The Design and Methods of Construction of Welded Steel Merchant Vessels

REPORT OF AN INVESTIGATION

15 JULY 1946

FINAL REPORT *OF A* BOARD OF INVESTIGATION

Convened by Order of

THE SECRETARY OF THE NAVY

To Inquire Into

THE DESIGN AND METHODS OF CONSTRUCTION OF WELDED STEEL MERCHANT VESSELS

15 JULY 1946

GOVERNMENT PRINTING OFFICE
WASHINGTON: 1947

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Foreword

Early in the war, welded merchant vessels experienced difficulties in the form of fractures which could not be explained. The fractures, in many cases, manifested themselves with explosive suddenness and exhibited a quality of brittleness which was not ordinarily associated with the behavior of a normally ductile material such as ship steel. It was evident that the implications of these failures on welded ships might be far-reaching and have a signal effect upon the war effort. Steps were taken immediately by Government and private maritime agencies, individually, to cope with this problem.

In April 1943, the Secretary of the Navy, pursuant to his responsibility through the Coast Guard for certificating vessels in accordance with the Marine Inspection Laws of the United States, established a Board of Investigation to Inquire into the Design and Methods of Construction of Welded Steel Merchant Vessels. This Board was composed of the Engineer-in-Chief, United States Coast Guard; the Chief of the Bureau of Ships, United States Navy; the Vice Chairman of the United States Maritime Commission; and the Chief Surveyor of the American Bureau of Shipping. The Secretary's directive to the Board read in part as follows: "* * * make a complete investigation of the matter hereby submitted and upon the conclusion of its investigation will report the facts established thereby. If the facts establish the existence of defects in the designs of, or in the methods being followed in the construction of such merchant vessels which in the opinion of the board adversely affect the seaworthiness thereof, the board will also submit its recommendations as to the measures which should be taken to correct such defects."

The Board appointed a Sub-Board which was ultimately composed of representatives of the four member agencies and of the War Metallurgy Committee of the National Academy of Sciences. The Sub-Board was directed to formulate in detail, and supervise the execution of, all phases of the investigation as outlined by the Board.

The Board immediately took steps to coordinate the efforts of the member agencies and embarked upon an extensive program of investigation. Technical and statistical analyses of all casualties were initiated; strength studies were undertaken of each type of vessel involved; loading and ballasting conditions were checked and analyzed; convoy routes with accompanying sea and weather conditions were examined; many specific investigations and extensive laboratory research projects were initiated, aimed at studying design, fabrication and materials used in the construction of welded ships. In addition, close liaison was maintained with private shipyards and with the British, who were also conducting studies of phases of the same problem.

In the course of the investigation a Research Advisory Committee and a Welding Advisory Committee were appointed by the Board to take cognizance of pertinent research and to survey shipyard welding practices, respectively.

The investigation has been in progress for more than three years. During that time two interim reports have been made to the Secretary of the Navy, the first dated 3 June 1944, and the second dated 1 May 1945.

This is the third and final report of this Board. It is intended to cover all phases of the Board's activity during the entire period of its existence. This report follows the outline established in the interim reports. All salient results are discussed, findings listed and conclusions drawn. At the end of the report recommendations are made for future work which appears to be necessary or desirable in the solution of unfinished phases of the problem.

Appended to the report are three exhibits:

- EXHIBIT I —Statistical Analysis of Structural Failures on Welded Steel Merchant Vessels.
- EXHIBIT II —Summary of Research Investigations.
- EXHIBIT III—Survey of Shipyard Welding Practices.

References made to the exhibits and sources not appended to this report are annotated and a complete bibliography will be found appended.

Introduction

Welding is a relatively new process in the building of ships. From a meager beginning during World War I, when it was used only as an auxiliary method of fabrication and erection, welding has become a major process in the construction of steel ships, and has largely replaced riveting.

The advantages of welding in ship construction are numerous. There is a direct saving of weight in the elimination of plate laps, flanged attachments and rivet heads, which may be utilized in carrying additional useful load. In addition, the difficulties associated with riveting in making and keeping structures oil and water tight are obviated. Particularly pertinent to the establishment of new yards in connection with the accelerated program of shipbuilding prior to and during the war was the saving in time, manpower and tool manufacturing capacity effected through the use of welding in lieu of riveting. This saving was brought about by the shorter time needed in welded construction for training operators, and the availability and smaller amount of equipment required, making it possible for a new welding yard to be outfitted and in production in a fraction of the time which would have been required if the yard had been equipped for riveting.

It is safe to say that without welding it would have been impossible to build, in such a short time, the enormous fleet of ships which played such a vital part in winning the war.

There are, however, certain disadvantages connected with welding which were not fully realized at the outset of the expedited building program. Although the technique of depositing weld metal and the application of welding sequences to minimize shrinkage, distortion, and cracking were fairly well understood, relatively little was known of other, deleterious, conditions accompanying the welding process on large ship structures. Consequently, when fractures in all welded steel merchant vessels first began to manifest themselves (as in the *Schenectady*[a,60,61] and *Esso Manhattan*[62]), conditions were found which did not conform to previous experience. There was a general feeling that the accelerated shipbuilding program and the concomitant quantity production of all-welded ships had resulted in a general disregard for proper construction practices and workmanship. It was particularly felt that insufficient care was being devoted to welding sequences, with the result that locked-in stresses were present in many ships to a higher degree than would be expected. The presence of these high stresses was considered to be an important factor in the incidence of the observed fractures.

However, it must be recognized that structural failures are not confined entirely to welded ships. A few cases of serious fractures in riveted ships are well known, such as the *Leviathan*[64] and the *Majestic*,[65] both of which suffered fractures across the strength deck. The chronic occurrence of fractures in riveted ships would have appeared in a different light if the fractures had been generally more spectacular or if the results of research of the last three years had been known at the time of their occurrence. When a crack starts in a riveted structure, it generally progresses only to the first break in the continuity of the metal, e.g., a seam. There it awaits reloading to a stress which will give it a fresh start. In a welded structure, however, the crack will continue to propagate as long as sufficient energy is available.

Particularly bewildering phenomena in the welded ship casualties were the appearance and nature of the fracture itself. It was generally believed that medium ship steel incorporated in ship structure would deform elastically when loaded within the elastic limit, and that if it were loaded beyond that point plastic flow would take place and a permanent deformation would result, evidenced by a reduction in thickness or area. If the load were increased sufficiently it was believed that the material would fail only after considerable elongation, as this is the behavior which would ordinarily be expected from a ductile material.

In the observed ship fractures, however, the fractured surface appeared crystalline rather than silky as would be the case in a ductile failure. The break was square and the line of separation normal to the surface of plate, rather than at 45 degrees as would be the case in a failure on the plane of maximum shear. Very little ductility was evidenced, as indicated by practically zero reduction in the thickness of the plate at the fractured edge. This type of fracture is termed cleavage, denoting a separation of the surfaces of the crystal lattice rather than sliding action along slip planes.

[a]Reference number listed in Bibliography.

The factors which might cause a normally ductile material to seem brittle were not understood. There was evidently a great need for fundamental study of the mechanism of fracture. As an index of the state of knowledge at the outset of the study, as well as to indicate the experimental difficulties which were encountered, it is considered noteworthy that brittle fractures in medium ship plate of ¾ inch thickness, comparable to those found in ships, were not reproduced in the laboratory until early in 1944[40,41,47].

The findings of the research program served to correlate the circumstances observed to accompany the fractures which occurred in ships. As soon as the factors contributing to failure were recognized, corrective measures were taken wherever possible.[b] Modifications of square cargo hatch corners were designed and incorporated into vessels, both under construction and already completed. Cut-outs in the sheer strake were closed and sharp structural discontinuities and changes in section were eased wherever possible. As a means of preventing the propagation of cracks which might originate in spite of other precautions, "crack arrestors" were installed in personnel-carrying vessels and in a great many others. In addition, vessels assigned to operate in low temperature areas were selected from those in which modifications had been incorporated. The beneficial effects of these remedial measures are demonstrated by the reduction in the number of casualties from about 140 per month in March 1944 to less than 20 per month during January 1946.[c]

A. *Historical Study of Hull Fractures*

The collection and correlation of information relative to fractures has been a task of considerable magnitude, involving the detailed description of each case of fracture by an observer on the scene, a classification of each case, tabulation of data, and finally detailed analyses which attempt to derive some measure of correlation between the types of fractures and their frequency, and factors which have appeared to contribute to their occurrence. The tabulation[d] presented below indicates the scope of the fracture problem with respect to major merchant vessels constructed under the Maritime Commission program and remaining in merchant service.

[b]Exhibit I, Part IV.
[c]Exhibit I, fig. 24.
[d] Data taken from Exhibit I

	1 April 1946
Total number of ships	4,694
Total number of these ships reporting no casualties	3,724
Total number of these ships which sustained casualties	970
Total number of casualties	1,442
Total number of fractures	4,720
Total cases of serious casualties (Class 1)	127
Total ships sustaining a complete fracture of strength deck	24
Total ships sustaining a complete fracture of the bottom	1

Eight vessels have been lost, as follows:

Name	Date of Casualty	Remarks
THOMAS HOOKER	5 Mar. 1943	Abandoned.
J. L. M. CURRY	7 Mar. 1943	Abandoned.
JOHN P. GAINES	24 Nov. 1943	Broke in two; abandoned.
JOSEPH SMITH	9 Jan. 1944	Abandoned.
SAMUEL DEXTER	21 Jan. 1944	Abandoned.
JOEL R. POINSETT	4 Mar. 1944	Broke in two; stern portion salvaged.
SACKETT'S HARBOR	1 Mar. 1946	Broke in two; stern portion salvaged.
FORT SUMTER[1]	10 May 1946	Broke in two; both portions scuttled.

[1] This vessel fractured after the terminal date for statistical accounting used in Exhibit I.

Four other ships broke in two but were not lost.

