BIENNIAL REPORT OF THE SHIP STRUCTURE COMMITTEE

SSC-176

U.S. Coast Guard Headquarters
Washington, D.C.
1 June 1966

SHIP STRUCTURE COMMITTEE

MEMBER AGENCIES:
NAVAL SHIP ENGINEERING CENTER, DEPT. OF NAVY
MILITARY SEA TRANSPORTATION SERVICE, DEPT. OF NAVY
UNITED STATES COAST GUARD, TREASURY DEPT.
MARITIME ADMINISTRATION, DEPT. OF COMMERCE
AMERICAN BUREAU OF SHIPPING

ADDRESS CORRESPONDENCE TO:
SECRETARY
SHIP STRUCTURE COMMITTEE
U. S. COAST GUARD HEADQUARTERS
WASHINGTON, D. C. 20226

1 June 1966

Dear Sir:

Herewith is a copy of the Biennial Report of the Ship Structure Committee to the convening authority, the Secretary of the Treasury, covering the activities of the Committee and its affiliated research groups for the period 30 October 1964 to 31 May 1966. Technical portions of this report are a continuation of the series of technical progress reports that began with the publication in 1946 of the Final Report of the Board to Investigate the Design and Methods of Construction of Welded Steel Merchant Vessels.

Any questions, comments, criticisms, or other matters pertaining to the report should be addressed to the Secretary, Ship Structure Committee.

This report is being distributed to those individuals and agencies associated with and interested in the work of the Ship Structure Committee.

Sincerely yours,

John B. Oren

John B. Oren
Rear Admiral, U. S. Coast Guard
Chairman, Ship Structure Committee

CONTENTS

CHAPTER I

AUTHORITY FOR THE SHIP STRUCTURE COMMITTEE

The Ship Structure Committee was established on July 26, 1946 by the Secretary of the Treasury. The text of the letter of establishment follows:

Dear Sir:

Subject: Establishment of a Ship Structure Committee

A committee, to be known as the Ship Structure Committee, consisting of the Engineer-in-Chief, U.S. Coast Guard, as Chairman, and, subject to the approval of the Secretary of the Navy, the Chief of the Bureau of Ships, and, subject to the approval of the Chairman of the U.S. Maritime Commission, the Technical Assistant to the Chairman, U.S. Maritime Commission, and subject to the approval of the President of the American Bureau of Shipping, the Vice President-Chief Surveyor, American Bureau of Shipping, as additional members, is hereby constituted for the purpose of prosecuting a research program to improve the hull structures of ships by an extension of knowledge pertaining to design, materials and methods of fabrication.

The Committee is charged with the following functions:

1. Initiate, arrange for financing, and coordinate research and development pertaining to ship structure;

2. Integrate and interpret results;

3. Disseminate pertinent information to all parties having an interest in the building and operating of ships and to research investigators.

The Committee may utilize the laboratories, equipment and services of government agencies and institutions. The Committee, through the medium of member agencies, may contract with and transfer funds to existing governmental agencies and institutions and may enter into contracts and agreements with individuals, educational and scientific institutions, industrial organizations, and other agencies for services, advice, studies, experimental investigations, and reports.

Although but four representatives of interested agencies are named as members of this Committee, it is not the intent to exclude other agencies who desire to participate in research work subject to conditions outlined herein, and the Committee may be expanded upon receipt of requests from other agencies to join in this enterprise.

The Committee is authorized to sit in Washington, D.C., and in such other places in the continental United States as it may consider necessary for the proper discharge of its duties hereunder.

Very truly yours,

/s/E. H. Foley, Jr.
Acting Secretary of the Treasury

Engineer-in-Chief
United States Coast Guard
Washington, D.C.

Since 1946, both membership and titles describing the duties of the agency representatives have changed. The present membership is:

1. Chief, Office of Engineering
   U.S. Coast Guard
   Department of the Treasury

2. Head of Ship Systems Engineering Department
   Naval Ship Engineering Center
   Department of the Navy

3. Maintenance and Repair Officer
   Military Sea Transportation Service
   Department of the Navy

4. Chief, Office of Research and Development
   Maritime Administration
   Department of Commerce

5. Vice President - Technical
   American Bureau of Shipping

A Secretary of the Ship Structure Committee is appointed by the chairman.

CHAPTER II

ORGANIZATION

The Ship Structure Committee is assisted in its operation by a Ship Structure Subcommittee and an Executive Group. In addition, technical advice is provided to the Ship Structure Committee by the National Academy of Sciences utilizing its Ship Hull Research Committee.

Description of the Ship Structure Committee Organization

A. The Ship Structure Committee (SSC):

Membership: One member from each of the participating agencies, to be nominated by the Secretary of his department, and to be appointed by the Secretary of the Treasury.

Roles: Establish policies and rules for operation. Review objectives, budgets and reports forwarded by the Ship Structure Subcommittee. Provide general guidance to the program. Obtain funds for the program.

B. The Ship Structure Subcommittee (SSSC):

Membership: Members shall comprise two representatives from each of the participating agencies, plus a member from the Office of Naval Research and a contract administrator from the Naval Ship Engineering Center. Members shall be nominated by each agency's member of the Committee, and shall be appointed by the Chairman of the Committee.

Liaison members may be appointed by the Chairman of the Committee as mutually agreed by the Committee and groups with whom liaison is desired.

Roles: The Subcommittee acts for the Ship Structure Committee on technical matters, providing technical coordination for the entire program. Its primary functions are:

(a) to determine the goals or objectives of the program and the priorities which should be assigned to them.

(b) to develop and execute research programs to meet the goals.

(c) to evaluate and interpret the results of research programs in terms of ship structural design, construction and operation.

C. The Executive Group:

Membership: The members shall be members of the Ship Structure Subcommittee. The group shall comprise one representative from each member agency and a contract administrator from the Naval Ship Engineering Center.

The Executive Group representation is provided for by the following:

Director, Naval Ship Engineering Center
Chairman

Assistant Repair Officer
Military Sea Transportation Service

Chief, Division of Hull Research
Maritime Administration

Senior Surveyor
Hull Technical Staff
American Bureau of Shipping

Secretary of the Ship Structure Committee
United States Coast Guard - Secretary

Head, Hull Scientific & Research Section
Naval Ship Engineering Center
Contract Administrator

Roles: Acts for the Ship Structure Commitee and conducts the business of the Ship Structure Committee program. This is an administrative group concerned with funding, budgeting and administrative supervision of the program.

D. The National Academy of Sciences-National Research Council (NAS-NRC)

The NAS-NRC is the scientific and engineering research advisory group for the Ship Structure Committee program. It provides advice and assistance to the Ship Structure Committee during the establishment of objectives and priorities, in the development and execution of projects to meet those objectives, and in the interpretation and evaluation of research results. It does this by:

(a) Providing assistance and advice in determining realistic, specific objectives to which the program should be directed.

