SSC–203

ANNUAL REPORT OF THE SHIP STRUCTURE COMMITTEE

U.S. Coast Guard Headquarters
Washington, D.C.

November 1969

SHIP STRUCTURE COMMITTEE

MEMBER AGENCIES:
UNITED STATES COAST GUARD
NAVAL SHIP SYSTEMS COMMAND
MILITARY SEA TRANSPORTATION SERVICE
MARITIME ADMINISTRATION
AMERICAN BUREAU OF SHIPPING

ADDRESS CORRESPONDENCE TO:
SECRETARY
SHIP STRUCTURE COMMITTEE
U.S. COAST GUARD HEADQUARTERS
WASHINGTON, D.C. 20591

November 1969

Dear Sir:

The attached report covers the current status of the Ship Structure Committee, the organization of the Committee and descriptions of current and future research projects.

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

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

Sincerely,

C. P. Murphy
Rear Admiral, U.S. Coast Guard
Chairman, Ship Structure Committee

SSC-203

Annual Report

to the

Ship Structure Committee

1 July 1968 - 30 June 1969

U. S. Coast Guard Headquarters
Washington, D. C.

November 1969

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CHAPTER I

AUTHORITY FOR THE SHIP STRUCTURE COMMITTEE

The Ship Structure Committee was reestablished on 27 June 1968 by the Secretary of Transportation. A reprint of the authority follows:

"TO: Commandant, U.S. Coast Guard

SUBJECT: Establishment of Ship Structure Committee

"1. The standing interagency advisory committee known as the "Ship Structure Committee" is hereby approved.

"2. PURPOSE. The purpose of the Committee is to conduct an aggressive research program which will, in the light of changing technology in marine transportation, improve the design, materials, and construction of the hull structure of ships by an extension of knowledge in those fields for the ultimate purpose of increasing the safe operation of ships.

"3. MEMBERSHIP. The Committee is composed of -

A representative of the Commandant, U.S. Coast Guard, Department of Transportation
A representative of the Commander, Naval Ship Systems Command, Department of the Navy
A representative of the Commander, Military Sea Transportation Service, Department of the Navy
A representative of the Administrator, Maritime Administration, Department of Commerce
A representative of the President, American Bureau of Shipping

"4. CHAIRMAN. The member representing the Commandant, U.S. Coast Guard, is the Chairman of the Committee.

"5. SPONSOR. The Commandant, U.S. Coast Guard, is the sponsor of the Committee.

"6. FUNDING. Funds for the work of the Committee shall be obtained by the transfer of funds from each of the participating organizations listed in paragraph 3. The Committee shall control and account for the funds transferred to it.

"7. REPORTS. The Committee shall submit an annual report of its activities to the Commandant, U.S. Coast Guard. This report shall include an outline of its research program, results therefrom, and an accounting of expenditures. In addition, the Committee shall disseminate pertinent information to all parties having an interest in the building and operating of ships and to research investigators.

"8. The Committee is established in accordance with Executive Order No. 11007, Part 95 of the Regulations of the Office of the Secretary of Transportation, and Department of Transportation Order No. 1100.22.

"9. I consider that the establishment and use of the Ship Structure Committee is in the public interest in connection with the performance of the duties of the Department of Transportation and the Coast Guard.

/s/John E. Robson
Acting Secretary of
Transportation

Date: June 27, 1968"

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 Research Committee.

Description of the Ship Structure Committee Organization

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 Department of Transportation.

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.

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.

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 by the following:

Division Head, Naval Ship Engineering Center Chairman

Assistant Repair Officer
Military Sea Transportation Service

Project Engineer
Office of Research & Development
Maritime Administration

Senior Surveyor
Hull Technical Staff
American Bureau of Shipping

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

Head Structures Branch
Naval Ship Engineering Center
Contract Administrator

Roles: Acts for the Ship Structure Committee 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.

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 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 project, 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 Research Committee (SRC) is the group within the National Academy of Sciences which provides advisory service for the Ship Structure Committee. The SRC in turn is directed by the Maritime Transportation Research Board of the NAS-NRC. The Board is concerned with the broader aspects of marine transportation. 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 Maritime Transportation Research Board.

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 SSC, 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.

