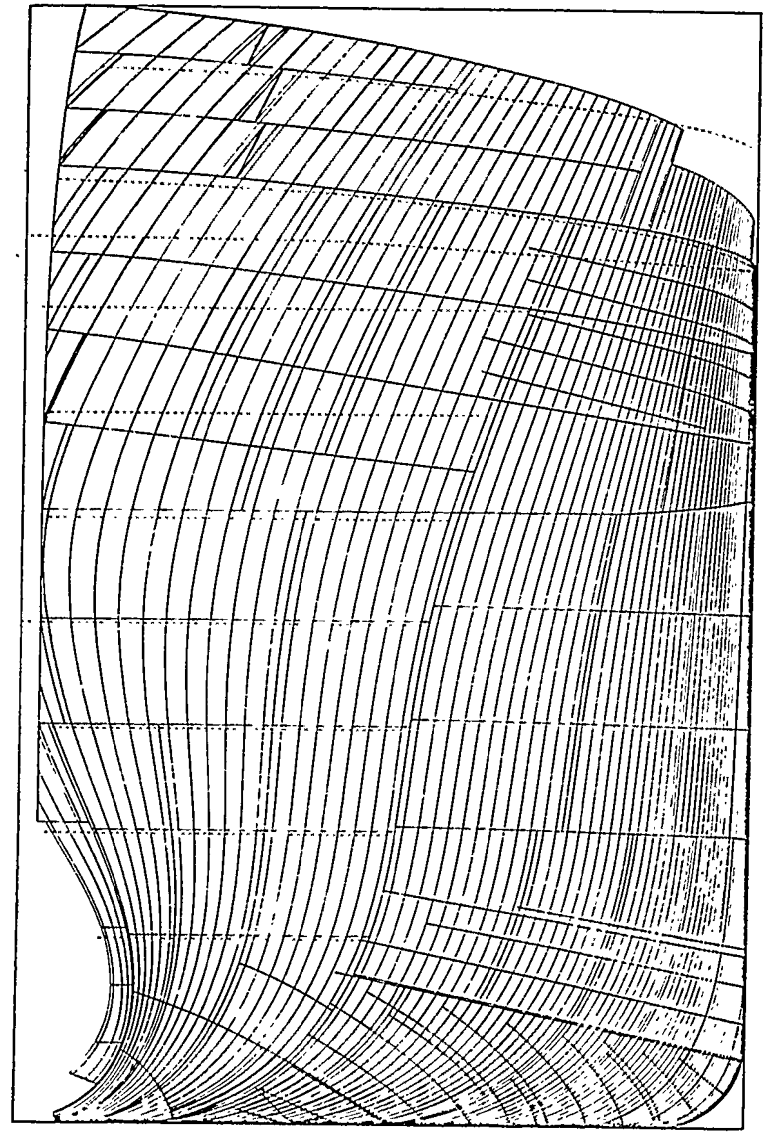

FIG. 5 SHELL ARRANGEMENT LONGITUDINALS AND DECK-AT-SIDE LINES AS DEFINED IN THREE DIMENSIONS

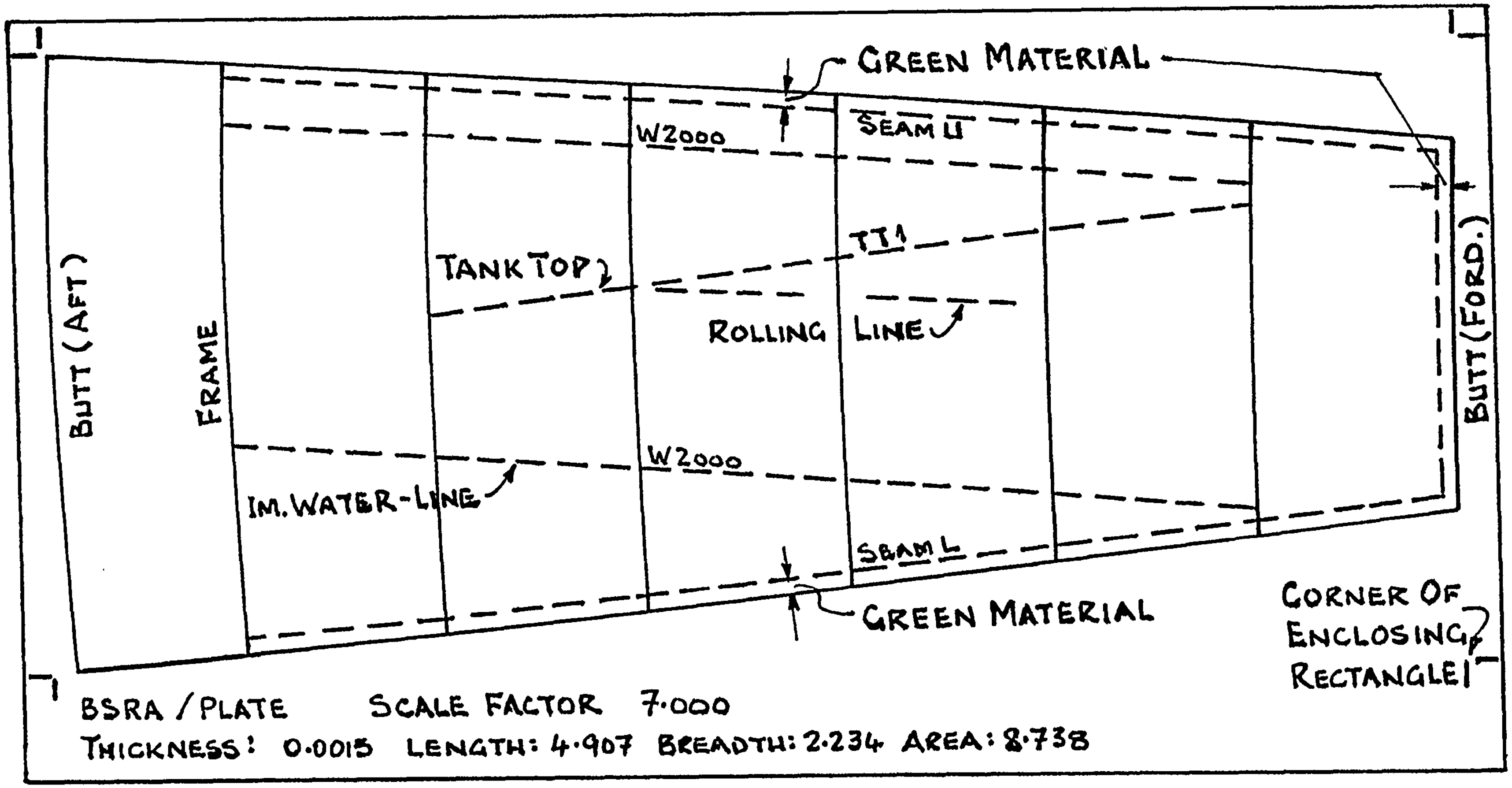

FIG. 6 CHECK DRAWING FOR DEVELOPED SHELL PLATE

BSRA No. 1/ 1	SHIP 99999	BSRA/PLATE 1
	PART	ORDERED PLATE
GRADE		
THICKNESS	0.015 M.	0.015 M.
LENGTH		4.907 M.
BREADTH		2.234 M.
AREA	8.738 SQ.M.	10.961 SQ.M.
WEIGHT	1028.935 KGS.	1290.701 KGS.
SCRAP	20.281 %	261.766 KGS.