(b) Assisting in planning research projects to attain these objectives.

(c) Providing assistance and advice in selecting organizations and personnel capable of carrying out the research projects.

(d) Providing technical surveillance over such projects, and providing advice on the progress and direction of the work.

(e) Preparing technical reports and summaries of research work relating to the Ship Structure Committee program.

(f) Providing assistance and advice in evaluating and interpreting the results of research.

The Ship Hull Research Committee (SHRC) is the group within the National Academy of Sciences which provides advisory service for the Ship Structure Committee. The SHRC in turn is directed by the Marine Transportation Research Board of the NAS-NRC. The Board is concerned with the broader aspects of marine transportation such as transportation of perishable foods and manning requirements of merchant ships. Hence, the work of the Ship Structure Committee is integrated with the total, marine transportation picture. Figure II.1 gives the organizational structure of the Marine Transportation Research Board.

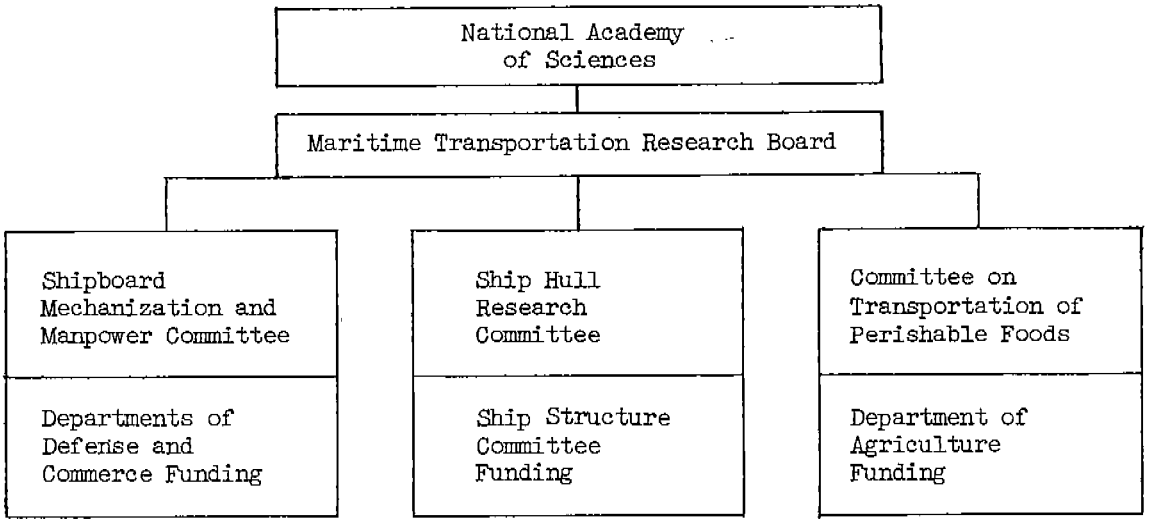


Fig. II.1

Operations

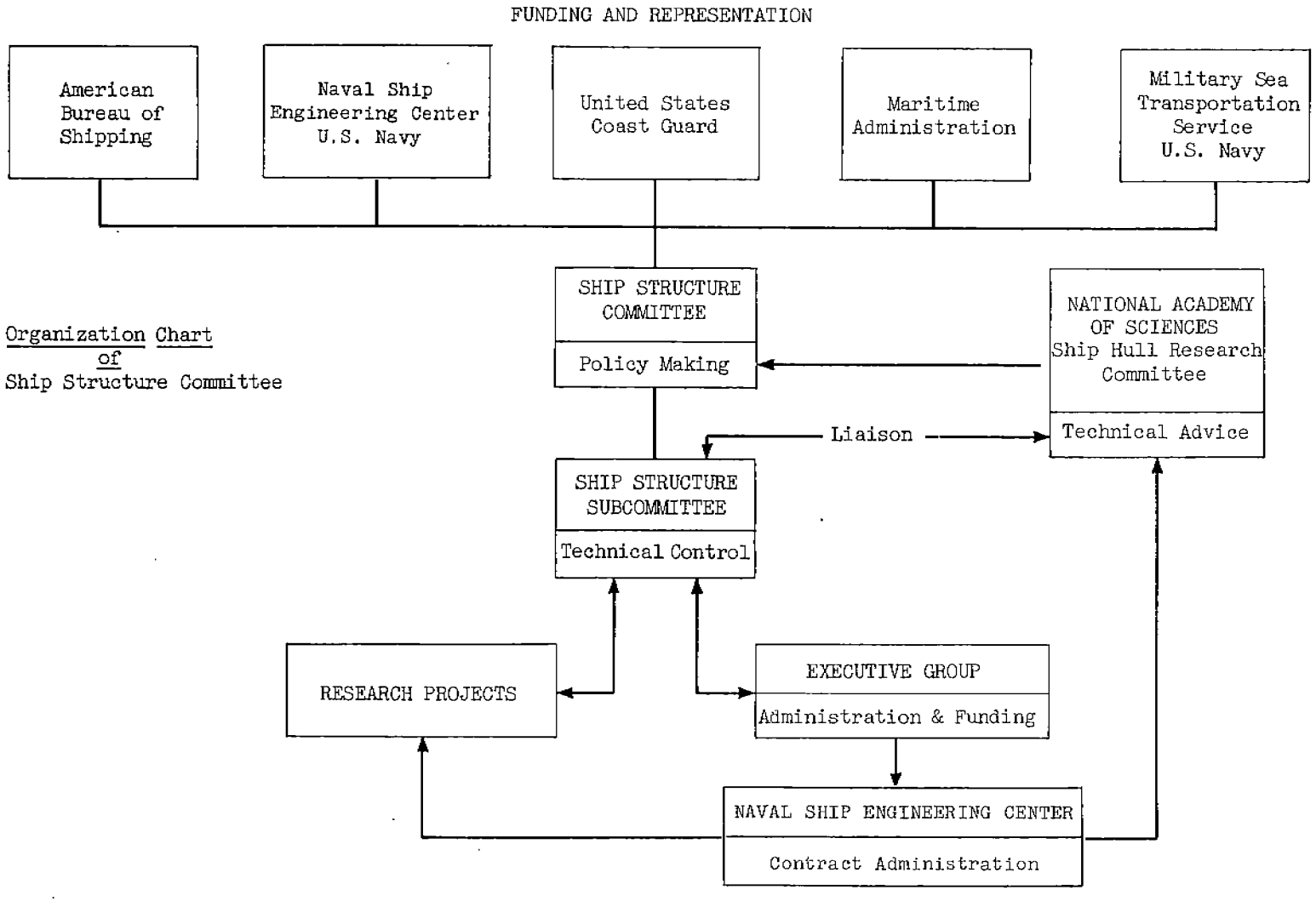
The focus of the SSC and its auxiliary committees, including NAS-NRC, is the research program. The operations of these several groups concern the steps necessary to institute the several projects within the program, provide technical advice and guidance to the program, and assure widespread dissemination of the research results to interested technologists.