Name	Date of Casualty
SCHENECTADY	15 Jan. 1943.
ESSO MANHATTAN	29 Mar. 1943.
VALERI CHKALOV	11 Dec. 1943.
DONBASS III	17 Feb. 1946.

In connection with these casualties, 26 lives have been lost; 11 men from the *John P. Gaines,* missing after successfully embarking in a lifeboat, and 15 from the American-built Russian-operated vessel, *Donbass III.*

The results of the efforts to control and eliminate the occurrence of hull fractures are graphically shown in figure 24 of Exhibit I, which depicts the number of casualties for each month from February 1942 through January 1946, as well as the number of ships in operation during the same period. It will be seen that after reaching a maximum in March 1944, the number of fractures per month decreased sharply and has shown a decreasing trend ever since. The beneficial effects have been due to remedial measures in the form of improvements in workmanship, design and operation, such as the installation of crack arrestors, modifications of cargo hatch corners, elimination of square sheer-strake cut-outs for accommodation ladders, general elimination or modification of structural discontinuities, careful attention to loading and ballasting, and judicious selection of ship types for rigorous duty, especially on cold weather routes.

Photographs and data sheets pertaining to the 12 most serious casualties, which are listed above, are included in Exhibit I.

B. *Design*

1. GENERAL

One of the first steps taken in the investigation was to recalculate the longitudinal strength of all types of vessels involved in structural failures. These calculations showed that the scantlings were ample and that there was a margin of strength in every case over that required by existing standards.

Static structural tests made on riveted ships prior to the advent of welding in shipbuilding had confirmed the general validity of the basic analytical methods used in calculating the stresses in the main hull girder. However, several factors involved were considered sufficiently significant to justify making similar experiments on welded ships. These factors included: the possibility of a difference in the overall behavior between riveted and welded construction as affected particularly by the differences in rigidity and geometry of riveted and welded joints; the fact that photoelastic studies showed appreciable stress concentration at hatch corners where so many cracks occurred on Liberty ships; the development of new strain gages which permitted the measurement of highly localized strains and the determination of unusual stress distributions that might not have been discovered in previous experiments.

The desirability of subjecting welded ships to the static structural test received further impetus from the large number of hull structural failures recorded, particularly during the winters of 1942-43 and 1943-44. Those failures were not limited to any one type of vessel, but occurred in ore carriers and tankers, as well as dry cargo vessels, particularly Liberty ships.

Outstanding examples of the earlier static structural tests carried out on riveted ships were those on the *Wolf*,[1] *Cuyama*,[2] *Preston* and *Bruce*.[3] These ships were all of the destroyer type with the exception of the *Cuyama*, which was a Navy tanker. None of these vessels had a structure comparable to that of the usual merchant cargo vessel, and all except the *Cuyama* were of relatively light scantlings with thin plating. No similar data appeared to be available for vessels of the merchant type.

In the investigation to determine the structural behavior of welded ships, at least a dozen vessels of several types were subjected to the static structural test. As a result of these studies[4,5,6] the theoretical principles by which hull girder strength is computed have been found to be equally applicable to welded and riveted construction.

2. DETAIL

For operational reasons, it is necessary to introduce into the ship's hull, numerous openings, erections, foundations and so on. At every point where such a structural discontinuity is introduced, uniform straining of the material under a bending load is interrupted and concentrations result.

Until the short base length (less than 1 inch) strain gage became available, experimental measurements of strain concentrations in ships were not possible. The need for accurate determinations of concentrations was not as great in the riveted ship as in the welded ship. The monolithic character of the welded ship resulting from the method of fabrication can produce joints, particularly at structural discontinuities, that have high stress concentrations and severe restraint, thereby tending to inhibit plastic flow. This condition did not exist generally in the riveted ship. The danger of high concentration at points of structural discontinuities in the welded ship is further aggravated by welding usually present at such points. Welding produces a complex metallurgical condition which is frequently aggravated by discontinuities in the form of defects in the weld.

That stress concentrations of dangerous magnitudes actually exist at structural discontinuities in welded ships has been amply demonstrated by the numerous fractures which started at such points, e.g., hatch corners, sheer strake cut outs, defective welds, etc. In the Liberty ships, 25 percent of all fractures reported originated at hatch corners.[e] 18 percent of all fractures were found to occur in the vicinity of No. 3 cargo hatch.[e] In addition, an analysis of serious fractures showed that 24 percent started in the sheer strake cut-out for the accommodation ladder and 52 percent started at hatch corners.[e]

Investigations conducted on welded ships revealed that stress concentration factors at the inside radius

[e]Exhibit I—figs. 30, 31 and 32.

of the rounded hatch corners of a Liberty ship at deck level were of the order of 2.0. (A stress concentration of 3.4 was found in a similar corner at sea under dynamic conditions.)[f]

Accordingly, one of the first remedial steps which was taken in an effort to eliminate fractures was the modification of cargo hatch corners in the Liberty ships. Ultimately 2,047 vessels out of a total of 2,212[g] were fitted with one of several types of hatch corner reinforcements.[h] Table IX of Exhibit I shows that a substantial decrease in the incidence of fractures followed.

In an immediate attempt to stop fractures which might otherwise cause possible loss of the vessel a number of "crack arrestors" were installed in various types of vessels. These, in general, consisted of two types, one in which the deck just outboard of the cargo hatch was slotted and a riveted seam strap fitted over the slot, and a second in which either a similar slot and strap were placed in the sheer strake just below the deck line or, in lieu thereof, the deck and sheer strake were connected by a riveted gunwale angle. Altogether, crack arrestors of one or both types were installed in more than 1,400 vessels of all types. The gunwale crack arrestors functioned effectively and stopped cracks which had started in 26 cases in vessels on which they were fitted. No crack has been known to pass an arrestor.

The investigation pertaining to structural details has strongly emphasized that too much attention cannot be paid to the elimination of discontinuities (notches), whether they be small or large, and that the effect of discontinuities is aggravated by welding.

3. FULL SCALE SHIP TESTS

A great many tests on complete ships have been conducted in the course of this investigation. Various types of vessels involved in structural failures have been included in the testing program. Among them are:

Four L-6 Great Lakes ore carriers[4]
Twenty Liberty ships[5,10,23,24,27,29,30,50]
Six T-2 tankers[6,8,9,25,26]
Three C-4 troop carriers[26]
Twenty-one Victory ships[23b,27,28]
One C-2 refrigerated cargo ship[27]

Among these investigations were: full scale hull bending studies in still water[4,5,6,8,9,25,26]; an exploration of stress concentrations at structural discontinuities[5,25,50]; an investigation of the strains experienced by the hull girder of a Liberty ship when loaded in torsion;[5] tests to determine locked-in stresses including those caused by temperature variations during assembly[23 to 31], tests to determine thermal stresses in service,[27] tests to determine locked-in stresses caused by a controlled temperature differential in the insertion of a large closing deck section;[29] and the low temperature relief of residual welding stresses.[10]

[f]Exhibit II—(1cii).
[g]Exhibit I—table VIII.
[h]Exhibit I—figs. 44, 45 and 46.

C. *Materials*

1. STRUCTURAL STEEL

The incidence of serious failures of large welded steel structures both in construction and during service indicated the need for a better understanding of the fundamental factors affecting steel performance. Lack of reliable information in this field has led designers to over-design in the interest of safety, a procedure which may in some cases enhance the possibility of failure.

At the present time the mechanism of metal fracture is not well understood[32,33]. Since some plastic deformation, even though highly localized, usually precedes fractures even in the case of cleavage or so-called "brittle" fractures of structures, an understanding of the phenomenon of flow is essential in considering the fracture problem. Perhaps the best theory yet formulated involves the concepts of resistance to flow and resistance to fracture;[34] the theory postulates that if the stress required for fracture is greater than that required for flow, plastic deformation will occur; conversely, if the stress required for flow is greater than that required for fracture, rupture will take place. Flow may teminate in either shear or cleavage separation. The former is characterized by high ductility, a fibrous or silky appearing fracture generally at 45° to the direction of applied load, and high energy absorption. The latter shows relatively low ductility, a granular or crystalline appearing fracture generally normal to the direction of applied load, and in most cases, lower energy absorption. Cleavage fracture often occurs after appreciable flow. The term cleavage fracture refers to a mode of separation and is not intended to apply only to completely brittle fracture without measurable deformation, although this case is included.

Resistance to flow and resistance to fracture are extremely complex quantities influenced by a number of factors, the interrelationship of which is at present unknown. These factors[i] are: State of Stress (Constraint); Temperature; Velocity (Strain Rate); Metallurgy.

During the course of the investigation many research projects were initiated to investigate the behavior of ship steel[35 to 59]. In addition, extensive material surveys by sampling methods were made, designed to determine the adequacy of steel used in welded ship construction as judged by present physical requirements[57,58,59]. These studies indicated that steel as furnished to shipyards complies in every respect with physical requirements as they exist at the present time. In spite of this, impact tests of steel samples taken from vessels which suffered fractures indicated that in many cases the steel was notch sensitive, i.e., that its ability to absorb energy in the notched condition, and especially at low temperature, was low. In addition, it was found that some samples of the steel furnished to shipyards under existing physical requirements were also notch sensitive.

The research investigations explored the behavior of ship steel in the welded and unwelded condition under the influence of multi-axial stress in the presence of discontinuities, such as notches, especially at low temperatures. These studies indicated that notch sensitivity is an important factor in the occurrence of "brittle" failures; i.e., failures which exhibit a low degree of ductility.