KNUCKLE ON UPPER SEAM AT 'FRS' 1 8 8 8 8
KNUCKLE ON LOWER SEAM AT 'FRS' 1 8 8 8 8

PREPARATION STATISTICS

LENGTH OF RAPID TRAVEL	=	24.0M
LENGTH OF BURN ON MAJOR HEAD	=	8.6M
LENGTH OF MARK MOTION	=	5.6M
LENGTH OF NORMAL MOTION	=	3.9M
NUMBER OF PIERCE COMMANDS	=	3
NUMBER OF POP SEQUENCES	=	69

FIG. 7 PLATE PREPARATION STATISTICS

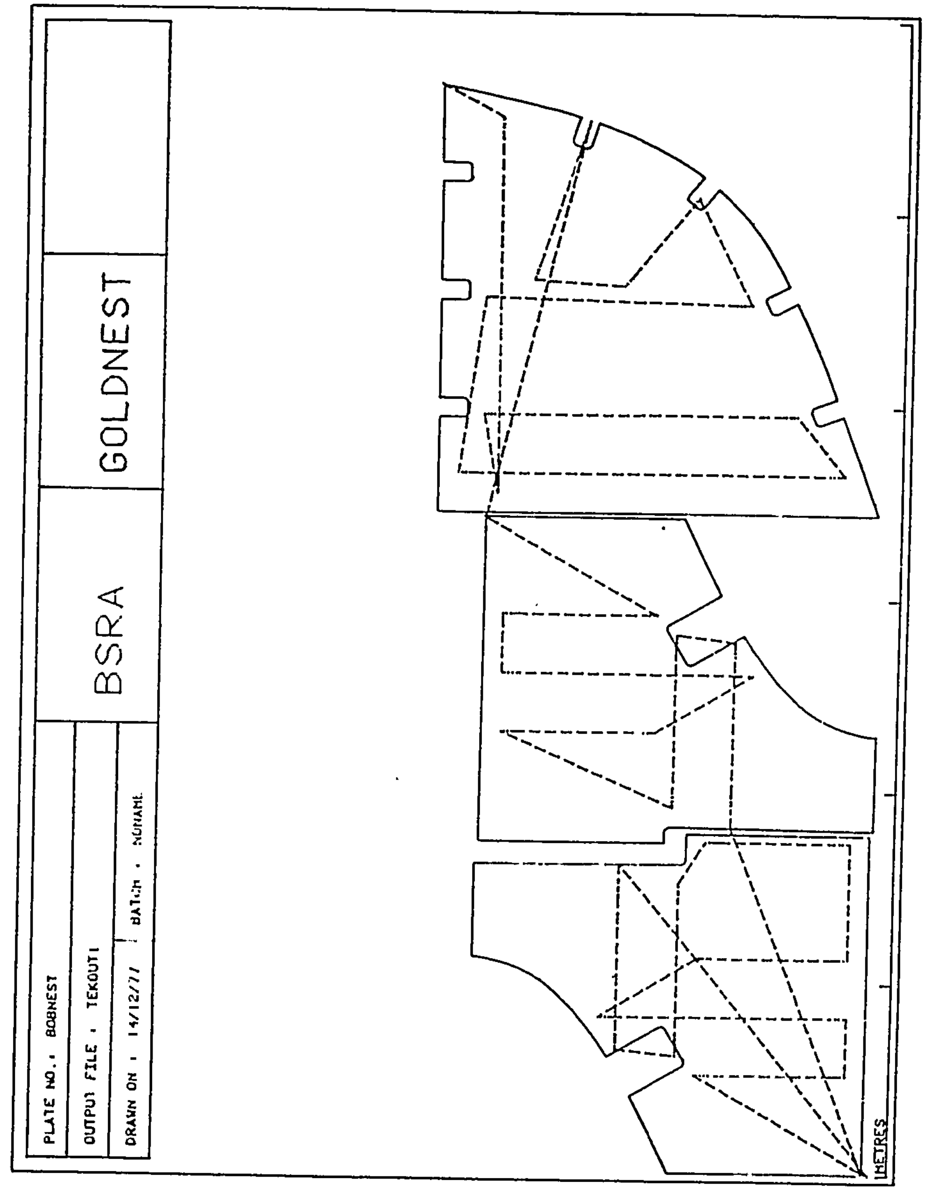

FIG. 8 VERIFICATION DRAWING FOR NESTED PLATE

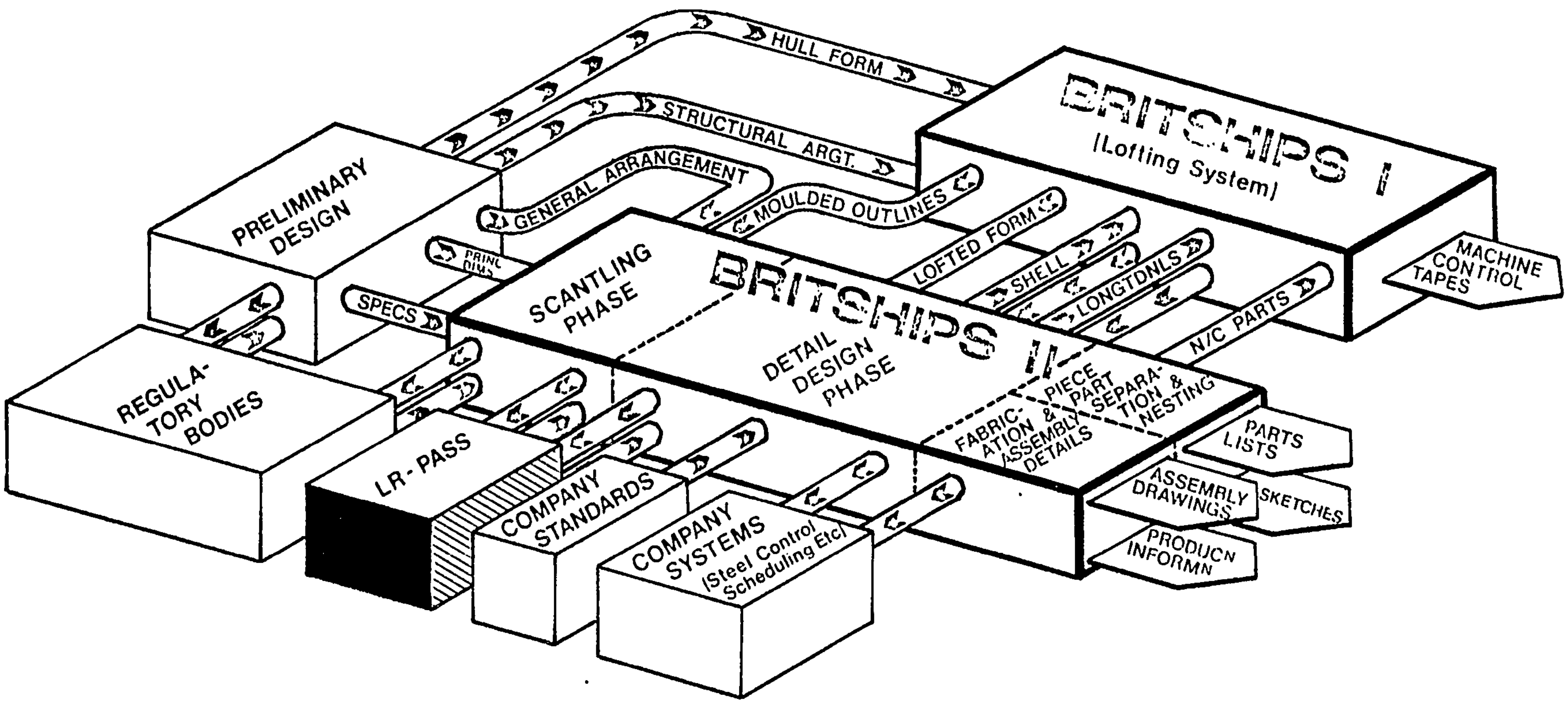

FIG.9 BRITSHIPS II INFORMATION FLOW

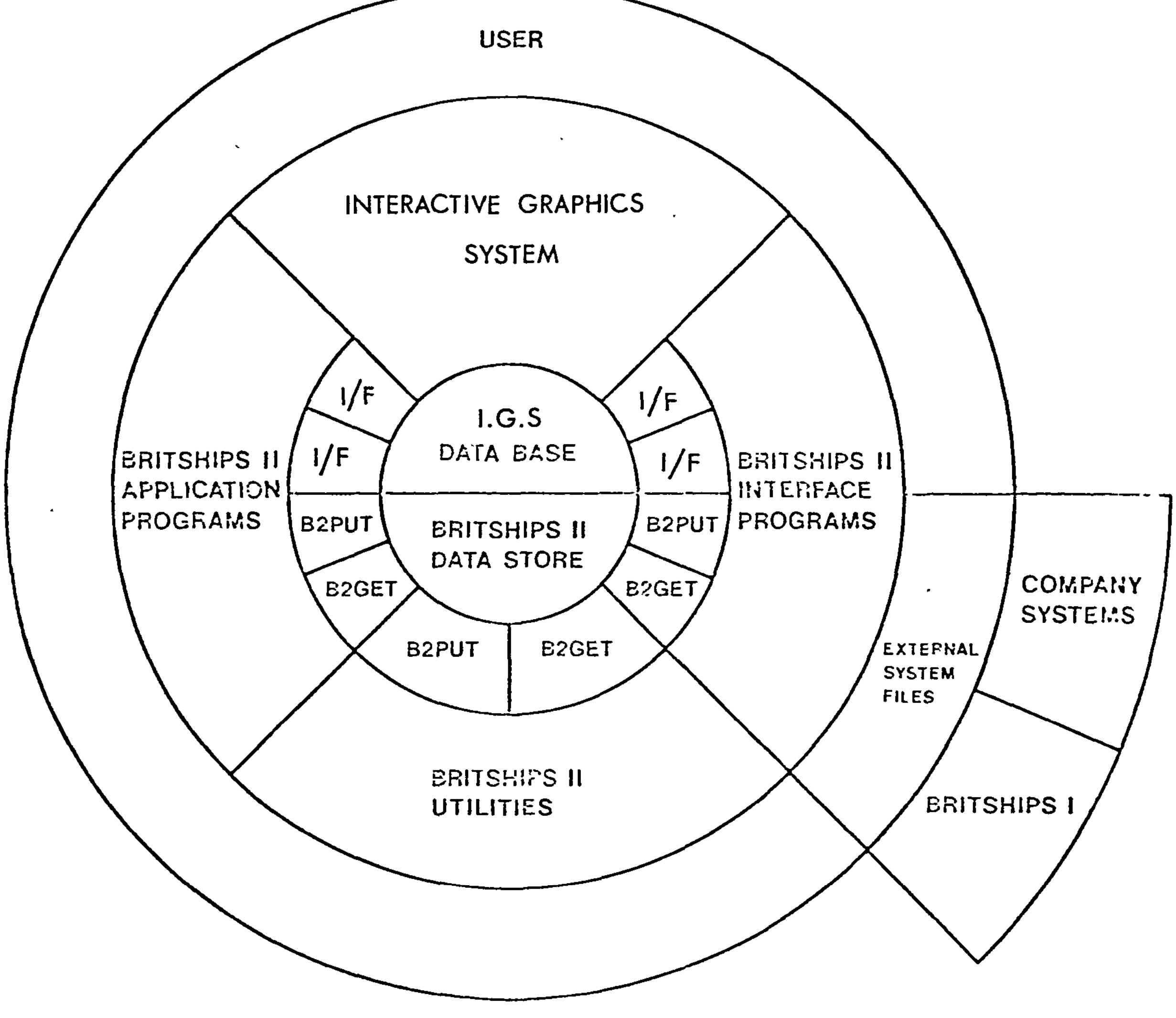

FIG. 10 BRITSHIPS II SYSTEM OVERVIEW

DESCRIPTION OF SFOLDS PROGRAMS

ABSOLUTE PROGRAM NAME	PROGRAM NOTICE NUMBER	BRIEF DESCRIPTION
BODY	PN17	Program to compute a control tape file for an ESSI drawing machine, for drawing a complete body plan including super-structure and other appendages using the standard 23 station offset file.
BPLOT	PN25	Program to produce a rough plot of a body plan and simple portion data on the line printer or the User's terminal.
BSAD	PN60	Program to generate bending moment, shearing force and deflection curves.
COLLECT	PN57	Program to collect and generate input to TRISTA.