In performing the above operations the SSC through the SSSC and with the advice of NAS-NRC periodically sets up an objective toward which all projects should be aimed. Each year recommendations are made to the SSC of a series of research projects aimed at this objective. These recommended projects are selected from suggestions received from not only NAS-NRC but from the SSSC, other groups within the SSC complex and through unsolicited proposals submitted directly to the Secretary of the SSC.

The list of recommended projects is submitted to the SSSC by NAS-NRC together with a description of the work to be done, an indication of the results that may be anticipated, an analysis of how this project relates to the general program objectives and an estimate of the probable annual cost. In order to assist in the establishment of new projects a prospectus is prepared for bidding purposes.

The SSSC in conjunction with the Executive Group reviews these recommendations in relation to available monies, degree of emphasis in each area, and conformance to broad goals. Their recommendations are then transmitted to the SSC who has final responsibility in matters of financing, suitability of projects to overall objectives, assurance of coordination of research projects, and degree of dissemination of research results.

The investigators conduct the actual research and prepare such reports for the sponsor as are needed to adequately report the progress or termination of the research. The NAS-NRC works closely with the investigators during the course of the research and in the preparation of the final report. After review of such reports by the NAS-NRC and SSSC they are forwarded to the Ship Structure Committee for approval and public distribution.



Organization Chart
of
Ship Structure Committee

Fig. II.2

CHAPTER III

CURRENT SHIP STRUCTURE COMMITTEE ORGANIZATION DIRECTORY

Ship Structure Committee Membership

Rear Admiral John B. Oren, USCG - Chairman
Chief, Office of Engineering
U.S. Coast Guard Headquarters
Washington, D.C.

Captain William M. Nicholson, USN
Head of Ship Systems Engineering Department
Naval Ship Engineering Center
Department of the Navy
Washington, D.C.

Captain P. E. Shetenhelm, USN
Maintenance and Repair Officer
Military Sea Transportation Service
Department of the Navy
Washington, D.C.

Mr. E. M. MacCutcheon
Chief, Office of Research and Development
Maritime Administration
Washington, D.C.

Mr. D. B. Bannerman, Jr.
Vice President - Technical
American Bureau of Shipping
45 Broad Street
New York 4, New York

Lieutenant Commander Richard Nielsen, Jr., USCG
Secretary, Office of Engineering
U.S. Coast Guard Headquarters
Washington, D.C.

Ship Structure Subcommittee Membership

Naval Ship Engineering Center - U.S. Navy

Captain S. R. Heller, USN - Chairman
Mr. John Vasta - Contract Administrator
Mr. George Sorkin - Member
Mr. T. J. Griffin - Alternate
Mr. Ives Fioriti - Alternate

David Taylor Model Basin

Mr. A. B. Stavovy - Alternate

Ship Structure Subcommittee Membership--Continued

OFFICE OF NAVAL RESEARCH

Mr. J. M. Crowley - Member

NAVAL RESEARCH LAB

Dr. G. R. Irwin - Alternate
Dr. W. G. Rauch - Alternate

MILITARY SEA TRANSPORTATION SERVICE

Lieutenant Commander C. E. Arnold, USN - Member
Mr. R. R. Askren - Member

MARITIME ADMINISTRATION

Mr. R. W. Black - Member
Mr. A. Maillar - Member
Mr. Robert Falls - Alternate
Mr. William G. Frederick - Alternate

AMERICAN BUREAU OF SHIPPING

Mr. G. F. Casey - Member
Mr. F. J. Crum - Member

U.S. COAST GUARD

Lieutenant Commander R. Nielsen, Jr. - Member
Lieutenant Commander J. F. Lobkovich - Alternate
Lieutenant Commander J. L. Howard - Alternate
Mr. J. B. Robertson, Jr. - Member

Ship Structure Subcommittee Liaison Representatives

NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL

Mr. A. R. Lytle - Director, Ship Hull Research Committee
Mr. R. W. Rumke - Executive Secretary

AMERICAN IRON AND STEEL INSTITUTE

Mr. J. R. LeCron

BRITISH NAVY STAFF

Mr. A. C. Law
Constructor Commander T. R. Rumens, RN

WELDING RESEARCH COUNCIL

Mr. K. H. Koopman, Director
Mr. Charles Larson - Executive Secretary

Members, Ship Structure Subcommittee - EXECUTIVE GROUP

Captain S. R. Heller, Jr., USN - NAVSEC
Lieutenant Commander C. E. Arnold, USN - MSTS
Mr. R. W. Black - MarAd
Mr. G. F. Casey - ABS
Lieutenant Commander R. Nielsen, Jr., USCG
Mr. John Vasta - Contract Administrator, NAVSEC

SHIP HULL RESEARCH COMMITTEE MEMBERSHIP

Mr. T. M. Buermann, Chairman
Gibbs & Cox, Inc.

Mr. M. L. Sellers, Vice Chairman
Naval Architect
Newport News Shipbuilding & Dry Dock Co.

Dr. J. M. Frankland, Vice Chairman
Consultant, Mechanics Division
National Bureau of Standards

Members

Dr. H. Norman Abramson
Director, Dept. of Mechanical Sciences
Southwest Research Institute

Mr. H. G. Acker
Naval Architect, Shipbuilding Division
Bethlehem Steel Co.

Mr. A. E. Cox
Assistant Naval Architect
Newport News Shipbuilding & Dry Dock Co.

Mr. Robert Dippy, Jr.
Structural Design Engineer
Sun Shipbuilding & Dry Dock Co.

Dr. N. H. Jasper
Technical Director
U.S. Navy Mine Defense Lab.

Mr. F. J. Joyce
National Bulk Carriers, Inc.

Mr. W. R. Jensen
Structural Methods Engineer
Grumman Aircraft Engineering Corp.

Mr. J. A. Kies
Head, Ballistics Branch
Mechanics Division
Naval Research Laboratory

Mr. Wilbur Marks
Executive Vice President
Oceanics, Inc.

Dr. William R. Osgood (Retired)
Professor of Mechanics

Dr. Manley St. Denis
Chief Scientist
National Engineering Science Co.

Dr. G. M. Sinclair
Research Professor of Theoretical and
Applied Mechanics
Department of T.A.M.
University of Illinois

Mr. Merville Willis
Naval Architect
New York Shipbuilding Corp.

Professor Raymond A. Yagle
Professor of Marine Engineering
University of Michigan

NOTE: Membership is made up of three-year appointments, one-third of the appointments being made annually.

CHAPTER IV

PROJECTS AND REPORTS

Description of Items in 1965-1966 Program.

SR-153, "Ships Response Statistics," Lessells & Associates, Inc.