In further studies to investigate the factors contributing to the cleavage failure of ship steel, tests were made on unwelded flat plates in widths varying from 12 inches to 72 inches and on large welded structural specimens[47 to 51]. These tests indicated that, in the presence of notches which are comparable to those found on board ship, ordinary ship steel may fail at nominal stresses which are considered extremely low by accepted engineering standards. It should be noted that nominal failure stresses decrease from about 45,000 p. s. i. in the 12-inch plates to stresses approximating the yield point in 72-inch plates, and in the welded structural hatch corner tests failures occurred at nominal stresses as low as 23,000 p. s. i. In connection with the latter tests it was found that two specimens welded with a 400° Fahrenheit preheat treatment showed a significant increase in ultimate strength (about one-third) over comparable specimens not preheated. However, the 400 Fahrenheit preheat had no effect upon the magnitude or distribution of residual welding stresses.

Studies of the speed with which fractures of the cleavage type propagate have disclosed that it is extremely high (about 5,000 feet per second[48]). This finding substantiates reports which have been received from the masters of vessels which have broken in two in regard to the suddenness with which such casualties have occurred.

There is a real necessity for the establishment of new specifications to include a practical test for the evaluation of the notch sensitivity of commercial steels.

2. WELDING ELECTRODES

There is no indication that inferior quality or misapplication of welding electrodes was responsible for welded ship fractures. This does not mean, however, that an improvement in electrodes and covering materials might not be beneficial. In fact, considerable variation within the applicable specification has been found in the cracking tendency of welds made with commercial E-6010 electrodes, deposited under high restraint.[28]

Specifications for welding electrodes are in the process of revision at the present time. Pilot tests[41,45,46,54] have indicated that when an estimate or measurement of service performance is desired, it is futile to make tests of weld metal, except in conjunction with the parent metal in a welded joint.

D. *Construction*

Construction methods and workmanship were believed to be responsible to a large degree for the difficulties being experienced by welded ships. It is interesting to note, in this connection, that the Welding Advisory Committee which made a survey[j] of representative shipyards, both government and private, on the Atlantic, Gulf and Pacific Coasts, found varying degrees of quality in workmanship and in methods of construction, but the analysis of structural failures failed to indicate a marked correlation between the incidence of fractures in welded ships and the shipyards' construction practices. However, with due allowance for difference in design, the ships constructed in yards utilizing sub-average shipyard construction practices showed a higher-than-average incidence of fracture.[k]

[i]Exhibit II—sec. 3a.
[j]Exhibit III.
[k]Exhibit I—table VI

The findings of the Welding Advisory Committee show the need for improvement in almost every phase of welded shipbuilding, and in particular, the need for standardization in operator training and upgrading. The identification of welding operators by degrees of skill and by individuals was found to be unsatisfactory. In most cases there was no means of tracing defective work to the operator who was responsible. Close inspection, including subsurface inspection of welds, was made in only about one-third of the yards. It was found that the piece work system which was in use by a great many yards did not serve as an incentive for good work. The supervisory organization varied between yards. The number of workmen and junior supervisors under each senior supervisor varied widely from yard to yard. The preparation of welding sequences and design of joint details was, in general, found to be satisfactory, but in many yards the sequences and edge preparations were not carried out satisfactorily. In most instances the welding engineer had been relegated to an advisory status. The result of these circumstances was inferior workmanship. High quality workmanship is still an important need in the building of welded ships.

An educational program was established by the member agencies of the Board. Instruction pamphlets were circulated by the American Bureau of Shipping[66,67], the Maritime Commission,[65] the Navy Departments[17,72], and the Coast Guard[68] for the use of their surveyors and inspectors. The Maritime Commission, Navy Department and other government agencies instigated shipyard training programs to promote better construction practices. This concerted effort markedly improved shipyard workmanship. The member agencies are jointly preparing comprehensive booklets incorporating the findings of this Board. They deal with the various phases of construction, workmanship, and shipyard organization. The first of these booklets, entitled "Shipyard Welding Workmanship",[69] already has been completed and distributed. The second, entitled "Shipyard Management for Welding"[70] is being printed. In addition, it is anticipated that two booklets will be prepared, dealing with welding supervision and inspection, and the design of ship details for welding.

The feeling that workmanship had suffered due to the pressure of wartime production programs was substantiated in the findings of the Welding Advisory Committee. The importance of maintaining adequate standards of workmanship has been clearly established by the analysis of structural failures in the past 3 years. Poor workmanship engenders fracture, since a fracture may originate at a small notch, such as is occasioned by peened-over cracks, by undercut welds, by porosity and inclusions in the weld, or by "saddle" welds resulting from incomplete penetration, which leave voids at the center of the joint.

The early importance attached to residual welding stresses and locked-in stresses directed the first research efforts to an investigation of those factors. While there had been much dicussion of these stresses, little was known of their magnitude, distribution, or their effect on the performance of welded structures. The existence of residual and of locked-in stresses was usually associated with the procedures and sequences followed in the course of welding a structure. Inasmuch as the two terms have aroused much comment in the past few years it is considered advisable here to define them in order to clarify the sense in which they have been considered by the Board.

(a) Residual Welding Stresses:
Residual welding stresses are those resulting from the welding of unrestrained members.

(b) Locked-in Stresses:
Locked-in stresses include residual welding stresses, and stresses resulting from other fabrication and assembly processes.

The results of the several research investigations bearing on residual and on locked-in stresses have been conclusive[12 to 18, 23 to 31]. It has been determined that residual stresses in the welds approximate the yield point of the weld metal in a direction parallel to the weld and are less than 25 percent of this value in a transverse direction[12 to 22]. In way of the weld metal these stresses are both tensile. The magnitude of these stresses it was found, was generally unaffected by variation in the welding procedure or assembly sequence[12 to 15].

The failure of welding sequences to show any influence on the magnitude of residual stresses should not be misconstrued to mean that the sequence is unimportant. Experience demonstrates the importance of the effect of welding sequence in the control of shrinkage, distortion and cracking during construction.

A number of means have been found for reducing residual welding stresses. Among these are mechanical stretching of the weld,[13] thermal stretching as in low temperature stress relief[11,15], peening of the last pass of the weld[13,15], and heat treatment[14,15].

It was also determined that locked-in stresses are not reduced appreciably in service[23a,23b,23c,24].

Locked-in stresses in plate areas away from welds have been found to be of low magnitude and generally compressive.

Although a large amount of work has been accomplished in the investigation of residual and of locked-in stresses, resulting in a considerable extension of knowledge in this respect, no evidence has been found to indicate that these stresses are important in causing the fractures in welded ships.

E. *Operating Conditions*

1. LOADING AND BALLASTING[l]

Early in the investigation it was suspected that the loading and ballasting methods employed in both cargo ships and tankers during the war emergency might have resulted in excessive bending moments, which when aggravated by heavy weather conditions, might be important factors in causing structural failures.

The relaxation of load line regulations, permitting the deeper loading of vessels in wartime, and the fact that most vessels made the return trip in ballast, gave additional weight to this suspicion. Accordingly, all methods of loading employed and all types of ballasting systems in use were carefully checked in each type of vessel involved and the corresponding bending moments were computed. The net result of this study was the finding that the loading and ballasting conditions did not create abnormal bending moments. This conclusion is presented graphically in figure 29 of Exhibit I.

In the case of Liberty ships, little change could be made in the loading plan, but some latitude was possible in arranging the ballasting system. Accordingly, the Maritime Commission "London Glasgow" ballasting system was eliminated in favor of the Maritime Commission 1500-ton ballasting schedule, which is now in use. This resulted in a reduction of bending moment stresses of about 4,000 p. s. i

A much wider range of loading was found possible in the case of tankers, where, with an abnormal loading system, a still-water bending moment stress of 14,540 p. s. i. was found possible, although stresses resulting from uniform loading in tankers were less than those found in Liberty ships.

[l]Exhibit I—part IIC.

2. WEATHER, COURSE, SPEED AND SEA ROUTES

The wartime operation of cargo ships in convoys and over sea routes which are only infrequently used in normal times imposed unusual hardships on the vessels. Especially during the early part of the war, convoys were being routed through extremely cold waters where heavy seas prevail during the winter months. The risks involved were accepted as far as heavy seas were concerned, but at the start the adverse effects of low temperature were not fully appreciated. When these facts were recognized, vessels modified to increase their resistance to fracture were assigned to the most rigorous trade routes.

F. *Specific Investigations*

Many research investigations were undertaken in government and university laboratories.

Most of the research studies which were conducted in connection with the investigation were carried out under the supervision of the Welding Division of the War Metallurgy Committee. This organization operated under a contract with the Office of Scientific Research and Development and was part of the National Academy of Sciences. In utilizing the facilities of this organization the Board was able to bring to bear on its problems some of the best scientific minds in the country. Many of the research investigations were carried out in the finest engineering laboratories available in the United States. Through the supervision of the War Metallurgy Committee, a complete coordination of effort in research was achieved and results were obtained in a minimum of time. One of the outstanding contributions of the War Metallurgy Committee of the National Academy of Sciences was the stimulation of interest among steel manufacturers, ship builders and other industrial organizations concerned with the fabrication of welded structures, and the obtaining of the active participation of these industries in the solution of the problems which confronted the Board. Without the assistance of the National Academy of Sciences the questions which were raised pertaining to metallurgy, physics and the mechanism of metal fracture would not be as near to a solution as they are today.

At the present time much unfinished research work pertaining to the subject of this investigation remains to be done. It is hoped that it will be possible to continue the efforts of the research investigators, and add further to the knowledge and experience they have gained in the past three years. The fine spirit of cooperation and coordination which has been engendered in that same period is the best assurance that a solution of the unfinished phases of the problem can be found.

For specific research investigations which came under the cognizance of the Board, refer to the Bibliography appended.

G. *International Exchange of Information*

Close liaison has been maintained throughout the investigation with the British, and with other Allied nations, who are concerned with the operation of welded merchant vessels. There has been a free and complete exchange of information between the Board and the British agencies involved, notably the Admiralty Ship Welding Committee. Inasmuch as the British are operating all-welded merchant vessels, some of which were constructed in the United States, they have shown great interest in the problem of determining the causes of structural failures in welded ships. Consequently, numerous investigations, both experimental and analytical, have been initiated and conducted in Great Britain[11,73], many of them paralleling investigations conducted in this country. It is interesting to note that the endeavors of these two separate groups have been directed along the same lines in approaching the solution of the problem, and it is gratifying that the results obtained on both sides of the Atlantic have agreed in almost every respect.