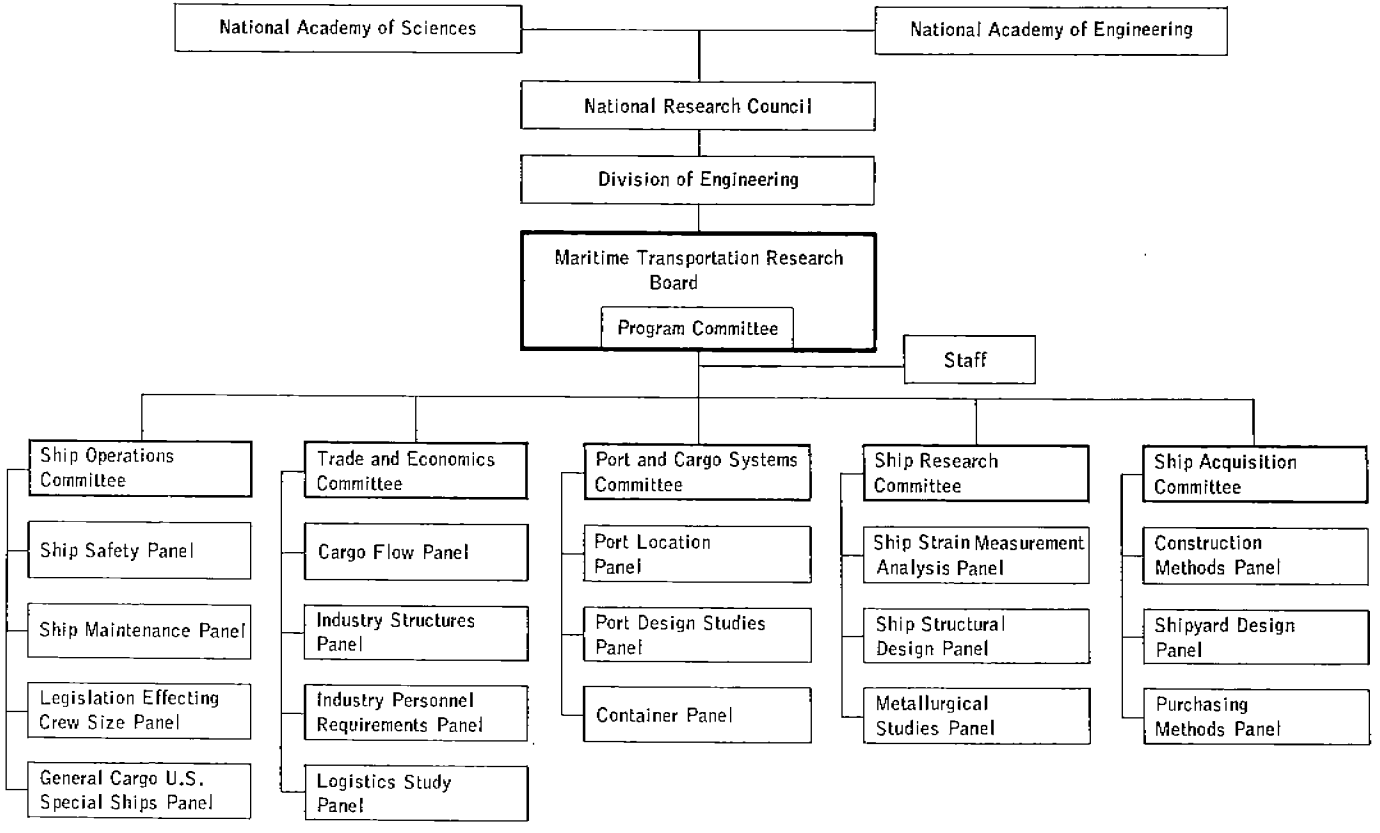
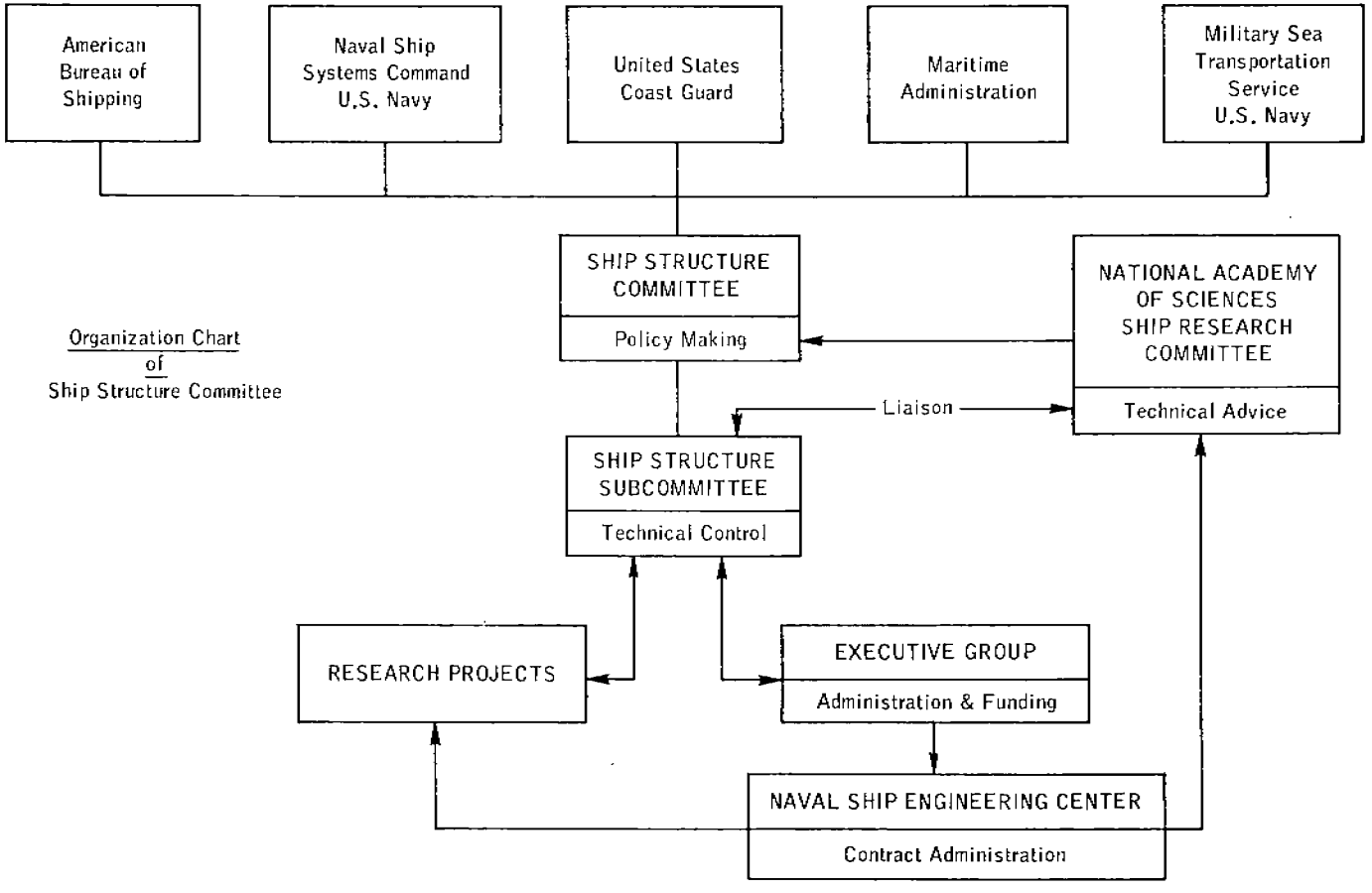

National Academy of Sciences
National Academy of Engineering
National Research Council
Division of Engineering
Maritime Transportation Research Board
Program Committee
Staff
Ship Operations Committee
Ship Safety Panel
Ship Maintenance Panel
Legislation Effecting Crew Size Panel
General Cargo U.S. Special Ships Panel
Trade and Economics Committee
Cargo Flow Panel
Industry Structures Panel
Industry Personnel Requirements Panel
Logistics Study Panel
Port and Cargo Systems Committee
Port Location Panel
Port Design Studies Panel
Container Panel
Ship Research Committee
Ship Strain Measurement Analysis Panel
Ship Structural Design Panel
Metallurgical Studies Panel
Ship Acquisition Committee
Construction Methods Panel
Shipyard Design Panel
Purchasing Methods Panel