The objective of this project is to obtain long-term data on vertical bending experienced by various types of ships operating on different routes. These data will enable the prediction of extreme values of these loads which, when appropriately combined with the other loads to which a ship is subjected, will establish the basis for rational design of the hull structure. A report has been submitted on data collection in two C-4 dry cargo vessels in North Atlantic Service for over 12,000 ship-hours of operation. The results of this long study have been fed into another program for detailed analysis and have guided the present continued data collection projects. The unit on the S.S. Mormacscan is securing data on another type ship in a different trade route, and a new installation on the S.S. California Bear will yield data on a Mariner in Pacific service. One ship, the S.S. Wolverine State has been instrumented to record the effects of slamming on pressure distribution and on ship and bow accelleration and to obtain an automatic measurement of wave height directly associated with the induced bending moment.

SR-165, "Bending Moment Determination," Stevens Institute of Technology,
Mr. Edward Numata

Since the results of previous model testing being carried out in this project have shown promise of yielding significant conclusions in the field of distribution of bending moments, the next step will be an attempt at correlation of wave bending moment data on models and full-scale ships. A program of model testing is being carried out on a model of the ship used in the full-scale tests, instrumented to measure wave bending moments at a location corresponding to that on the full-scale ship. Tests will be conducted in waves of various levels, of various levels of severity, and at direct and oblique headings to provide conditions directly comparable with the long-term distributions of ship bending moment as a function of sea state.

SR-171, "Ship Statistics Analysis," Webb Institute of Naval Architecture,
Professor E. V. Lewis

The basic data from SR-153 and SR-165 are aimed at a long-range objective of serving ultimately for revising and improving ship structural design. To accomplish this, the data from both projects are being analyzed separately and collectively on bases that will be pertinent to this aim. A typical analysis would result in long-term prediction of bending moment distribution for several ship types and loadings over typical trade routes. With adequate correlation factors derived from such studies, the long-term performance of new or unusual ship types could be predicted.

SR-174, "Ship Computer Response," Dr. W. Kaplan, Oceanics, Inc.

The purpose of the project is to explore the degree and extent to which the hull-girder bending-moment response of a ship to given wave conditions can be predicted by computer technique. It is believed that the extensive records built up within several Ship Structure Committee programs can serve as an excellent base for extending and confirming computer techniques to the study of cargo ships.

Plans are now underway for a project of computer simulation of ship structural behavior to be realized in three basic steps:

1. Assembly of a system of equations that adequately describes the ship response to wave action. Adequacy would be established by key calculations for comparison with known results.

2. Conversion of the equations to a computer program or to the design of a computer analog.

3. Verification of the entire procedure using data from full-scale tests already reported.

SR-175, "Rational Ship Design," Dr. M. St. Denis, National Engineering Science Company

The purpose of this investigation is to study the possible value that may accrue from the rational rather than the emperical procedure in the design of ships.

The clearly indicated procedure for investigating this approach, is through the medium of computer techniques. The program will be within the following framework: to optimize, on a rational basis, the design for midship section under currently recognized design bending-moment loading for the hull girder. The program should be capable of optimizing on minimum weight with provision for, at a later date, extending to other criteria. The study will be directed toward a standard dry-cargo ship on which design and costs are available.

SR 173, "Ship Stiffness Studies," Dr. M. St. Denis, National Engineering Science Company

A program has been undertaken to study the factors that affect the deflection criterion so that a sound, well-substantiated basis can be set up for the degree of stiffness acceptable in ship design and operation.

There are many possible effects of decreased stiffness, but the most important seems to be the stress amplification due to whipping, slamming, etc. These effects can be studied only through computer techniques. As this effect is rapidly becoming a matter of great importance in advanced ship design, a research program has been set up to investigate it within the following framework:

> A program to investigate the dynamic effect of impulse loading on a ship as effected by decreased stiffness, such decrease resulting from reduced moment of inertia only. The program will be set up so that additional studies of the effect of the changes of vibration amplitudes and frequencies can be studied at a later time. Suitable data for confirmation will be sought among current statistics.

SR-162, "Optimum Composition--Experimental," Lehigh University Dean R. D. Stout

This project has been concerned with developing methods of testing plates over 1 in. in thickness for their applicability to ship structures and with testing at least one steel composition suitable for this usage. A report now in course of preparation describes one steel composition which is commercially available and has successfully passed the test criteria set up earlier in the program. Final metallurgical studies will aid in the correlating these findings with other studies related to steel performance.

SR-136, "Metallurgical Structure," Massachusetts Institute of Technology,
Professor Morris Cohen

The overall purpose of this long-range program has been to study the metallurgical factors that govern the brittle behavior of ship steels. The research carried out over these years has developed to a major degree the fundamental principles of brittle fracture as related to ship steel. It has now been shown how these findings, which were obtained

on special steels applied to the case of ABS-B and C steels. Several comprehensive reports have been or are in course of being prepared covering the many facets of this extensive investigation.

SR-158, "Macrofracture Fundamentals," Brown University, Professor C. Mylonas

Work in this project has concentrated on the various means which can embrittle an otherwise normally ductile steel and has pointed out the major significance of compressive plastic prestrain and strain aging as mechanisms which can cause embrittlement. It has also been shown that temperature of straining is very important and that straining in close proximity to a notch is critical. It is expected to show how these effects can develop in weld zones. This explains why welding is so influential.

SR-164, "Local Strain Measurement," Battelle Memorial Institute, Dr. George Hahn

The purpose of this project is to obtain information on the strain field, and how the plastic behavior in the microscopic region at the tip of a notch is changed as material properties or test conditions are changed. Previous work has resulted in the development of excellent techniques not available previously for revealing plastic strains near notches and cracks in silicon steel. Recent work has extended some of this capability to low-carbon steel. Because of the significant progress that has been made in visualizing the plastic patterns adjacent to notches this work has been continued.

SR-169, "Simulated Performance Testing," Southwest Research Institute, Mr. Andrew Pickett

The purpose of this project is to develop a prototype test structure and procedure that will adequately represent brittle type performance. Work on this project is now underway with the construction of a large testing machine and the development of a suitable test specimen in which the effects of materials, specimen configuration, welding procedures, etc., can be properly studied for their effect on brittle performance of large unit structures similar to those in ships.

_____, "Shipyard Flaw Evaluation--Special ad hoc N.A.S. Committee

The purpose of this project is to recommend steps that can be taken toward uniform inspection procedure and standards adapted to the shipbuilding industry. Principal activity has been to set up a series of radiographs and accompanying radiographic procedures, showing acceptable type and degree of flaws in a manner similar to that already in use in other large fabrication industries as pressure vessels, bridges, etc. It is expected also to identify the capability of other techniques such as ultrasonic and dye penetrant methods. This is now in draft form and is being studied by several interested groups.