The British are at present engaged in a long range, full scale study of the loads imposed upon vessels at sea, together with the strains experienced in service. The need for such a study was also recognized in this country and the findings of the Board's investigation have served to accentuate this need.

A number of American observers, including representatives of the member agencies of this Board, have been afforded access to these studies and have, in several cases, made voyages in the experimental vessels.

It is hoped that the United States may also find it possible to initiate long range instrumental studies of loads and strains experienced in ships at sea.

H. *Findings*

The Board finds that:

(a) 4,694 welded steel merchant vessels were built by the Maritime Commission in the United States and considered in this investigation.

(b) 970 of these vessels suffered casualties involving fractures.

(c) 24 vessels sustained a complete fracture of the strength deck.

(d) 1 vessel sustained a complete fracture of the bottom.

(e) 8 vessels were lost; of these, 4 broke in two and 4 were abandoned after fracture occurred; 4 additional vessels broke in two, but were not lost.

(f) 26 lives were lost incident to structural failures of welded steel merchant vessels.

(g) The highest incidence of fracture occurs under the combination of low temperatures and heavy seas.

(h) The age of the vessel has no appreciable influence on the tendency to fracture.

(i) The loading and ballasting systems employed in vessels under study by the Board did not create abnormal bending moments.

(j) No marked correlation between the incidence of fracture on the ships and the construction practices of parent shipyards could be found. However, with due allowance for design, the ships constructed in yards utilizing subaverage shipyard construction practices showed a higher-than-average incidence of fractures.

(k) Only 33 casualties were reported in Victory ships. None of these was serious.

(l) The steel currently supplied for ship construction complies with applicable specifications for ship steel.

(m) Locked-in stresses in the decks of completed vessels are not appreciably reduced in service.

(n) Welding sequence in general has no effect upon the magnitude of residual welding stresses in free subassemblies.

(o) Every fracture examined started in a geometrical discontinuity or notch resulting from unsuitable design or poor workmanship.

(p) There is a large variation in the notch sensitivity of steel used in welded ship construction. Steel removed from fractured vessels showed high notch sensitivity.

I. *Conclusions*

The Board concludes that:

(a) The fractures in welded ships were caused by notches and by steel which was notch sensitive at operating temperatures. When an adverse combination of these occurs the ship may be unable to resist the bending moments of normal service.[m]

(b) The serious epidemic of fractures in the steel structure of welded merchant vessels has been curbed through the combined effect of the corrective measures taken on the structure of the ships during construction and after completion, improvements in new design, and improved construction practices in the shipyards.

(c) Locked-in stresses do not contribute materially to the failure of welded ships.

(d) Existing specifications are not sufficiently selective to exclude steel which is notch sensitive at ship operating temperatures.

(e) A tendency for certain ships to incur repeated casualties can be measured but the trend is not great and the effect is not significant.

(f) The basic analytical method used in calculating nominal stresses in the main hull girder under a known bending moment is valid.

(g) The overall strength of the Maritime Commission ships is satisfactory.

J. *Opinions*

(a) The results of the investigation have vindicated the all-welded ship. The statistics show that the percentage of vessels sustaining serious fractures is small. With proper detail design, high quality workmanship, and a steel which has low notch sensitivity at operating temperatures, a satisfactory all-welded ship structure may be obtained.

The mechanism of fracture is still not clearly understood, but the investigation has yielded much new information and has contributed to a partial solution of the problem of why welded ships have failed.

Until experience can be had with vessels constructed under normal conditions, of improved design, with carefully checked, high quality workmanship, and employing steel of low notch sensitivity, some form of crack arrestor, such as a riveted gunwale angle, should be incorporated in the hull girder of all large welded vessels.

(b) Notwithstanding the above opinion, the Board considers it imperative to reaffirm the statement that if welded construction in the building of both merchant and naval vessels had not been adopted at the outset of the program, the extraordinary results in speed and volume of construction would have been impossible of accomplishment.

K. *Recommendations*

As the investigation is brought to a close, the existence of several unfinished studies which were initiated by the Board, as well as a list of desirable items for future investigation, impels the Board to make certain recommendations.

The Research program conducted in connection with the investigation has produced at least partial answers to most of the more urgent questions and has given an adequate solution for the purposes of the present Board. It now appears that some of the specific investigations already laid out must be carried beyond the termination of the Board. It thus becomes necessary to assure the continuance and extension of this work. These projects have opened up new fields of investigation; they point out paths along which real improvement can be made in structural design, material and fabrication methods.

It is beyond the scope of this Board to follow these leads. However, it is important that we maintain our present position in maritime affairs and protect our standing in world wide competition by continuing fundamental research work on design and methods of construction of steel ships. Accordingly, the recommendations of the Research Advisory Committee, as contained in part 5 of Exhibit II, for continued and extended experiments, are endorsed.

It is also recommended that the compilation of data on structural failures be continued and that these data be analyzed together with those already collected, using valid statistical methods. In particular,

[m]*A notch* may be defined as any discontinuity. As used in this report, a notch means a structural discontinuity, such as is occasioned by hatch openings, sheer strake cut-outs, foundations, vent openings, bilge keels, the abrupt termination of structural members, etc., and imperfections in the structure resulting from fabrication, such as peened-over cracks, undercut welds, porosity and inclusions in welds, and incomplete penetration which leaves voids at the center of the joint.

Notch sensitivity may be defined as the property of a material which reflects its reluctance to absorb energy in the presence of notches and other strain inhibitors, such as low temperature and high rates of strain.

it is recommended that service-time data be tabulated by temperature and state of the sea, vessel by vessel, from the logs of the individual ships.

Finally, it is hereby recommended that an organization be established to formulate and coordinate research in matters pertaining to ship structure in the same manner as has been the practice during the tenure of the Board.

Rear Admiral U. S. C. G.
Engineer-in-Chief, United States Coast Guard.
Chairman

Captain, U. S. N.
Technical Assistant to the Chairman, United States Maritime Commission.
Member

Vice Admiral, U. S. N.
Chief, Bureau of Ships, United States Navy.
Member

Vice President and Chief Surveyor, American Bureau of Shipping.
Member

Approved:

Secretary of the Navy.

Appendix 'A'

Composition of Board, Sub-Board and Committees functioning thereunder.

BOARD

(Established 20 April 1943)

Chairman:
Rear Admiral HARVEY F. JOHNSON, U. S. C. G.,
Engineer-in-Chief,
United States Coast Guard.

Vice Admiral E. L. COCHRANE, U. S. N.,
Chief, Bureau of Ships,
United States Navy Department.

Vice Admiral HOWARD L. VICKERY, U. S. N.
Vice Chairman,
United States Maritime Commission.
(To 25 January 1946).

Captain. T. L. SCHUMACHER, U. S. N.
Technical Assistant to the Chairman,
United States Maritime Commission.
(From 25 January 1946).

MR. DAVID ARNOTT,
Vice President and Chief Surveyor,
American Bureau of Shipping.

Secretary:
Captain R. B. LANK, JR., U. S. C. G.
Assistant Chief, Naval Engineering Division,
United States Coast Guard.
(19 May 1943 to 28 March 1946).

Commander R. D. SCHMIDTMAN, U. S. C. G.
(From 28 March 1946).

SUB-BOARD

(Appointed 19 May 1943)

Capt. CHARLES D. WHEELOCK, U. S. N.,
(Chairman to 17 June 1944).

Capt. L. A. KNISKERN, U. S. N.
(Chairman from 17 June 1944 to 28 March 1946).

Capt. R. B. LANK, JR., U. S. C. G.
(Secretary to 28 March 1946).
(Chairman from 28 March 1946).

Capt. WENDELL P. ROOP, U. S. N.
(To 23 August 1944, and from 18 March 1946).

Capt. P. W. SNYDER, U. S. N.
(From 27 March 1945 to 7 September 1945).

Capt. JESSE ORMONDROYD, U. S. N. R.
(From 23 August 1944 to 18 March 1946).

Capt. L. V. HONSINGER, U. S. N.
(From 7 March 1946).

Comdr. C. R. WATTS, U. S. N.
(To 27 March 1945)

Comdr. E. G. TOUCEDA, U. S. N. R.
(From 7 September 1945).

Comdr. R. S. MANDELKORN, U. S. N.
(From 27 March 1945)

Comdr. P. A. OVENDEN, U S. C. G. R.
Comdr. R. D. SCHMIDTMAN, U. S. C. G.
(From 14 August 1944)
(Secretary from 28 March 1946).

Lt. Comdr. (T) E. M. MACCUTCHEON, U. S. C. G. R.
Lt. (jg) R. C. MADDEN, U. S. N. R.
(From 17 May 1946)

MR. JAMES L. BATES, *United States Maritime Commission*

MR. A. G. BISSELL, *United States Navy Department*

MR. D. P. BROWN, *American Bureau of Shipping.*

MR. HUGO HIEMKE, *War Metallurgy Committee.*
(From 14 August 1944 to 1 August 1945)

DR. FINN JONASSEN, *War Metallurgy Committee.*
(From 14 August 1944)

MR. S. W. LANK, *United States Coast Guard.*

MR. E. E. MARTINSKY, *United States Maritime Commission.*
(From 19 May 1945)

MR. G. S. MIKHALAPOV, *War Metallurgy Committee.*
(From 14 August 1944)

DR. ALBERT MULLER, *War Metallurgy Committee.*
(From 1 August 1945)

MR. JOHN VASTA, *United States Maritime Commission.*

MR. J. LYELL WILSON, *American Bureau of Shipping.*

RESEARCH ADVISORY COMMITTEE

(Appointed 14 August 1944)

Mr. G. S. Mikhalapov, *War Metallurgy Committee, Chairman*

Capt. Jesse Ormondroyd, U. S. N. R. *(From 23 August 1944 to 18 March 1946)*

Capt. W. P. Roop, U. S. N. *(To 23 August 1944, and from 18 March 1946)*

Capt. L. V. Honsinger, U. S. N. *(From 7 May 1946)*

Comdr. E. G. Touceda, U. S. N. R. *(From 7 May 1946)*

Comdr. R. D. Schmidtman, U. S. C. G.