Fig. II.2



Organization Chart
of
Ship Structure Committee

Fig. II.1

CHAPTER III

CURRENT SHIP STRUCTURE COMMITTEE ORGANIZATION DIRECTORY

Ship Structure Committee Membership

RADM C. P. Murphy, USCG, Chairman
Chief, Office of Merchant Marine Safety
U.S. Coast Guard Headquarters
Washington, D. C. 20591

Capt. W. R. Riblett
Head, Ship Engineering Division
Naval Ship Engineering Center
Department of the Navy
Washington, D. C. 20360

Capt. T. J. Banvard, USN
Engineer Officer
Military Sea Transportation Service
Department of the Navy
Washington, D. C. 20390

Mr. E. S. Dillon
Acting Chief, Office of Ship Construction
Maritime Administration
Washington, D. C. 20235

Mr. D. B. Bannerman, Jr.
Vice President - Technical
American Bureau of Shipping
45 Broad Street
New York, New York 10004

Cdr. C. R. Thompson, USCG, Secretary
Office of Engineering
U.S. Coast Guard Headquarters
Washington, D. C. 20591

Ship Structure Subcommittee Membership

Naval Ship Systems Command - U.S. Navy

Mr. J. J. Nachtsheim - Chairman
Mr. J. B. O'Brien - Contract Administrator
Mr. G. Sorkin - Member
Mr. H. S. Sayre - Alternate
Mr. I. Fioriti - Alternate

Naval Ship Research and Development Center

Mr. A. B. Stavovy - Alternate

Office of Naval Research

Mr. J. M. Crowley - Member
Dr. W. G. Rauch - Alternate

Maritime Administration

Mr. F. Dashnaw - Member
Mr. A. Maillar - Member
Mr. R. Falls - Alternate
Mr. W. G. Frederick - Alternate

Military Sea Transportation Service

LTJG T. E. Koster, USN - Member
Mr. R. R. Askren - Member

American Bureau of Shipping

Mr. R. S. Little - Member
Mr. F. J. Crum - Member

U.S. Coast Guard

Cdr. C. R. Thompson, USCG - Member
LCdr. C. S. Loosmore, USCG - Member
Cdr. L. C. Melberg, USCG - Alternate
Cdr. L. A. Colucciello, USCG - Alternate

Members, Ship Structure Subcommittee - EXECUTIVE GROUP

Mr. J. Nachtsheim, NAVSEC, Chairman
Mr. F. Dashnaw, MARAD
LTJG T. E. Koster, USN, MSTS
Mr. R. S. Little, ABS
Mr. J. B. O'Brien, Contract Administrator, NAVSEC
Cdr. C. R. Thompson, USCG. Secretary

Ship Structure Subcommittee Liaison Representatives

National Academy of Sciences - National Research Council

Mr. A. R. Lytle - Technical Director, Maritime Transportation Research Board
Mr. R. W. Rumke - Executive Secretary, Ship Research Committee
Mr. M. L. Sellers - Chairman, Ship Research Committee

American Iron and Steel Institute

Mr. J. R. LeCron

British Navy Staff

Mr. H. E. Hogben
Cdr. D. Faulkner, RCNC

Welding Research Council

Mr. K. K. Koopman, Director
Mr. C. Larson - Executive Secretary

SHIP RESEARCH COMMITTEE

Mr. M. L. Sellers, Chairman
Newport News Shipbuilding and
Dry Dock Company

Members

Dr. H. N. Abramson
Director, Department Mechanical Sciences
Southwest Research Institute

Mr. W. H. Buckley
Chief, Structural Criteria
Bell Aerosystems Company

Dr. D. P. Clausing
Senior Scientist
U.S. Steel Corporation

Mr. D. P. Courtsal
Principal Hull Design Engineer
Dravo Corporation

Mr. A. E. Cox
General Project Director
Newport News Shipbuilding and Dry Dock Co.

Mr. J. F. Dalzell
Senior Research Scientist
Hydronautics Inc.

Cdr. D. Faulkner, RCNC
Staff Constructor Officer
British Navy Staff

Prof. J. E. Goldberg
School of Civil Engineering
Purdue University

Mr. J. E. Herz
Chief Structural Design Engineer
Sun Shipbuilding and Dry Dock Company

Mr. G. E. Kampschaefer, Jr.
Manager, Application Engineering
ARMCO Steel Corporation

Prof. B. R. Noton
Department of Aeronautics and Astronautics
Stanford University

Prof. S. T. Rolfe
Department of Civil Engineering
University of Kansas

Prof. J. Weertman
Professor Materials Science
Northwestern University

Cdr. R. M. White, USCG
Chief, Applied Engineering Section
U. S. Coast Guard Academy

Prof. R. A. Yagle
Department of Naval Architecture and
Marine Engineering
University of Michigan

Mr. R. W. Rumke
Executive Secretary

MEMBERSHIP OF ADVISORY GROUPS
(Ship Research Committee)

Mr. M. L. Sellers - ex officio member of all
Advisory Groups

Advisory Group I, Ship Strain Measurement & Analysis

J. F. Dalzell - Coordinator
H. N. Abramson
A. E. Cox
D. Faulkner
J. E. Goldberg
J. E. Herz
R. M. White

Advisory Group II, Ship Structural Design

R. A. Yagle - Coordinator
H. N. Abramson
W. H. Buckley
D. P. Courtsal
A. E. Cox
D. Faulkner
J. E. Goldberg
J. E. Herz
B. R. Noton
J. Weertman
R. M. White

Advisory Group III, Metallurgical Studies

S. T. Rolfe - Coordinator
D. P. Clausing
D. P. Courtsal
G. E. Kampschaefer
B. R. Noton
W. W. Offner
J. Weertman

CHAPTER IV

PROJECTS

Description of Items in 1969-1970 Program

SR-153 - SHIP RESPONSE STATISTICS
Teledyne Materials Research Company

Objective. To obtain long-term data on vertical bending moments 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 which a ship is subjected to, will establish the basis for rational design of the hull structure. Four ships have been instrumented during the course of this program. From past experience with analysis of the strain measurements, a minimum of two years duration for any one ship was found desirable to develop sufficient data for statistical analysis. The switching of trade routes for the WOLVERINE STATE from the Atlantic Ocean to the Pacific Ocean in 1967 has provided an opportunity to collect data on the same ship in both oceans. The data collection for bending moment measurements, ship-borne wave measuring information, and slamming pressure profiles will be continued through the 1968-1969 winter season. This project is scheduled for termination in the spring of 1969 with a final report due in late 1969.