Reports Published and Distributed by the Ship Structure Committee Since the "Biennial Report" dated 1 December 1965

SSC-165, Local Yielding and Extension of a Crack Under Plane Stress by G. T. Hahn and A. R. Rosenfield. December 1965.

SSC-166, Reversed-Bend Tests of ABS-C Steel with As-Rolled and Machined Surfaces by K. Satoh and C. Mylonas. April 1965.

SSC-167, Restoration of Ductility of Hot or Cold Strained ABS-B Steel by Treatment At 700 to 1150 F. by C. Mylonas and R. J. Beaulieu. April 1965.

SSC-168, Rolling History in Relation to the Toughness of Ship Plate by B. M. Kapadia and W. A. Backofen. May 1965.

SSC-169, Interpretative Report on Weld-Metal Toughness by K. Mesubuchi, R. E. Monroe and D. C. Martin. July 1965.

SSC-170, Studies of Some Brittle Fracture Concepts by R. N. Wright, W. J. Hall, S.W. Terry, W. J. Nordell and G. R. Erhard. September 1965.

SSC-171, Micro-and Macrocrack Formation by B. L. Averbach. October 1965.

SSC-172, Crack Estension and Propagation Under Plane Stress by A. R. Rosenfield, P. K. Dai and G. T. Hahn, March 1966.

SSC-173, Exhaustion of Difficulty Under Notch Constraint Following Uniform Pre-Straining by C. Mylonas, S. Kobayashi, A. Armenakas

SSC-174, Investigation of Residual Stresses in Steel Weldments by K. Masubuchi, D. C. Martin

SSC-175, Mechanical Properties of High Manganese Low Carbon Steel for Welded Heavy Section Ship Plate by R. D. Stout, C. R. Roper, Jr.

CHAPTER V

FIVE-YEAR PROGRAM FOR SHIP STRUCTURE COMMITTEE RESEARCH

GOALS

The long-range goals of the Ship Structure Committee are:

a. To sponsor a program of research which will provide a sound basis for

(1) Designing of more efficient ship structures of the same or greater safety than are currently used.

(2) Adoption of new materials of greater strength-weight ratios than are currently used as a possible avenue to increased cargo carrying capacity.

(3) Assuring the adequacy of ship construction incorporating the new design methods and the new materials with a view to decreasing the cost on the life cycle of ships.

b. To disseminate the results of such a research program promptly and in language readily understandable by the Ship design and shipbuilding industries.

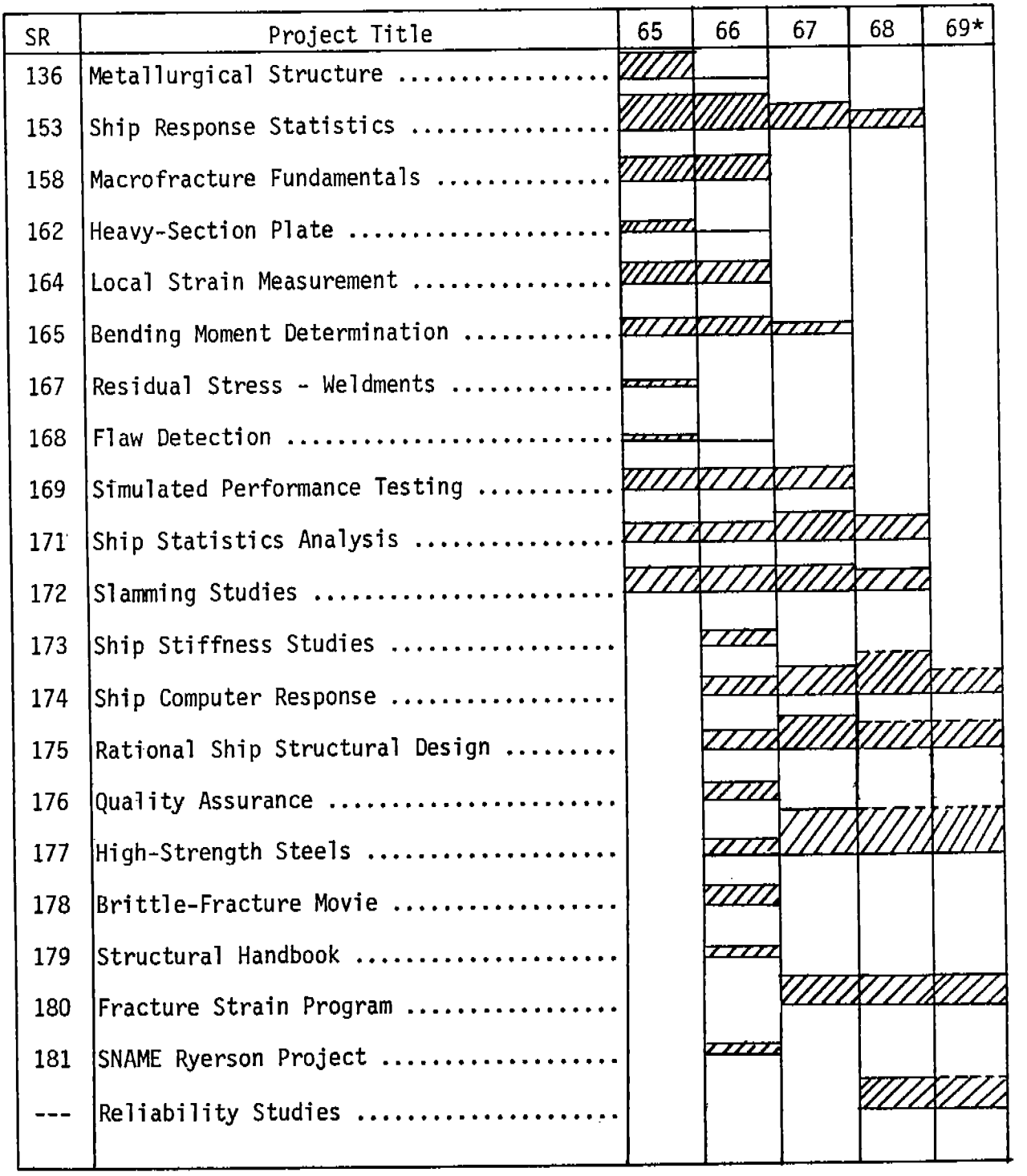
The goal of research sponsored by the Ship Structure Committee for the next five years will be to secure such data and make such analyses and studies as are needed to provide a sound basis for improved structural design and construction of modern merchant vessels of the several types required to meet the needs of up-to-date U.S. Merchant Marine.

To these ends emphasis will be placed on (1) obtaining more complete knowledge of loads on and response of ships under a wide spectrum of service; (2) studying ship model and computer techniques for their usefulness as aids to appraising new designs and forecasting performance; (3) exploration of new or modified design principles and the choice and efficient use of material; and (4) minimizing the effects of design and construction restrictions and conventions that limit design freedom and increase costs. It is the aim of this five-year program not only to advance in a major way the understanding of the principles whereby improved merchant ships can be designed and built but to provide the data and justification needed to warrant the indicated changes in regulations and classification rules.