Lt. Comdr. (T) E. M. MacCutcheon, U. S. C. G. R.

Mr. James L. Bates, *United States Maritime Commission.*

Mr. Hugo Hiemke, *War Metallurgy Committee. (To 20 July 1945)*

Dr. Finn Jonassen, *War Metallurgy Committee.*

Dr. Albert Muller, *War Metallurgy Committee. (From 20 July 1945)*

Mr. John Vasta, *United States Maritime Commission. (From 13 July 1945)*

Mr. J. Lyell Wilson, *American Bureau of Shipping.*

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WELDING ADVISORY COMMITTEE

(Appointed 26 July 1944)

Capt. D. R. Simonson, U. S. C. G., *Chairman.*

Mr. T. J. Griffin, *United States Navy Department*

The Following Members Served Temporarily in the Areas Indicated:

American Bureau of Shipping:
- Mr. Basil A. MacLean, *Portland, Oregon*
- Mr. William B. Murray, *Northern California*
- Mr. Charles J. L. Schoefer, *Southern California*
- Mr. Sidney K. Smith, *Seattle, Washington*
- Mr. Sydney Swan, *Gulf Coast*
- Mr. R. T. Young, *East Coast*

United States Maritime Commission:
- Mr. George Darsam, *Gulf Coast*
- Mr. E. E. Martinsky, *New Jersey*
- Mr. H. L. Morris, *Pennsylvania*
- Mr. Anthony Simatovich, *Pacific Coast*
- Mr. Arnim A. Smith, *South Atlantic and Gulf Coast*
- Mr. J. W. Wilson, *New England*

WELDING ADVISORY COMMITTEE
LIAISON GROUP

(Appointed 12 September 1944)

Mr. J. Lyell Wilson, *American Bureau of Shipping, Chairman.*

Mr. A. G. Bissell, *United States Navy Department.*

Lt. Comdr. (T) E. M. MacCutcheon, U. S. C. G. R.

Mr. E. E. Martinsky, *United States Maritime Commission.*

EXHIBIT I

Statistical Report of Structural Failures on Welded Steel Merchant Vessels

1 April 1946

Statistical Report

Structural Failures on Welded Steel Merchant Vessels

1 April 1946

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PART I

Structural Failure History

A. *Scope and Description of Report*

In preparing this analysis, structural failure reports have been assimilated in accordance with a schedule designed to achieve the greatest possible accuracy in the trends indicated by the comparisons. The analysis concerns itself with American-built ships only and in some cases where probability comparisons are drawn, only American-built and American-operated ships are used. In all cases where a numerical analysis has been made, the failures enumerated have been the result of natural causes which might be anticipated as certain to occur in the normal life of any ship. War casualties, collisions, groundings and other abnormal casualties are not included in this analysis unless a particularly interesting structural failure resulted indirectly from the other damaging influence. On all such particular descriptions, a notation has been made to indicate that the failure was precipitated by unusual circumstances.

Data used in the analysis include everything pertaining to structural failures which has been submitted since the beginning of the Maritime Commission construction program. The totals are brought up to 1 April 1946, but it will be noted that the dates of individual parts of the report are independently specified.

Every effort has been made to see that percentages and relations are drawn between quantities that are comparable. In indicating the effects of various factors, an attempt has been made to keep other influences constant where possible. Where additional factors are suspected as influencing the results, such factors are mentioned. It is easy to make misleading comparisons with these data. As an example, attention has been drawn to the large number of casualties on ships with the name of William. Up to 1 August 1945, 73 or 5.3 percent of all reported casualties occurred on such ships. A more careful check shows that all of the 73 casualties were on Liberty ships and the list of Liberty ships shows 195 Williams in 2,710 ships or 7.2 percent. There were 978 casualties reported on the Liberties, the name William is present in 7.5 percent of the cases and the percentage is quite reasonable.

The basic postulate that the predicted number of casualties will be proportional to length of service time and number of ships in service is accepted, other things being equal. For this reason, whenever a comparison is made between the service records of different groups of ships, the accumulated data are referred to the corresponding length of service time over which the particular group of vessels operated in accumulating the failures.

B. *Definitions*

Structural failure.—A structural failure may consist of either a fracture or a buckle. (Buckles were involved in very few of the casualties and in no case were they responsible for endangering the vessel. They have not been analyzed in this report.)

Casualty.—A casualty consists of one or more structural failures which have occurred on the same occasion, on a vessel which is afloat. Unless otherwise stated, the casualty occurred under normal operating conditions.

Class 1 fractures.—A Class 1 fracture is a fracture which has weakened the main hull structure so that the vessel is lost or is in a dangerous condition.

Class 2 fractures.—A Class 2 fracture is a fracture which does not endanger the ship but which involves the main hull structure at a location which experience has indicated is a potential source of a dangerous failure. Such locations include the strength deck, inner bottom, side and bottom shell and attachments thereto such as bilge keels and bulwarks.

Class 3 fractures.—Class 3 fractures include reported fractures which do not fail in Class 1 or 2.

Class 1 casualty.—A Class 1 casualty is a casualty involving at least one Class 1 fracture.

Class 2 casualty.—A Class 2 casualty is a casualty involving at least one Class 2 fracture and no Class 1 fractures.

Class 3 casualty.—A Class 3 casualty is a casualty involving Class 3 fractures only.

Ship month.—A ship month is a measuring unit for ship service experienced. It is equal to the service of 1 ship for 1 month.

Examples:—Ten ship months=1 ship operating for 10 months.

or—Ten ship months=2 ships operating for 5 months.

or—Ten ship months=10 ships operating for 1 month.

C. *Sources of Structural Failure Data*

The structural failure data used to assemble this report came from several sources and were cross-checked and combined to obtain the greatest possible accuracy in the structural failure records. Reports of the Merchant Marine Inspectors of the United States Coast Guard were supplemented with data from the following agencies:

- United States Maritime Commission
- United States Navy Department
- American Bureau of Shipping
- British Admiralty (Admiralty Ship Welding Committee)
- War Shipping Administration

The technical divisions of the Coast Guard systematically examined, assembled, and reduced the reports to uniform terms for purposes of analysis. The Naval Engineering Division prepared previous statistical reports and this report was prepared by the Merchant Marine Technical Division. The individual casualty reports are available for examination at Coast Guard Headquarters, Washington, D. C.

D. *Numbers of Structural Failures and Ships Involved*

To date (1 April 1946) there have been reported 1442 casualties which occurred on Maritime Commission-built ships, including ships on loan to foreign governments.

Casualties of all classes (1, 2, and 3) are included in the following:

	Number of ships reported suffering casualty	Number of Casualties
Maritime Commission-built ships only (table I)	970	1442
Maritime Commission-built ships in United States operation only	916	1387

Vessels which suffered no casualty	3724
Vessels which suffered 1 casualty	666
Vessels which suffered 2 casualties	211
Vessels which suffered 3 casualties	52
Vessels which suffered 4 casualties	26
Vessels which suffered 5 casualties	6
Vessels which suffered 6 casualties	2
Vessels which suffered 7 casualties	4
Vessels which suffered 8 casualties	3
Total vessels	4694

Various parts of the study refer to different types of vessels. The numbers of merchant vessels of each type launched under the Maritime Commission program and remaining in merchant service are listed (table I).

Forty-seven casualties occurred on 36 United States-built vessels not constructed under the Maritime Commission program. Since there are no corresponding service data for these vessels, they have not been included in the analysis in parts II through V of this report.

E. *Summary of Casualties by Classes*

The 1,442 casualties on the Maritime Commission-built ships have been classified according to the damage resulting and the extent to which the vessel was endangered.

Class 1	127
Class 2	739
Class 3	571
Unknown	5
Total	1,442

Fortunately, greater care is generally taken in preparing the reports on the more serious failures and so it has been possible to arrange a fairly complete summary of the Class 1 casualties, which appears in the appendix. This is followed by an alphabetical list of all casualties reported as occurring before 1 August 1945, and another alphabetical list of the casualties occurring from 1 August 1945 to 1 April 1946.

TABLE I

Accumulated Number of Vessels Launched Under Maritime Commission Program and Remaining in Merchant Service

	to 1 August 1945	to 1 February 1946[1]
EMERGENCY:		
EC2-S-C1...	2,580	2,580
Z-ET1-S-C3	62	62
Z-EC2-S-C2.	8	8
Z-EC2-S-C5.	28	36
EC2-S-AW1	22	24
	2,700	2,710
TANKERS:		
T1....	81	54
T2......	498	523
Tanker.	25	Reclassified to T2 or T3
T3 ..	42	35
	646	612
STANDARD CARGO:		
C1A & C1B.........	160	160
C2 & C2 Refrig....	251	243
C3...............	143	108
C4...............	1	16
C5.......	1	2
R1-M-AV1	17	17
R2......	11	12
	595	558
COMBINATION:		
Pass. & Cargo.	6	3
C2 P & C....	3	1
C3 P & C.....	18	14
	27	18
MISCELLANEOUS:		
C1-M-AV1......	199	218
C1-MT-BU1.....	2	4
L6....	16	16
N3..	95	95
V4	49	49
	361	382
VICTORY:		
VC2-S-AP2...	248	272
VC2-S-AP3. ..	134	141
VC2-S-AP4....	1	1
	383	414
Total.......	4,712	4,694[1]

[1] Between 1 August 1945 and 1 February 1946, 279 vessels were removed from merchant service to be permanently operated by the armed forces. These were excluded from the figures.