SR-171 - SHIP STATISTICS ANALYSIS
Webb Institute of Naval Architecture

Objective. First, analyze the data obtained from full-scale ship bending-moment tests, correlate with sea state data and develop long term predictions of bending moment. Second, to compare model test data and full-scale ship test data and determine correlation factors which will permit the projection of model test results into full-scale design data. This project tied closely with SR-153 will complete in late 1969 with a final report incorporating all data collected.

SR-172 - SLAMMING STUDIES
Teledyne Materials Research Company

Objective. To obtain full-scale ship data on loads and responses caused by slamming in rough weather. Bottom pressures, bow accelerations and hull stresses will be correlated with sea conditions to check the validity of theoretical methods for predicting the incidence and magnitude of slamming. The instrumentation has been aboard the WOLVERINE STATE for the past two years so far no slamming has been recorded. Instrumentation for SR-172 and SR-153 are common and data gathering for both projects will terminate in the spring of 1969. A final report will be completed in late 1969.

SR-174 - SHIP COMPUTER RESPONSE
Oceanics, Inc.

Objective. The purpose of this project is to develop suitable analytical and computational methods to predict ship dynamic response caused by ship-wave interaction. The first phase, now complete, was the development of the dynamic-response equations. The second phase, also completed, was the development of a computational method to exploit the analytical development. The third phase, which will provide verification of the analytical-computational method by comparison with available experimental data, is now underway and is scheduled for completion in 1969.

SR-177 - HIGH-STRENGTH LOW-ALLOY STEEL WELDMENTS
Southwest Research Institute

Objective. The purpose of this project is to study the factors which affect the adequacy of high-strength low-alloy steel weldments for commercial ship usage and environment. It encompasses the required mechanical properties of the weldment; the appropriate welding electrodes, acceptable welding processes, required welding procedures - and the qualification of the welding procedures. A means for evaluating the finished weldment, for evaluation of fatigue and for determining the influence of corrosion will be studied by this research. The goal is a laboratory specimen and test which, with correlation with large-scale specimens and tests, can be used to accept or reject proposed weldments. Phase I was a survey of current shipyard practices and procedures and a recommendation for temporary repair practice. Large-scale tests to determine weldment strength will be performed in Phase II. During Phase III, a test procedure and specimen for evaluating weldments will be developed and verified by comparison with large-scale tests of Phase II. The survey of Phase I has been completed and a report is being written. Phase II is nearly complete and work on Phase III has started.

SR-180 - FRACTURE STRAIN PROGRAM
Battelle Memorial Institute

Objective. This project is intended to develop a technique which will permit fracture analysis from basic material characteristics. Experimental and analytical research is being undertaken over a three-year contract period to describe a comprehensive analysis of fracture in ship materials. The project started in late 1967. A cantilever test specimen

which permits a time variable stress field and resulting crack quenching has been developed. Using the wedge opening cantilever specimen a tentative criteria for fracture has been developed.

SR-182 - CONTAINER SHIP RESPONSE
Teledyne Materials Research Company

Objective. To gather full-scale data on a containership with particular emphasis upon torsion response of the "open deck". Longitudinal bending moment, transverse bending moment, torsion and rigid body ship motions will be measured and correlated with sea state. Sea state will be measured by expendable wave buoys. The ship selected is a modified C-4 hull operated by SeaLand, Inc. with some 83% of the main deck removed for container access. Research engineers will ride the ship during the winters of 1969 to 1970 to collect and analyze data. The first season of 68-69 hampered by strikes and installation difficulties was moderately successful. After one season of experience the project should provide much useful data during the oncoming season.

SR-183 - HULL GIRDER MODEL STUDY
Mithras, Div. of Saunders Assoc., Inc.

Objective. To investigate the response of a hull girder as a composite of separate elements by using a ship-like box girder model. The response of this hull model, loaded in bending, should be tested past the buckling limit to failure, under flexural loads, under hydrostatic loads, and then under a combination of these. In addition to establishing the ultimate or failure load, some of the variables that can be evaluated are the value of high-strength steels, and the effect of varying degrees of fabrication mismatch.

SR-183 was the first phase of this program and was a feasibility study of the model and test procedure. Project SR-193 is the next phase of the program and will be described later. A third phase, Design of Hull Girder Model and Test Fixture will be included in the 1970 program.

SR-184 - CHEMICAL TANK-BARGE DESIGN
Electric Boat Div. of General Dynamics

Objective. To develop a suitable design procedure for large cylindrical low-pressure liquid cargo tanks supported by multiple saddles and carried on barges. The project was divided into three phases of which SR-184 was the first phase. This phase now completed was a feasibility study to outline current design procedures, to define the basic theory of approach and to propose an experimental program to gain necessary data for application to the design of larger barges suitable for full ocean service. SR-194, Barge Tank Saddle Reactions was an outgrowth of the Phase I study.

SR-185 - STRAIGHTENING DISTORTED WELDMENTS
Battelle Memorial Institute

Objective. To find a suitable method of straightening ship structures which have warped during welding or have been damaged by impact. The complicating factor is that flame straightening used so widely on conventional ship steels has a severe metallurgical effect on high-strength low-alloy steels. A literature search and critical review of the state of the art has been completed. A test program is now underway. This program will be extended into the 1970 program.