The basic program implies work in several distinct but related areas; first, collection and analyses of data concerning the character and distribution of seaway-induced loads on a ship and of the ship response to such loads, with parallel tests on ship models and correlated computer studies; second, studies of how the ship should best be designed to withstand such loads and to meet a low-cost criterion; third, studies of alternate structural materials and of their fabrication characteristics; and fourth, studies of quality control techniques as applicable to shipbuilding operations and requirements.

In setting up this moderately long-range program, it is assumed that the annual budget during the period would not be less than now holds. Figure V.1 gives the planned distribution of SSC projects and relative budgets for the years 1965-1969.

SSC PROJECTS AND RELATIVE BUDGETS - 1965--1969



Notes: Height of bar ≈ relative budget
////// = probably continued; level determined later
——— = Investigators writing final reports
* = 1969 Areas of work, not necessarily project continuation

May 1966

Figure V.1

LOAD AND RESPONSE STUDIES

The scope of research for this phase is:

(1) to obtain direct comparative information for several typical ships on trends of seaway-induced maximum bending moment as related to wave proportions and spectrum, ship characteristics, loading, and speed.

(2) to increase our understanding of the nature, level and distribution of the hydrodynamic loads on ship hulls (this includes slamming and other seaway loads).

(3) to determine correlation of model and full-scale ship response and the applicability of computer techniques to ship design.

A number of specific research projects were proposed in this area in a report SSC-124, "A Long-Range Research Program in Ship Structural Design," dated November 30, 1959. These have served as a basis for much work since then. In planning for the projects which should be undertaken during the next five years, it was recognized that this earlier analysis of the research necessary in ship response should be updated. Much recent work has been published around the world, it needs assembling, and correlating to give a clearer picture of the present needs for research in this area and to formulate justification for and aims of future research. It is therefore considered that a necessary precursor to a long-range program would be a reappraisal of the program aims in the field of dynamic ship response. This analysis should indicate what data or experience are yet needed, how it should be obtained and for what type of analysis or application it is intended.

Pending the results of the above study, research will continue or be initiated in the following project areas. It is believed that none of these projects will become too involved to permit moderate or radical revision if so indicated by the above study. It is recognized also that alternate projects may develop from this or other programs and these may be introduced if they offer more promise of meeting the goal of the program.

Figure V.2 gives the relative tie-in of the projects for 1966-67.

Item 1. Statistical Studies of Seaway Loads Aboard Ship

Objective: To obtain records, adequate for statistical analysis, of vertical longitudinal wave-bending moments experienced by various types of ships operating on different trade routes, with the emphasis being placed on extreme values of external loads. Measurements will also be made of S & P peak-to-peak stress. Sea-wave characteristics and sea state will be defined by both observation and by ship-borne wave recorders and will be coordinated with the response data records. These data will be analyzed not only for the trends in ship response to its environment but also for the long-range predictions of the expected service and performance of the ship class. Appreciable work has been done in this project area and it is planned to broaden the coverage to include not only additional types of ships but also different sea routes so that the ships will have been exposed to a very broad spectrum of sea states, weather, loading, etc. Current work is under SR-153, "Ship Response Statistics," at Lessells & Associates, Inc., and the analysis is being done by Webb Institute of Naval Architecture, SR-171, "Ship Statistics Analysis."

Item 2. Response to Ship Hulls to Slamming Loads

Objective: To measure the distribution, level and type of pressure load on hull structures caused by slamming, correlate these data with associated sea and motion data and determine the elastic response of the hull to these impact loads. Compare the experimental results with those derived from extensive theory. Determine the effect of hull form and of such hull structural characteristics as damping, framing, bottom design, etc. Current work in this research is under SR-172, "Slamming Studies" at Lessells & Associates, Inc.