F. *Ships Which Broke in Two or Were Lost*

Seven vessels have been lost:

Name	Date of casualty	Remarks
THOMAS HOOKER..	5 Mar. 1943	Abandoned.
J. L. M. CURRY. .	7 Mar. 1943	Abandoned.
JOHN P. GAINES ...	24 Nov. 1943	Broke in two; abandoned.
JOSEPH SMITH....	9 Jan. 1944	Abandoned.
SAMUEL DEXTER....	21 Jan. 1944	Abandoned.
JOEL R. POINSETT...	4 Mar. 1944	Broke in two; stern portion salvaged.
SACKETT'S HARBOR	1 Mar. 1946	Broke in two; stern portion salvaged.

Four other ships broke in two but were not lost:

Name	Date of casualty
SCHENECTADY........ ..	15 Jan. 1943.
ESSO MANHATTAN.. ...	29 Mar. 1943.
VALERI CHKALOV........	11 Dec. 1943.
DONBASS III..... ...	17 Feb. 1946.

Details of the above casualties will be found in figures 1 through 23.

In 14 additional cases, the entire strength deck was fractured and in one other case, the entire bottom.

G. *Lives Lost Due to Structural Failure*

A total of 26 lives have been lost as a result of the structural failures. In the case of the *Donbass III,* fifteen persons lost their lives. In the case of the *John P. Gaines,* 11 people are missing after successfully embarking in a lifeboat.

H. *Casualties Occurring Each Month*

Figure 24 shows the casualties reported each month and indicates the peaks which occur during the winter months of each year. The dotted line indicates the corresponding number of Maritime Commission-built ships which were afloat and in operation. The steady increase shows the growth of our merchant marine and the slight drop at the end is the result of transferring many ships from the merchant service to permanent military operation. The curves indicate clearly that the measures adopted have been successful in suppressing the serious epidemic of structural failures reflected in the first peak.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Oct. 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
THOMAS HOOKER	242094	Dry Cargo Vessel	EC2-S-C1
BUILDER		BUILDER'S HULL NO.	DATE COMPLETED
New England Shipbuilding Corporation		203	11 Aug., 1942
OWNER		OPERATOR	
War Shipping Administration		American-West African Line	

EXTENT OF WELDING

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
No	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE

(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION	
5 March, 1943	2025 GMT	Lat. 54°N., Long. 47°W - Westbound in North Atlantic	
SHIP'S SPEED	COURSE	DRAFT FWD.	DRAFT AFT
About 9 knots	---	14'	22'
SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP	
Rough with heavy swells	Heavy	On starboard beam	
WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE
7	WSW	About 22°	---

DESCRIPTION OF FAILURE

(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

Unknown

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS

A loud cracking sound was heard. The upper deck and shell plating on port side abreast of #3 hold were cracked from the bulwark down to tween deck, and from the bulwark to the hatch coaming, including the longitudinal members. A crack from the after starboard side of the hatch coaming extended out to the bulwark and down to tween deck abreast of the dry store room about thirty feet abaft of #3 hold. These cracks were in the center of the plates and not in the welding.

Bending moment in still water = 55,800 Ft. x Tons Hog at #3 Hold
Stress in crown of deck = 6500 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Cracked deck

DISPOSITION OF VESSEL

(Repaired, lost, etc.)

Vessel was abandoned at 0900 GMT on 6 March, 1943, and when last seen she had a list of 10° to the port side.

SIGNED (Name and Title)	DISTRICT

(P)

Figure 1.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Oct., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
J. L. M. CURRY	241520	Dry Cargo Vessel	EC2-S-C1
BUILDER: Alabama DD & SB Company		BUILDER'S HULL NO.: 231	DATE COMPLETED: 15 May, 1942
OWNER: War Shipping Administration		OPERATOR: Lykes Brothers SS Co., Inc.	

EXTENT OF WELDING

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
No	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE
(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
7 March, 1943	1320	Lat. 70°-44' N., Long. 00°-24' E.--Greenland Sea		
SHIP'S SPEED: 5 knots	COURSE: 210°		DRAFT FWD.: 12'-0"	DRAFT AFT: 19'-0"
SEA CONDITION: Very high seas	WEATHER: Heavy	DIRECTION OF WAVES WITH RESPECT TO SHIP: ----		
WIND FORCE: 10 knots	WIND DIRECTION: North and West	AIR TEMPERATURE: 14°-30°	WATER TEMPERATURE: ---	

DESCRIPTION OF FAILURE
(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

The fractures apparently began from the corners of #3 and #4 hatches in the upper deck.

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS:

The vessel came down on a very high sea and split in four places. The upper deck plating, bulwark and side shell fractured on the starboard side from the forward ends of #3 and #4 hatches and on the port side at the after ends of the same hatches. The cracks extended down through the shell plating to below t[illegible]ween decks. The cracks did not occur along the welds but were clea[illegible] breaks in the plating, which opened and closed with the working of the ship.
Bending moment in still water = 50,000 Ft. x Tons Hog at #3 Hold
Stress in crown of deck = 5600 Lbs./in.^{2} Tension

CLASSIFICATION OF FAILURE: Cracked deck

DISPOSITION OF VESSEL
(Repaired, lost, etc.)

The vessel was abandoned by 1115 on 8 March, 1943, and sunk by shells from an allied vessel.

SIGNED (Name and Title)	DISTRICT

Figure 2.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2757

This report includes all available information up to.
1 Apr., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
JOHN P. GAINES	243861	Dry Cargo Vessel	EC2-S-C1
BUILDER		BUILDER'S HULL NO	DATE COMPLETED
Oregon Shipbuilding Corporation		725	8 July, '43
OWNER		OPERATOR	
War Shipping Administration		Northland Transportation Co., Inc.	

EXTENT OF WELDING

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
No	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE
(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
24 Nov., 1943	0241 #10 time zone	55-07 N. 155-30 W. 40 miles bearing 175° true from Chirkoff Island.		
SHIP'S SPEED	COURSE		DRAFT FWD.	DRAFT AFT
9 knots	Dutch Harbor to Seattle, 76° true		13'-0"	10'-0"
SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP		
Long ground swell	Fairly clear	15° - 20° off port bow		
WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE	
5-6 Beaufort	ENE	40° - 45° F	About 40° F	

DESCRIPTION OF FAILURE
(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

Near Fwd. corners #3 hatch between Frames #74 and 75

GENERAL HISTORY AND DESCRIPTION OF FAILURE INCLUDING KNOWN CONTRIBUTORY FACTORS

At about 2200 on 23 November, 1943, loud noises were heard but the source could not be located in the dark. At about 0241 on 24 Nov., 1943, an exceptional sea struck the port bow and boarded near the forward gun. The fracture immediately propagated. It appears that the vessel broke partially as it passed either over or between swells and the following swell completely broke off the forward end. All crew and passengers were on the after end. Survivors were picked up by U. S. Army Transports except for 11 men, including six soldiers in one lifeboat, which was lost.

Bending moment in still water = 54,000 Ft. x Tons Hog at #3 Hold
Stress in crown of deck = 6200 Lbs./in.^{2} Tension

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL
(Repaired lost, etc.)

The bow is believed to have sunk. The stern is aground on Big Koniuji Island.

SIGNED (Name and Title)	DISTRICT

Figure 3.

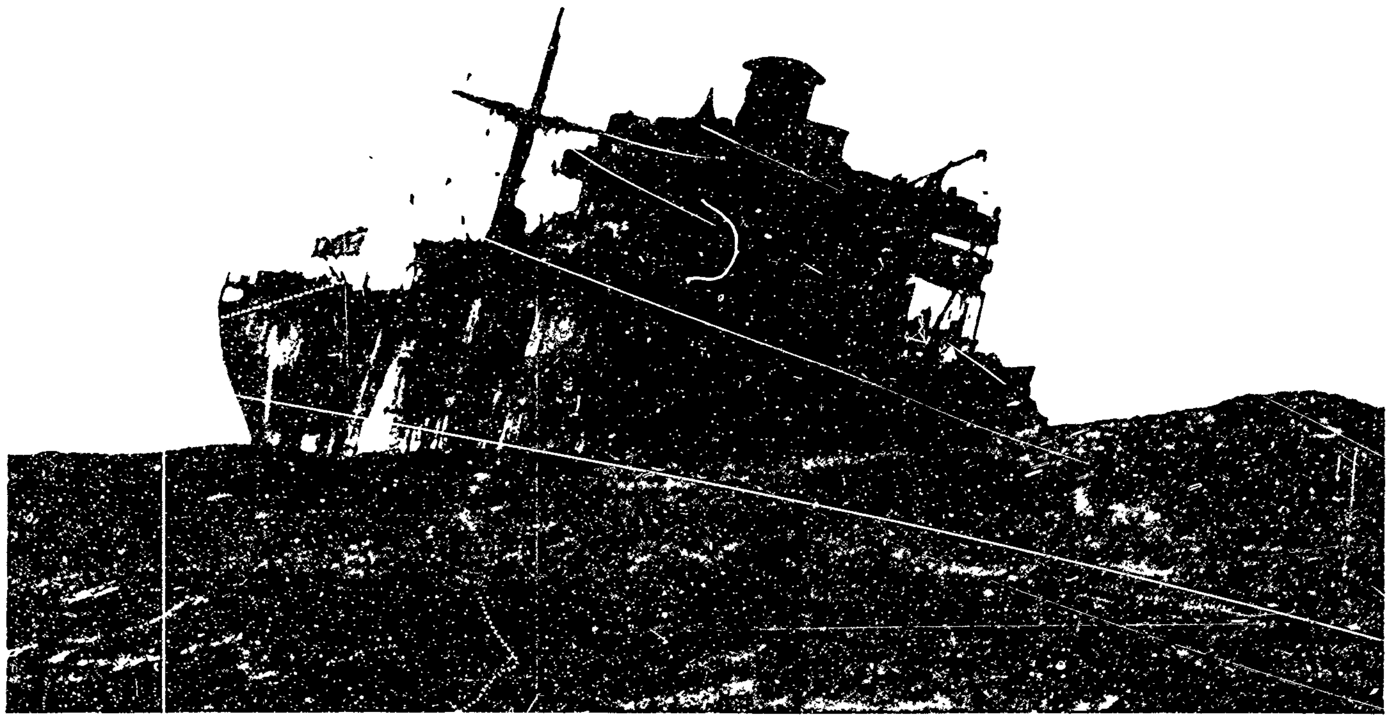


FIGURE 4.—Stern portion of *S. S. John P. Gaines*.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to 1 Oct., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger etc.)	M.C. DESIGN
JOSEPH SMITH	243593	Dry Cargo Vessel	EC2-S-C1
BUILDER		BUILDER'S HULL NO.	DATE COMPLETED
Permanente Metals Corporation #2		119	4 June, '43
OWNER		OPERATOR	
War Shipping Administration		Alaska Packers Association	