SR-186 - DELTA TEST VALIDATION
Lafayette College

Objective. A project sponsored jointly by Ship Structure Committee and the Pressure Vessel Research Committee of the Welding Research Council is intended to develop a new test, "Delta Test," to determine the degradation of toughness and mechanical properties caused by welding. The initial report to PVRC indicates the Delta Test is indeed sensitive to test temperature, parent material, weld procedures, etc., and, in addition, allows the fracture to follow a path of least resistance without bias from the loading system. Because of the possible application to the High-Strength Low-Alloy Steel Weldments project, a validation test was initiated to include comparison of Delta Test results with those from drop weight tests, explosion bulge tests, and Charpy V-notch tests of plate, weld, and heat affected zone. This project is expected to complete in 1969.

SR-187 - SHIP RESPONSE DATA STUDY
Teledyne Materials Research Company

Objective. To reduce to useable digital form the ten ship years of full-scale data collected by the Ship Structure Committee. The project, which requires about one year for completion, is divided into three steps. Phase I is a study to determine who will use the data, what type of data is needed and what the format of the data should be. Phase II will be development of the Computer program for recording the data in digital form and Phase III will be reduction of data to digital form. Phase I has been completed and Phase II will be started in the near future.

SR-188 - ULTRASONIC GUIDE FOR WELD FLAW EVALUATION
Naval Ordnance Laboratory

Objective. To develop a guidance document for the ultrasonic test inspection of welds in ship hull structures. The guidance document shall include: (a) Calibration of ultrasonic test equipment, (b) Recommended inspection procedures, (c) Operator training and qualification, and (d) Acceptance and rejection levels. The important points to be considered in calibration will be the transducer characteristics, the ultrasonic instrument in the laboratory and the on-site adjustment of the ultrasonic instrument. An outline of recommended inspection procedures will be presented for butt, tee and as many other weld joints as practicable. The American Society of Nondestructive Testing personnel qualification procedures for ultrasonic testing methods will be studied for possible use in the document. Acceptance and reject levels will be established by utilizing ASTM weld plates in a test program that will provide compatibility with the radiographic standards established in Ship Structure Committee Report SSC-177. This program is the first step of a continuing program of Non-Destructive Testing.

SR-189 - SHIP RELIABILITY ANALYSIS
Robert Taggart, Inc.

Objective. To conduct a survey of ship structural failures as related to types, frequency, and location in order to develop meaningful trends and to assess the possibilities of eliminating or minimizing these failures and thus increase the reliability of ship hull structures. The project should collect and analyze the data on occurences of failures of cargo ship hull structures; characterize the occurrences such as location, frequency, extent of cracking, buckling or other modes of failure; and take into account such factors of the ship structure and environment as ship form, ship characteristics, sea state, weather state, route, design detail, material of construction. This survey should not extend to ships built prior to 1956. The first phase of this program is scheduled for completion in about one year.

SR-190 - DESIGN CONSIDERATIONS FOR ALUMINUM HULL STRUCTURES
Gibbs & Cox, Inc.

Objective. Conduct a study to evaluate the benefits and constraints that will develop when ship design as well as fabrication procedures are modified to employ aluminum alloys instead of steel for hull structure of a large deadweight carrier. This project will be a feasibility study of the economic practicability of building and operating a large deadweight carrier constructed of aluminum, in direct competition with a steel ship of equivalent capability. The following aspects will be considered: (a) Develop practical and verifiable design criteria for an all aluminum ship (i.e. a deadweight carrier). (b) Using the above developed criteria for an all aluminum ship, design a ship structure of a large deadweight carrier. (c)Using the data obtained from the above aluminum design and a corresponding steel counterpart, compare the life-cycle cost of the two designs. (d) Discuss all the problem areas encountered during designs, and anticipated during construction and operation such as deflection, welding, fatigue, corrosion, and fire. (e) Outline those problem areas where knowledge is inadequate, and recommend a research program to obtain this knowledge.

SR-191 - THERMAL STRESS
Mithras, Div. of Saunders Assoc., Inc.

Objective. Develop an analytical procedure to determine and confirm by laboratory experiment, the temperature and thermal stress distribution in the hull structure resulting from the rupture of a cold cargo container of a low temperature bulk liquid carrier. Research shall be undertaken with the aim of establishing analytically and confirming experimentally the distribution of temperature and the associated thermal stresses in the surrounding hull structure of cargo vessels resulting from the rupture of a cold cargo container. This will embrace development of a methodology for determining the temperature distribution, the corresponding thermal stresses, and their experimental confirmation. This program is expected to cover one year.

SR-192 - CATAMARAN DESIGN
M. Rosenblatt & Son

Objective. Analytical research will be undertaken to predict the requirement for structural research for the design of catamarans. The following aspects should be considered: (a) Determine the considerations which may limit the principal dimensions of catamaran ships, upkeep and construction. (b) Based on these considerations, and on the present rate of technological growth, estimate the probable limits to the principal dimensions of catamaran ships by 1990. (c) Review the structural design procedures employed and design of structure for catamaran ships up to the size limits anticipated. (d) Where existing procedures and criteria appear to be rational and adequate, summarize them in the form of recommended design methods. (e) Where there are deficiencies or

gaps in existing procedures, identify these and propose a research program aimed at providing solutions to problems in the structural design of catamaran ships of the dimensions predicted by 1990.

SR-193 - SMALL HULL GIRDER MODEL
Mithras, Div. of Saunders Assoc., Inc.

Objective. Based on the recommendations of SR-183, Hull Girder Model Study, a series of tests of small scale models to determine the ultimate strength of the hull girder was undertaken. The small models are made of thin gauge material and are fabricated using electron beam welding. Stiffeners are to be attached by electron beam welding and the models will be of various complexity starting with unstiffened square tubes and with the final tests conducted on a three-bay model. Approximately 40 models of b/t ratios of 30 to 90 will be tested. The theory of applying small scale model collapse values to full scale ship hull girder is based upon two presumptions: (a) the ultimate strength of a hull girder is limited by the buckling strength of the girder and, (b) buckling strength can be scaled from small models to full scale scantlings.