DAMAGE	PN56	Program to compute damage stability particulars allowing for the change in free surface in partly filled or intact compartments.
DEFORM	PN12	Program which uses the parent hull offset file data on the standard 23 stations to modify the form in order to derive a new form with specified form characteristics and principle dimensions. Four alternative methods of hull form derivation are available when using this program.
HYDRE	PN61	Program to compute trimmed hydrostatics of sectional properties.
HYTAB	PN23	Program to produce formatted tables of the hydrostatic particulars in A4 format using the output file created by the HYDRE program.
KNTAB	PN24	Program to produce formatted tables of the cross curves of statical stability in A4 format using the output file created by WSTAB.
KPORT	PN62	Program to generate simple portion data using the displacement station offsets, together with the positions of the transverse bulkheads and decks. These simple portions can be used by various other programs.

ABSOLUTE PROGRAM NAME	PROGRAM NOTICE NUMBER	BRIEF DESCRIPTION
LONSH	PN74	Program to compute launching particulars for a ship or any floating object for a series of travels down the launching ways.
MSHF	PN63	Program to create a design file from BSRA improved and revised standard series data.
MSPE	PN3	Program to estimate power requirements and calculate resistance particulars for BSRA improved and revised standard series data.
PARTS	PN5	Program to create an offset file on the 23 standard displacement stations between the 2 transverse bulkheads specified, given the offsets for up to 50 stations in the ship's length. Any simple portion data is also processed to define the ship between the transverse bulkheads specified.
TANK	PN9	Program to produce calibration tables in terms of soundings or ullages for any compartment defined by simple portion data, which may have been generated by KPORT.
SR60	PN1O	Program to create a design file from the US Series 60 forms.
TRISTA	PN22	Program to calculate the trim and stability for any number of loading conditions.
WSTAB	PN54	Program to compute the cross curves of statical stability allowing for super-structures, bossings and free trim.
BALCO	PN51	Program to compute sinkage, change in trim, change in draught fwd. and aft, for up to 50 compartments on any number of conditions.
VOLUME	PN83	This program computes the volumes and centre of gravity of the holds and tanks enclosed by decks and bulkheads.
BENDS	PN37	Program to calculate longitudinal strength particulars for any number of loading conditions.

ABSOLUTE PROGRAM NAME	PROGRAM NOTICE NUMBER	BRIEF DESCRIPTION
GRAIN	PN6	Carriage of grain program for partly filled compartments of bulk carried to check compliance with SOLAS 74 requirements.
FGRAIN	PN152	Full hold grain heeling moments in accordance with the IMCO SOLAS 74 Convention.
KGCRIT	PN153	Computation of critical KG values, maximum allowable deadweight moments and maximum allowable grain heeling moments.
FREEBD	PN15	Calculation of summer freeboards.
DBAL	PN67	Prediction of dBA noise levels.
APPROVE	PN151	Checks data in DESIGN or PORTN file.
OFFTAB	PN109	Tabulates DESIGN file.
FLOOD	PN7	Floodable length curve calculations.
DENSE	PN108	Increases the number of portions in a PORTN file.
OPDS	PN131	Optimum Propeller Design from TROOST Series.

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