EXTENT OF WELDING

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
No	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE
(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
9 January, 1944	1415	About lat. 44° -30' N., Long. 43° -01' W -- in North Atlantic		
SHIP'S SPEED	COURSE		DRAFT FWD	DRAFT AFT
7.2 knots	----		at departure 7'-0"	21'-0"
SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP		
Heavy	Very heavy	SW to W cross seas and swell		
WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE	
6-9	SW to W	34°	50°	

DESCRIPTION OF FAILURE
(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

After starboard and forward port corners of #3 hatch fractured in the upper deck.

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS:

At 1400 GCT on 9 January, the vessel was pounding and pitching when she came down heavily with her fore foot causing a fracture in the girder and deck plating at the after starboard corner #3 hatch. At 1600 GCT another fracture occurred in the girder and plating at the forward port corner of #3 hatch. At 0730 GCT on 11 January the third fracture occurred in upper deck plating at the starboard inside after corner of midship deckhouse to entrance of starboard alleyway extending to forward starboard corner of #4 hatch, across the deck to port side, through bulwarks, down side plating to light load line and then turned forward. Longitudinal girders fractured in line with break on upper deck. Tween deck plating cracked similar to that on main deck. All cracks developed across the center of a plate or stiffener and not in welding. Loading data inaccurate - No bending moment computed.

CLASSIFICATION OF FAILURE: Cracked deck

DISPOSITION OF VESSEL
(Repaired, lost, etc.)

The vessel was abandoned at 1400 on 11 January, 1944, and shelled to sinking condition by escort vessel.

SIGNED (Name and title)	DISTRICT

Figure 5.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Apr., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
SAMUEL DEXTER (2)	243200	Dry Cargo Vessel	EC2-S-C1
BUILDER: Delta Shipbuilding Co., Inc.		BUILDER'S HULL NO.: 42	DATE COMPLETED: 15 Apr., '43
OWNER: War Shipping Administration		OPERATOR: Waterman Steamship Agency, Ltd.	

EXTENT OF WELDING

Hull all welded

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
Yes	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE
(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
21 Jan., 1944	2100	Lat. 54° - 48' N.; Long. 22° - 45' W		
SHIP'S SPEED: Hove to 47 RPM	COURSE: United Kingdom to New York		DRAFT FWD.: 9'-8"	DRAFT AFT: 21'
SEA CONDITION: High seas	WEATHER: Bad weather	DIRECTION OF WAVES WITH RESPECT TO SHIP: 3 points on starboard bow		
WIND FORCE: 8	WIND DIRECTION: WSW	AIR TEMPERATURE: 40°	WATER TEMPERATURE: 43°	

DESCRIPTION OF FAILURE
(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

Forward corners of #3 and #4 hatches port and starboard, all four cracks starting exactly in corner. Aft port corner #3 hatch 3 cracks starting point uncertain.

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS

At 2100 on 21 January, deck cracked opposite #3 hatch and vessel was turned with stern to sea. At 2116 deck cracked at #4 hatch. A thorough examination was made on 22 January, and the two cracks from the forward corners of #3 hatch were found to extend across the deck and down the side to below the 2nd deck port and starboard. The crack across the deck from the starboard forward corner of #4 ran down the side below the waterline. The weather moderated during the 22 to 24 January but a watch was kept on the cracks which were gradually increasing and opened and closed 1" in the seaway. Bad weather was forecast so between 1530 and 1630 on 24 January, the vessel was abandoned.
Bending moment in still water = 43,200 Ft. x Tons Hog at #3 hold.
Stress in crown of deck = 5,000 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Cracked deck

DISPOSITION OF VESSEL
(Repaired, lost, etc.)

Vessel drifted ashore on Barra Island of the Hebrides. Future undetermined.

SIGNED (Name and Title)	DISTRICT

Figure 6.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Oct., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
JOEL R. POINSETT	242838	Dry Cargo Vessel	EC2-S-C1
BUILDER		BUILDER'S HULL NO.	DATE COMPLETED
Houston Shipbuilding Corporation		43	28 Feb., '43
OWNER		OPERATOR	
War Shipping Administration		Standard Fruit & Steamship Company	

EXTENT OF WELDING

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
No	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE
(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
4 March, 1944	0340	Lat. 53°-30' N., Long. 56°-30' W., in N. Atlantic		
SHIP'S SPEED	COURSE		DRAFT FWD.	DRAFT AFT
Approx. 5 knots	West by South		13'-0"	21'-5"
SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP		
Rough	Heavy	3 points on starboard bow		
WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE	
8 - 12	WNW	20°	40°	

DESCRIPTION OF FAILURE
(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

Unknown

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS

A loud report, followed by two smaller ones, was heard, the engines were stopped, and a general alarm was given. Immediately afterward, the forward end of the ship separated from the after end and floated away. The vessel parted between frames 82 and 83 on the starboard side and between frames 78 and 79 on the port side. The deck fracture passed between the after end of #3 hatch and the forward end of deck house from starboard side to inboard side of strake C-10 where the fracture ran longitudinally forward to frames 78-79 and went outboard on the port side.

Bending moment in still water = 58,900 Ft. x Tons Hog at #3 Hold.

Stress in crown of deck = 6,900 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL
(Repaired, lost, etc.)

Vessel was abandoned at 1600 on 5 March, 1944, with no loss of life. Forward end sank. The after end reached Halifax, N.S., at 0200, on 22 March, by towboat.

SIGNED (Name and Title)	DISTRICT

Figure 7.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2762

This report includes all available information up to: 1 June, 1946 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
SACKETT'S HARBOR	243882	Tanker	T2-SE-A1

BUILDER	BUILDER'S HULL NO.	DATE COMPLETED
Kaiser Co., Inc., Swan Island	20	July, 1943

OWNER	OPERATOR
War Shipping Administration	Pacific Tankers

EXTENT OF WELDING

Hull [illegible]l welded
No inner bottom

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	-	INNER BOTTOM SEAMS	Yes	DECK BUTTS
Yes	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	-	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	-	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE

(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION
3-1-46	2220	Long. 169° - 13' E.; Lat. 43° - 10' N.

SHIP'S SPEED	COURSE	DRAFT FWD.	DRAFT AFT
80 RPM	075° true	19'-6"	24'-0"

SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP
Small to moderate	Mild	30° to port bow

WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE
4	N.E.	37	38

DESCRIPTION OF FAILURE

(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

Unknown

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS

The starboard side cracked at Frame 60 and vessel opened to port. Stern section headed for Adak under own power. Was subsequently towed into this port. Bow section was capsized when located and sunk by gunfire as menace to navigation.
Photographs and Maritime Commission records show that this vessel was not fitted with longitudinal deck connected I-beam strengthening under the main deck transeverses which was fitted on later T2s.
Bending moment in still water = 41,100 Ft. x Tons Hog at Fr. #60
Stress in crown of deck = 3315 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL

(Repaired, lost, etc.)

Stern section awaiting tow; bow section sunk by gunfire.

SIGNED (Name and Title)	DISTRICT

Figure 8.