SR-194 - BARGE TANK SADDLE REACTIONS*

Objective. From the recommendations of SR-184, Chemical Tank Barge Design and from review of known design information, the solution of the interaction of the tank saddle and tank response to vessel loads was the problem for which the least was known and the area that could cause the greatest damage. While the tank and barge are not rigidly attached, the long tanks supported on multiple saddles do contribute to the strength of barge tank combination and the loads are transmitted from the tank to the barge and vice versa through the saddle supports. The saddle supports are capped by a resiliant material on which the tank rests. SR-194 will be a theoretical analysis of the barge, tank and tank saddle response to external loads such as sea action and grounding taking into account the nonlinear characters of the resiliant support material, the tank saddles and the tank itself.

SR-195 - REINFORCED PLASTIC SHIP FEASIBILITY*

Objective. Glass reinforced plastic has proven suitable for small boat construction and is being considered for some naval vessels of sizes up to about 200 feet in length. Its impact resistance evidenced in small boats makes reinforced plastic a possible material for construction of hull components such as bow sections and stern sections. Considering life cycle costs, multiple vessel purchases the investigator should conduct a feasibility study of reinforced plastics of any practical combination of fibers and plastic binder. In consideration of the criteria development the investigator shall consider the intent of building rules and regulations and not their application in the literal sense.

SR-196 - COMPUTER DESIGN OF LONGITUDINALLY FRAMED SHIPS
ComCode, Inc.

Objective. In SR-175, a computer code was developed for the analysis and design of transversely framed cargo ships. It was felt important to continue work in computer analysis and to expand the program to include longitudinally framed hulls. SR-196 is a project to produce a computer program for calculating the intensity and distribution of elastic stresses and deflections for each main transverse division of a longitudinally framed ship. The method of solution combines the finite element technique with beam-on-elastic-foundation theory. Finite element analysis techniques are applied to each transverse section as if it were uncoupled from adjacent members and the longitudinal solution obtained by considering the longitudinals as resting on elastic foundations throughout the vessel length. The combining of the two techniques is considered necessary to reduce the problem size to available computers and practical computing times. This two-year effort should develop a computer code suitable for practical use in analyzing hull structures.

UNNUMBERED - DESIGN OF HULL GIRDER MODEL AND TESTING FIXTURE*

Objective. The purpose of this investigation is to conduct a preliminary design study of a hull girder model representative of the midship section of a modern longitudinally framed ship and to design a suitable loading fixture for applying longitudinal bending moments, vertical shear loads, and external pressures corresponding to either hogging or sagging conditions. Consideration shall also be given to the feasibility of simultaneously applying lateral shears and bending moments, torsion, and simulated hydrostatic pressures corresponding to rolled attitudes in a seaway. As a result of this investigation, it is intended that detailed model and fixture drawings be provided together with an estimation of costs and schedules associated with the fabrication, and instrumentation. For this purpose, only longitudinal loading fixtures need be considered.

* (Not yet contracted)

UNNUMBERED - GUIDE FOR INSPECTION OF HIGH-STRENGTH STEEL WELDMENTS*

Objective. The increased demands for high-strength low-alloy steels in the shipbuilding industry, especially for hull construction, emphasizes the need to determine if conventional welding inspection levels (nondestructive methods) in this field should be revised and upgraded. SSC-177, Guide for Interpretation of Non-Destructive Tests of Welds in Ship Hull Structures, prepared by the Academy's Weld Flaw Evaluation Committee, covers flaws for ordinary carbon steel weldments. These flaw criteria were based on test data of welded coupons and many years of service life of weldments. In general, the problem in respect to HSLA steels lies in their greater sensitivity to cracking during weld fabrication and to higher unit loading which tends to increase the propensity for fracture to develop from small defects. This project is intended to publish a recommendation for the maximum size, type and number of defects that can be accepted in welded HSLA steels.

UNNUMBERED - COLLISION EFFECT STUDIES*

Objective. The progressively increasing number of ships carrying hazardous cargo, operating in the same seas and harbors as fast cargo and other vessels, some of which are nuclear powered, is introducing a new dimension into the general problem of survival of collision damage. Design of conventional cargo vessels for survival after collision is governed by many specified, accepted and controversial practices and regulations, but the change in mode of carriage -- namely separate but relatively frail tanks or containers -- introduces many new possibilities and may require a new level of design criteria. This study will review current practice in collision analysis and outline a research program to develop criteria and design procedures to reduce the danger from collision.

UNNUMBERED - ICE EFFECT STUDIES*

Objective. The SSC wishes to initiate a research project aimed at developing data on properties of massive ice that would provide the data base needed for a design procedure for ship hulls required to travel through heavy ice formations. As a primary step in this it is desired to measure the crushing and flexural strength of ice as encountered in large ice fields and to study the various factors that affect the ease of breaking ice and the loads imposed on the ship. Suitable test vehicles or assemblies rather than a full-size ship should be designed and used to develop the loads separately.

UNNUMBERED - LOAD CRITERIA FOR SHIP DESIGN*

Objective. The desirability for a more realistic structural design procedure for ships has been recognized in many continuing SSC programs. These programs have built and are continuing to build a sound basis for such advanced design procedures. Application of improved design procedures, however, are hampered by lack of definition of complete spectrum of applied loads. Much information is available on longitudinal bending moments but this does not encompass all the loadings which must be considered. Examples of other loads that must be defined and considered in realistic design are wave-induced torsion and lateral bending moments, and inertia loads. Some loads are more important in various aspects of design than others and such factors as trade routes and cargo characteristics can be very influential in their effect on loadings. This project is an attempt to analyze existing test data from previous SSC projects and other sea tests and failure data to develop load criteria for ship designers.

UNNUMBERED - EFFECT OF HOT OR COLD FORMING*

Objective. As the use of higher strength steels becomes more prevalent in hull structures, concern can be raised about the effect of a number and type of the treatments and conditions these steels are subjected to in their processing during construction and in subsequent service. Most of these steels owe their advanced properties to a given condition of heat treatment ranging from normalized to quenched and tempered. During normal ship construction, there is the need to change the shape of a plate to conform to the contour or dimensions of the section. This can be done either at ambient temperature or after local heating to some predetermined temperature. This forming operation therefore requires deformation, either hot or cold. As some steels are sensitive to becoming partly embrittled by aging after cold or warm working and as most of these steels are sensitive to tempering temperatures it is possible that adverse effects may accompany such fabricating action. This project will research the interrelationships between amount of forming and temperature at which it was done and the resulting change in properties of the steels.