SSC RESEARCH
1966-67

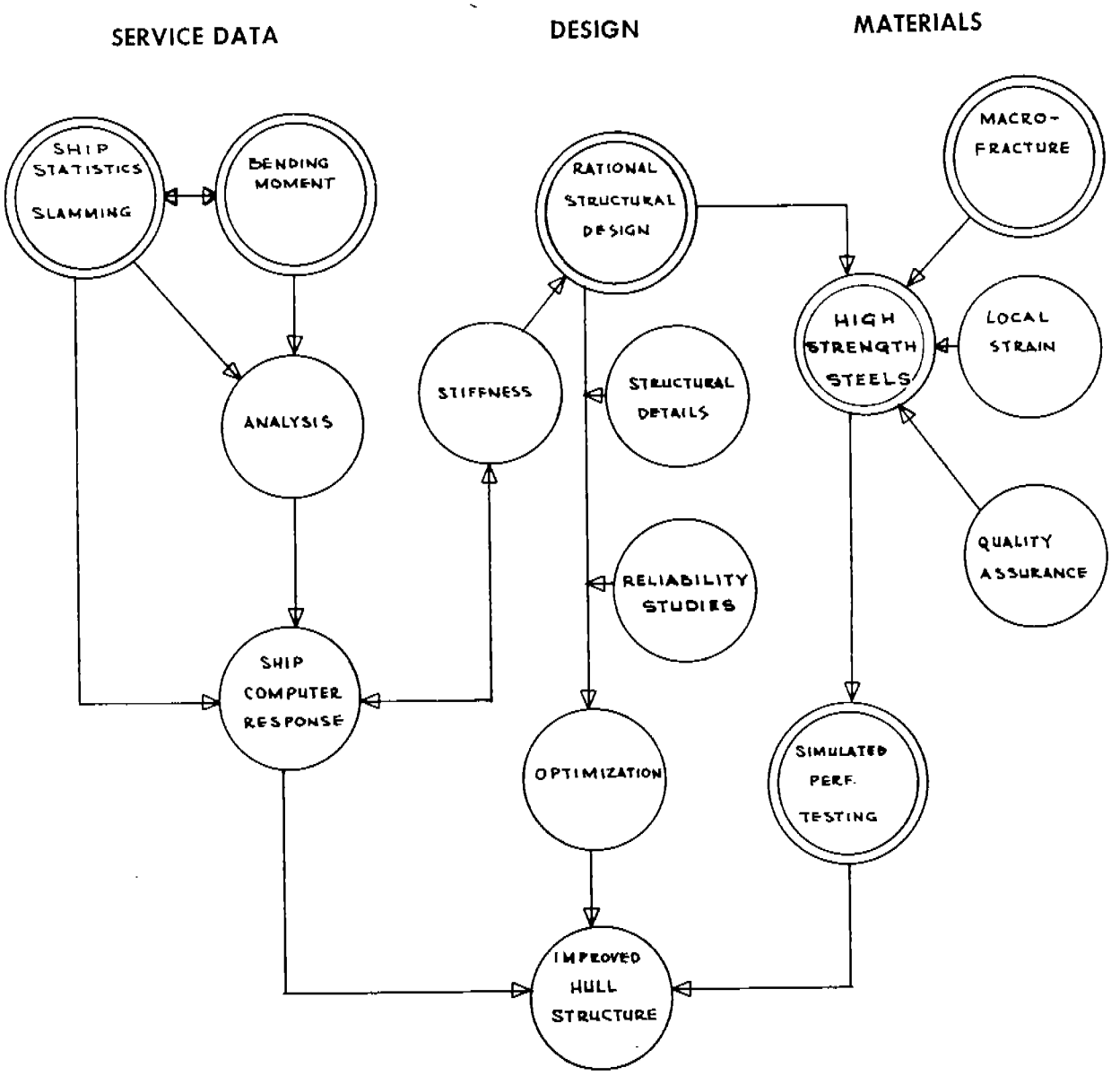


Figure V.2

Initial work on this item has been authorized in the 1965 budget to be closely coordinated with the "Statistical Studies of Seaway Loads on a Ship."

Item 3. Computer Simulation of Ship Response

The purpose of this item is to develop computer simulation of ship response to hydrodynamic and static forces of the sea. Following the development of a suitable and confirmed program, this technique can be used to predict maximum bending moment, and the relation between design factors and loads as in study of whipping and slamming and to confirm the indications of novel designs. The first steps toward setting up a confirmed program are now being carried out under SR-174, "Ship Computer Response" at Oceanics, Inc.

Item 4. Model Testing

Objective: To determine by model tests the response in respect to level and distribution of longitudinal wave-bending moments of models of full-scale ships in Item 1. This will be on the basis of regular as well as random irregular waves and over a broad enough spectrum to encompass the sea conditions experienced by the full-scale ship. It will also study horizontal bending moment as well as torsion effects. The data will be used to check available theories and to develop correlation factors with full-scale ships. Such analysis should give an insight into the maximum bending moment that might occur under most adverse conditions.

Appreciable work has been done in this general area and work which is now planned should, within three years, provide abundant data whereby correlation with full-scale ship performance can be studied. Current experimental work is under SR-165, "Bending Moment Determination," at Stevens Institute of Technology, and analyses are being made by Webb Institute of Naval Architecture under SR-171, "Ship Statistics Analysis."

STRUCTURAL ANALYSIS AND DESIGN

The scope of research for this phase is:

1. To set up bases for rational design of ships.
2. To study means of liberalizing certain criteria that restrict design flexibility.
3. To evaluate the use of higher performance steels and alloys.
4. To seek the optimum distribution of material.
5. To set up bases for design of larger, longer and/or faster ships, and ships having unusual characteristics such as excessively wide hatches, provision for cryogenic cargoes, etc.

To accomplish these ends, research will be undertaken or continued on the following project areas. It is recognized that alternate projects may develop from this or other programs and these may be introduced if they offer more promise of meeting the goal of the program.

Item 5. Development of Principles of Optimum Structural Design

Objective: It is the purpose of this project to determine (1) to what degree and in what elements of the design the rational approach to design procedures will produce an advantage over the empirical method; (2) to study the possibilities for more efficient utilization of steel that might lie in modifications of conventional structures; (3) to explore on a wide front the advantages and penalties from the design standpoint to the use of steels with higher yield and tensile strength, considering the effect of cargo handling and stowage on internal ship design.

Throughout these studies the analysis will probably be optimized for minimum weight in order to have a common basis; however, in certain instances minimum cost may be more determinant. The first steps in developing a computer program to assist in the rational design approach are under way in SR-175, "Rational Ship Structural Design - National Engineering Science Co.

Item 6. Limiting Design Criteria

The purpose of the project is to study the basis on which certain standard criteria have been set up and to develop data to determine whether they should and can be liberalized. A typical example is the ratio $L/D \leqq 14$ which is intended to control stiffness of the hull structure, but which in combination with other design factors limits freedom to improve design. The extrapolation procedures for ship lengths above 600 ft. are another example. A project, SR-173 "Ship Stiffness Studies" - National Engineering Science Company is currently developing the computer program for exploring the dynamic effect of impulse loading on a ship as affected by decreased stiffness, such decrease resulting from reduced moment of inertia only.

Item 7. Review of Methods of Computing Midship Bending Moment

The purpose of this project is to study the bases for the current method of computing the midship bending moment. With projected increased deflections, the use of thinner scantlings and the aim of rationalizing the design require that the computation of the basic element of the design be as nearly in accordance with the facts as possible. Part of this problem is tied in with other work in requiring a more exact description of the loads on the ship.

PROJECTS RELATING TO MATERIALS

Item 8. Brittle Fracture Research

Most of the long-range research on brittle fracture as related to normal ship steels will have been terminated as of the end of 1966. Several terminal reports are expected covering long-range projects the experimental portions of which were completed in 1965-6.

The work previously carried out under SR-164, "Local Strain Measurement" at Battelle Memorial Institute has taken a broader objective and is now a new project and is now SR-180 "Fracture Strain Program".

Item 9. Simulated Performance Testing

The purpose of this project is to develop a prototype test structure and testing procedure that will adequately represent the brittle type of service failure of cargo ships.

The large testing device has been constructed and suitable material secured. It is expected that testing will be well underway in the fall of 1966.

Item 10. Materials for Cryogenic Service

The purpose of this item is to study such factors relating to the design and performance of cryogenic equipment and structures on shipboard as are specific to ship design and service or are needed in order to assure safety of ship structures.

Item 11. Higher Performance Steels and Alloys

The purpose of this item is to study such factors relating to the use of steels with yield or tensile strength higher than present approved steels as are specific to ship design and service or are needed to confirm their acceptability in fabricated structures on shipboard. The possibility of increased susceptability to corrosion and fatigue with the use of lighter structures of different materials is recognized and will be part of these studies. Two projects are planned under SR-177, High Strength Steels: They are aimed at defining the criteria concerning strength and toughness needed for ship structures and means of repair welding such steels under conditions where the desired procedures cannot be applied.

Item 12. Quality Control Criteria

The purpose of this item is to develop a classification of weld defects as disclosed by standard nondestructive techniques, and recommend acceptance standards applicable to ship fabrication. The report on this project is now in the course of publication, will be widely distributed and comments will be sought in one year for possible revision.

CHAPTER VI

AMERICAN COUNCIL OF THE INTERNATIONAL INSTITUTE OF WELDING

The Ship Structure Committee, American Welding Society and the Welding Research Council make up of the American Council of the International Institute of Welding. The council co-ordinates the participation of the U.S. Government and U.S. universities and industrial concerns in the work of the International Institute of Welding, IIW.

IIW has the following commissions which meet annually:

Commission
- I - Gas welding and allied processes
- * II - Arc Welding
- III - Resistance welding
- IV - Documentation
- * V - Testing, measurements and control of welds
- VI - Terminology
- VII - Standardization
- VIII - Hygiene and safety
- * IX - Behavior of metals subjected to welding
- * X - Residual stresses and stress relieving
- XI - Pressure vessels, boilers and pipelines
- XII - Special arc welding processes
- * XIII - Fatigue testing
- XIV - Welding instructions
- * XV - Fundamentals of design and fabrication for welding
- XVI - Plastics

The Chairman of the Ship Structure Committee and the Chairman of the Ship Structure Subcommittee are members of the American Council's Executive Committee.

Present officers of the American Council are:

Dr. I. A. Oehler, Chairman
Rear Admiral J. B. Oren, USCG, Vice Chairman
Edward A. Fenton, Secretary-Treasurer

Ship Structure Subcommittee membership on this council is provided by the chairman and Secretary of the Ship Structure Subcommittee.

*Indicates commissions which are of particular interest to the Ship Structure Subcommittee and to which sponsorship of experts is provided.

CHAPTER VII

STATISTICAL REPORT OF STRUCTURAL FAILURES OF STEEL MERCHANT SHIPS THROUGH MARCH 1966

This appendix is a continuation of the reports of casualties in the Final Report of a Board of Investigation to Inquire Into the Design and Methods of Construction of Welded Steel Merchant Vessels, dated July 15, 1946, four Technical Progress Reports, subsequent Annual Reports issued by the Ship Structure Committee between 1960 and 1962, and the 1964 Biennial Report.

In accordance with the practice inaugurated in the Fourth Technical Progress Report, only Group I fractures are reported. A Group I fracture is one that is at least ten feet long and has weakened the main hull structure sufficiently either to sink the ship or place it in a dangerous condition until adequately repaired.

GROUP 1 CASUALTIES FROM 31 OCTOBER 1963 TO 31 MARCH 1966

(Continued from Ship Structure Committee Biennial Report of 1 May 1964, 1965)

ABS code	Type	Yard	Deliv. date	Cas. date	Loading	Sea cond.	Wind force	Ship speed	Air temp.	Sea temp.	Location of fracture	Origin of fracture	Remarks
380	Bulk Carr. 600'L	Brodogradil-iste 3 May (Rijeka)	7-64	12-64	Pellet-ized iron ore	H.W.	7 to 12		36°-45°F	43°F	Port shell plg. in way #5 d.b. tank for approx. 15' at shell fr. 113 E strake progressing through F, G, H & 1 strks.	In way riveted bilge seam E strk.	Seas confused, moun-tainous & crashing over dks. 26,230 l.t. cargo in #2, 3, 5 & 6 holds; #1, 4 & 7 holds & bal-last tks. empty. Vessel enroute Canada to Maryland.
381	Ex C4 (Conv. to ve-hicle & Contain-er Carr.)	Sun	6-44	11-64		H.W.					Mn. dk. pltg. aft end #5 hatch, fr. space 112/113, port, from hatch girder outbd. for approx. 18'.		
382	EC2	Oregon	3-43	12-64		H.W.					Mn. dk. stbd. abt. 3½' fwd. of mid-ship house for abt. 12' long & 3/16" wide.		Enroute New Orleans to Calcutta
383	EC2	Bethlehem Fairfield	1943	1-65	Scrap Metal 9,000 tons	H.W.					Broke in two and reportedly sank abt. 320 mi. S.E. of Tokyo.		
384	C1-M-AV1	South-eastern	11-45	1-65	In bal-last	H.W.	N.E.6		37°F	50°F	Stbd. mn. dk. plg. transv'ly for abt. 14' in way dk. beam #73	At extreme stbd. edge of dk. plg. about 3" fwd. of fr. #73.	Occurred near southern shore of Black Sea.
385	Cargo 432'2"L	Eriksbergs M/V A/B (Gothenburg)	6-45	2-65	In bal-last	H.W.	Gale Fc.				Port side amidships extending from shell into dk. for abt. 15'.		Ship rolling heavily
386	EC2	Permanents	1-44	12-64		H.W.					Reported #1 & 2 holds filled with water; vessel abandoned in Viet-namese waters & subsequently sank by the bows.		
387	EC2	Delta	3-44	2-65	Scrap Iron	H.W. 5' to 7' seas	S.W. 15 to 20 knots				Reported fractured #1 hold and vessel subsequently sank abt. 1200 mi. north of Oahu.		It was believed that pitching & rolling caused scrap rails to hit side of #1 hold.

388	EC2	Delta	12-44	1-65	Scrap iron		Broke up abt. 750 mi. N.W. of Honolulu.		
389	Ex C4 (Conv. to Vehicle & Container Carr.)	Sun	6-45	2-65		Moderate H.W.	Port upper dk. plg. bet. frs. 92 & 93 extending from Inbd. rivet hole of gunwale bar to rivet hole in first row outbd. of crack arrestor slot for abt. 9'	At burning scar in container stowage track cut-out.	Reasons for f (a) Notch at gap in upper container sto track; (b) Tr of stress to flange of hea section by cc welding conta age track to Occurred abre Is. off Nova
390	EC2	New England S.B.	7-44	1-65		H.W.	Stbd. side upper dk. plg. for 14'6" commencing at ship's side about 12" fwd. of line of bridge and terminating inbd.		Occurred near
391	Tkr. 497'3"L.	Burmeister & Wain, Copenhagen	1954	8-65	744 tons kerosene; 7302 tons diesel fuel		Hull sustained clean break into 2 pieces approx. 5' fwd. of midship house; fwd. section lost.		Approx. 15 mi Bahrain Islar Fractured fra way of break to be 40-50% (Classed NV)
392	EC2	Oregon S.B.	1943	1-66		H.W.	One weather dk. crack stbd. from #3 hold masthouse to gunwale, one crack port #3 hatch to gunwale, 3 corners #3 hatch cracked & numerous other weather dk. cracks; large crack side plg. in way #3 hold extending from dk. downwards.		Vessel subseq sank. Lat. 34 Long. 51 30 W Cp. 1 this ve
393	EC2	Permanents S.B.	1943	12-65		H.W.	Port side shell pl. B13 #5 hold bet. Frs. 146-151 longitudinally immediately above tank top for approx. 10'.		Occurred off coast near Br
394	EC2	Calif. S.B.	1944	1-66	Fully loaded bulk potash	H.W.	Stbd. mn. dk. plg., including gunwale angle, from Fr. 81½ at shell across hatch beam Fr. 82 about 5' inbd. of hatch corner.		Enroute Vanco Japan.
395	EC2	Oregon S.B.	1943	2-66		H.W.	Mn. dk. vertical cracks stbd. bulwark pl. near #3 hatchway, one abt. 16' long & one abt. 18', running from #3 hatchway to stbd. bulwark pl.		Occurred near

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13. ABSTRACT

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