UNNUMBERED - FASTENING TECHNIQUES EVALUATION*

Objective. This study will appraise the various mechanical and adhesive joining techniques, materials and processes that have been developed in other technological areas for their applicability in cargo ship hulls and superstruc-

* (Not yet contracted)

tures. The study should include, but not be limited to, the many different kinds of adhesives and mechanical fasteners that are available. In considering the applicability of a particular technique, the investigator must carefully consider the conditions under which the fastener must be used. Some modification to these conditions can be considered as long as they are thought to be within the range of possibility for the normal shipyard. The report should present appraisals of the feasibility and scope of possible use of any promising techniques, indicating the benefits gained such as cost, low maintenance, lower corrosion, describing the value of inspection procedures and offer recommendations for further work or study -- research or otherwise that may seem warrented in this field.

SHIP STRUCTURE COMMITTEE PROJECTS

SR	PROJECT TITLE	68	69	70*	71*	72*
153	Ship Response Statistics					
171	Ship Statistics Analysis					
172	Slamming Studies					
174	Ship Computer Response					
177	High-Strength Low-Alloy Steel Weldments					
180	Fracture Strain Program					
182	Container Ship Response					
183	Hull Girder Model Study					
184	Chemical Tank-Barge Design					
185	Straightening Distorted Weldments					
186	Delta Test Validation					
187	Ship Response Data Study					
188	Ultrasonic Guide for Weld Flaw Evaluation					
189	Ship Reliability Analysis					
190	Design Considerations for Aluminum Hull Structures					
191	Thermal Studies					
192	Catamaran Design					
193	Small Hull Girder Model					
194	Barge-Tank Saddle Reactions					
195	Reinforced Plastic Ship Feasibility					
196	Computer Design of Longitudinally Framed Ships					
- -	Design of Hull Girder Model and Testing Fixture					
- -	Guide for Inspection of High-Strength Steel Weldments					
- -	Collision Effect Studies					
- -	Ice Effect Studies					
- -	Load Criteria for Ship Design					
- -	Effect of Hot or Cold Forming					
- -	Fastening Technique Evaluation					

* = Areas of work, not necessarily project continuation

Note: Height of bar = relative expenditure level.

SHIP RESEARCH COMMITTEE'S ADVISORY GROUP COGNIZANCE

Ship Strain Measurement and Analysis - Advisory Group I

SR-153	Ship Response Statistics
SR-171	Ship Statistics Analysis
SR-172	Slamming Studies
SR-174	Ship Computer Response
SR-182	Container Ship Response
SR-187	Ship Response Data Study

Ship Structural Design - Advisory Group II

SR-183	Hull Girder Model Study
SR-184	Chemical Tank-Barge Design
SR-189	Ship Reliability Analysis
SR-190	Design Considerations for Aluminum Hull Structures
SR-191	Thermal Studies
SR-192	Catamaran Design
SR-193	Small Hull Girder Model
SR-194	Barge-Tank Saddle Reactions
SR-195	Reinforced Plastic Ship Feasibility
SR-196	Computer Design of Longitudinally Framed Ships
UNNUMBERED	Design of Hull Girder Model and Testing Fixture
UNNUMBERED	Collision Effect Studies
UNNUMBERED	Ice Effect Studies
UNNUMBERED	Load Criteria for Ship Design

Metallurgical Studies - Advisory Group III

SR-177	High-Strength Low-Alloy Steel Weldments
SR-180	Fracture Strain Program
SR-185	Straightening Distorted Weldments
SR-186	Delta Test Validation
SR-188	Ultrasonic Guide for Weld Flaw Evaluation
UNNUMBERED	Guide for Inspection of High-Strength Steel Weldments
UNNUMBERED	Effect of Hot or Cold Forming
UNNUMBERED	Fastening Techniques Evaluation

CHAPTER V

Future Program for Ship Structure Committee Research

The long-range goal of the Ship Structure Committee is to aid the ship designer and ship builder to respond to the rapidly changing demands of the marine phase of our transportation system by sponsoring a research program to:

(1) Develop rational design procedures and criteria.

(2) Refine the theories of the strength of the hull girder.

(3) Foster design improvement by developing a wider selection of materials.

(4) Improve hull fabrication procedures.

Research will be performed in three related, but distinct areas:

a. Ship Strain Measurement and Analysis.
Advisory Group I

Vessel loading, deflection, strain and motion and accompanying sea and weather data will be gathered from at-sea conditions on conventional and specialized ships and barges. These data will be compared with theoretically calculated values and with results of model tests.

b. Ship Structural Design.
Advisory Group II

Specific areas of design will be investigated, including rational design techniques with computer assistance, areas of recurrent failure to identify possible trends or weaknesses, barge-tank interactions under various load and seaway conditions, verification of basic design theories through large-scale model tests.

c. Metallurgical Studies.
Advisory Group III

New and improved shipbuilding materials will be investigated. Specific areas of investigation will include:

1. high-strength steel alloys
2. reinforced plastics
3. aluminum
4. basic failure mechanisms
5. test methods and procedures

Within the above framework of general research objectives, a number of individual sub-programs have been identified. Each covers one or more facets of the overall picture but, on the whole, they constitute the primary research that must be carried to completion if the general research objectives are to be gained within the five-year period. These sub-programs are described briefly in the accompanying section for their scope and part in the overall program.

FIVE-YEAR RESEARCH PLANNING PROGRAM AREAS SCHEDULE
(in order of category priority)

Priority And Area Title	1970	1971	1972	1973	1974
			RESPONSE		
R-1-- Full-scale Data Collection	Continue container ship study. Plan for instrumentation of tank barge.	Select second container ship. Commence with tank barge tests.	Collect data on second container ship and tank barges. Plan tests on catamaran or other advanced or significant ship.	Complete tank barge and container tests. Commence advanced ship instrumentation.	Continue data collection project.
R-2--Computer Simulation of Wave Loads	Incorporate slamming response subprogram.	Expand program to various vessel types.	Validate extended program with full-scale and model data.		
R-3-- Ice Studies problem	Survey and problem definition. Define test procedures.	Experimental and analytical studies.	Model test studies.	Model and full-scale testing.	Complete projects.
R-4-- Ship Model Testing	Model tests of container ship.	Model tests of ship(s) in R-1.	Model tests of ship(s) in R-1.	Model tests of ship(s) in R-1.	Complete model testing.

Priority And Area Title	1970	1971	1972	1973	1974
R-5-- Analysis of Service Recorded Data	Evaluate present analysis approach.	Analyze data obtained in R-1, R-4 tests.	Analyze data obtained in R-1, R-4 tests.	Analyze data obtained in R-1, R-4 tests.	Summary analysis of all data for generalized conclusions.
R-6-- Thermal Studies	Possible continuation of experimental program on temperature gradients, and thermal stresses.	Evaluate project results.	Plan full-scale measurement.	Complete program.	
R-7-- Measuring Waves and Sea State		Study of possible approaches and techniques	Design and test equipment or explore suggested systems.	Continue 1972 work.	Complete.
R-8-- Vibration Studies		Survey and define problem area.	Initiate project.	Continue project.	Complete.
		DESIGN			
D-1-- Ultimate Strength of Ship Hull Girder Elements	Design large model of hull girder and loading fixtures.	Conduct model tests.	Evaluate model data.		

Priority And Area Title	1970	1971	1972	1973	1974
D-2-- Tank Barge Design	Evaluate design basis for large tanks.	Confirm design basis on models. Plan for full-scale confirmation.	Full-scale data collection and analysis.	Full-scale data collection and analysis, 2nd and 3rd ships.	Complete data collection.
D-3-- Collision Protection	Literature search and project definition.	Determine credible accident.	Develop theoretical technique.	Plan experimental confirmation.	Continue experiment.
D-4-- Computer Design of Hull	Evaluation of program developed under 1969 project.	Extension of program in relation to objectives.	Development and validation of program.	Testing of program.	Testing and adjustment of program.
D-5-- Strength of Main Transverse Webs in Very Large Tankers	Develop theory and plan model tests.	Conduct model tests and evaluate theory.	Confirm by full-scale tests.	Complete full-scale tests. Report.	
D-6-- Hull Structure Research on Advanced Performance Ships	Evaluate Catamaran Study Report and recommendations.	Initiate theoretical or experimental studies.	Survey and problem definition for other ships.	Experimental or theoretical studies.	Experimental or theoretical studies.
D-7-- Superstructures and Non-Hull Girder Structures		Analysis of superstructure design basis.	Confirmatory. model and full-scale testing.	Complete program.	

Priority and Area Title	1970	1971	1972	1973	1974
D-8-- Fire Protection		Survey and problem definition.	Experimental and testing.	Experimental and testing.	Complete.
		MATERIALS			
M-1-- Criteria Studies on High Yield Steels a. HTS - to 70,000 yield strength b. HSLA steels over 70,000 yield strength	Initiate studies of hot and cold forming.	Initiate studies on either low-cycle fatigue, hydrogen insensitive base metal, or stress corrosion fatigue.	Continue 1971 projects.	Continue 1971 projects.	Complete projects.
M-2-- Straightening Distorted Weldments	Extension of work to variety of HS steels.	Testing of procedures in shipyard.	Initiation of study of distortion in AL structure.	Complete project.	
M-3-- Fracture Technology	Appraisal of fracture technology program results.	Evaluate new theories.	Extend theories to nonferrous materials.	Test nonferrous theories	Complete test program.
M-4-- Aluminum Alloy for Hull Structures	Evaluate feasibility study results.	Initiate selected project from feasi feasibility study.	Complete project.	Commence with second new project.	Complete second project.

Priority And Area Title	1970	1971	1972	1973	1974
M-5-- Ferro-Cement for Hull Structures	Explore possible application and define needs.	Develop basic data and design criteria.	Continue with studies.		
M-6-- Glass-Reinforced Plastics for Hull	Evaluate feasibility study results.				
M-7-- Corrosion of Structures		Survey and define problem areas.	Projects resulting from 1971 studies.	Continuation of 1972 projects.	Complete or initiate new program.
M-8--Fastening Techniques for Hull Structures	Develop state of art study of applicable vs. needs.	Laboratory testing and analysis.	Full-scale application testing.		
		TESTING AND DEVELOPMENT			
T-1--Nondestructive Testing	Preparation of NDT guide for high strength steels.	Plan project for correlation of defect indication with performance.	Commence 1971 project.	Continue project summary report.	

Priority and Area Title	1970	1971	1972	1973	1974
T-2-- Reliability Studies	Evaluate 1969 project results.	Continued collection and analysis of ship reliability data.	Continue 1970 program.		
T-3--Undersea Examination and Inspection		Survey and research definition.	Project resulting from 1971 survey.	Project resulting from 1971 survey.	

CHAPTER VI

American Council of The International Institute of Welding

The Ship Structure Committee, American Welding Society and the Welding Research Council make up the American Council of the International Institute of Welding. The council coordinates 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, brazing and cutting
	II - Arc Welding
	III - Resistance Welding
	IV - Special Welding Processes
	*V - Testing, measurement and control of welds
	VI - Terminology
	*VII - Standardization and Documentation
	VIII - Hygiene and safety
	*IX - Behavior of metals subjected to welding
	*X - Residual stresses and stress relieving
	XI - Pressure vessels, boilers and pipelines
	XII - Flux and gas shielded electrical welding processes
	*XIII - Fatigue testing
	XIV - Welding Instruction
	*XV - Fundamentals of design and fabrication for welding
	XVI - Welding of plastics
Study Group	212 - Physics of the Welding Arc

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 C. P. Murphy, 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.

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SSC-200, *Index of Ship Structure Committee Reports* January 1969. AD 683360.

SSC-201, *Midship Wave Bending Moment in a Model of the Cargo Ship "Wolverine State" Running at Oblique Headings in Regular Waves* by M. J. Chiocco and E. Numata. September 1969. AD 695123.

SSC-202, *Midship Wave Bending Moments in a Model of the Cargo Ship "California*