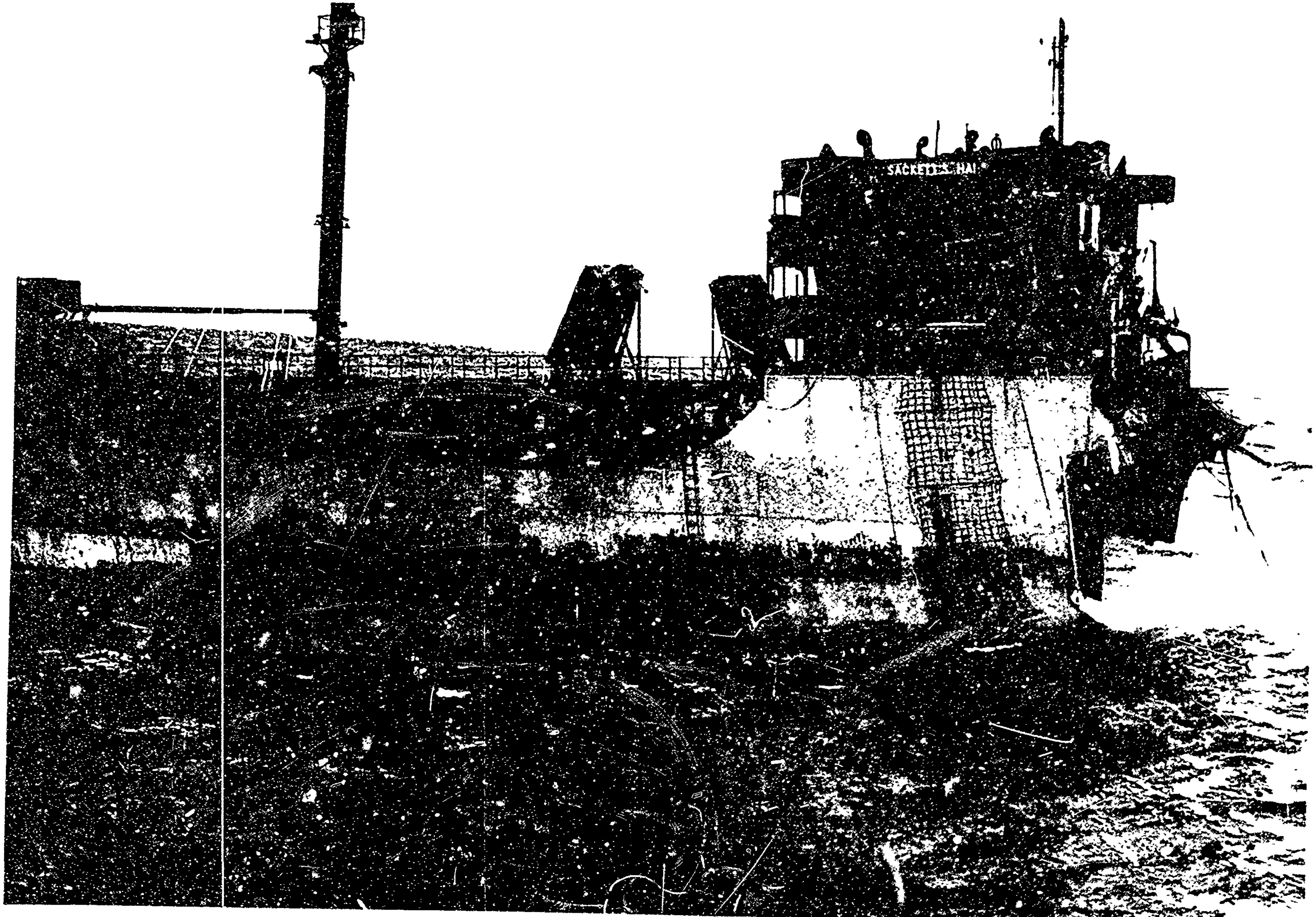


FIGURE 9.—Forward portion of *S. S. Sackets Harbor*.

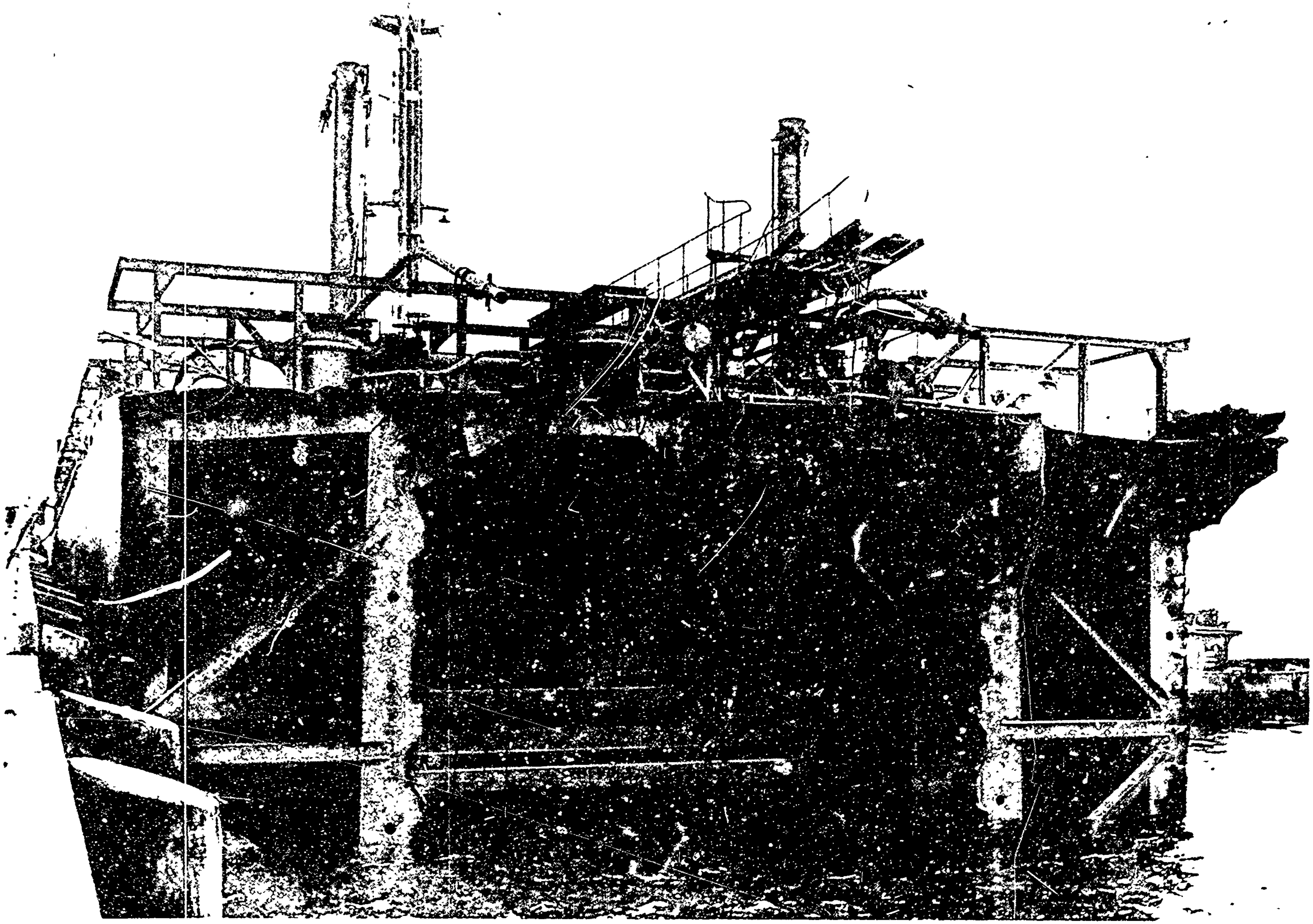


FIGURE 10.—Stern portion of *S. S. Sacketts Harbor*.

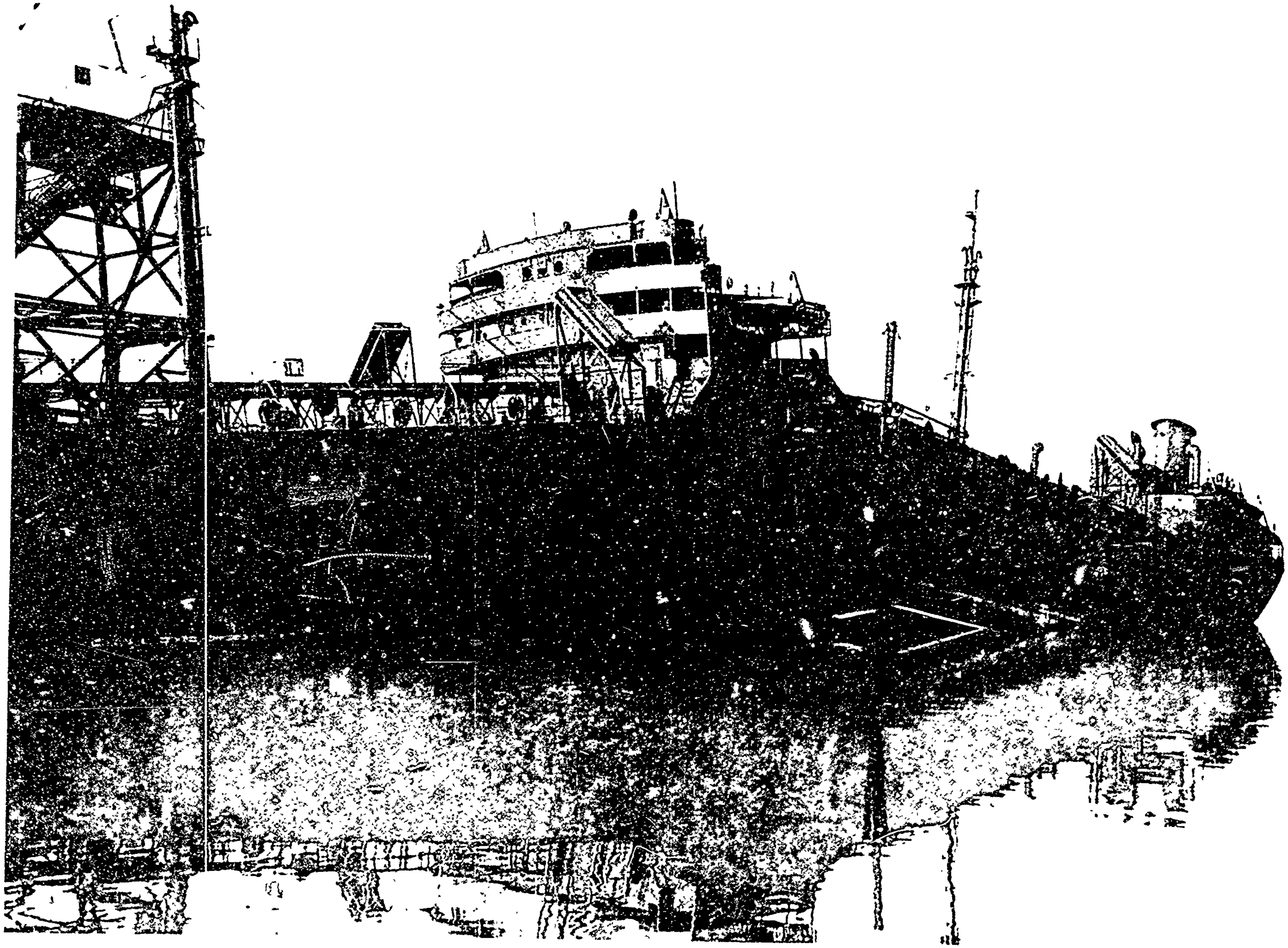


FIGURE 11.—View of *S. S. Schenectady* after splitting in two at her outfitting dock.

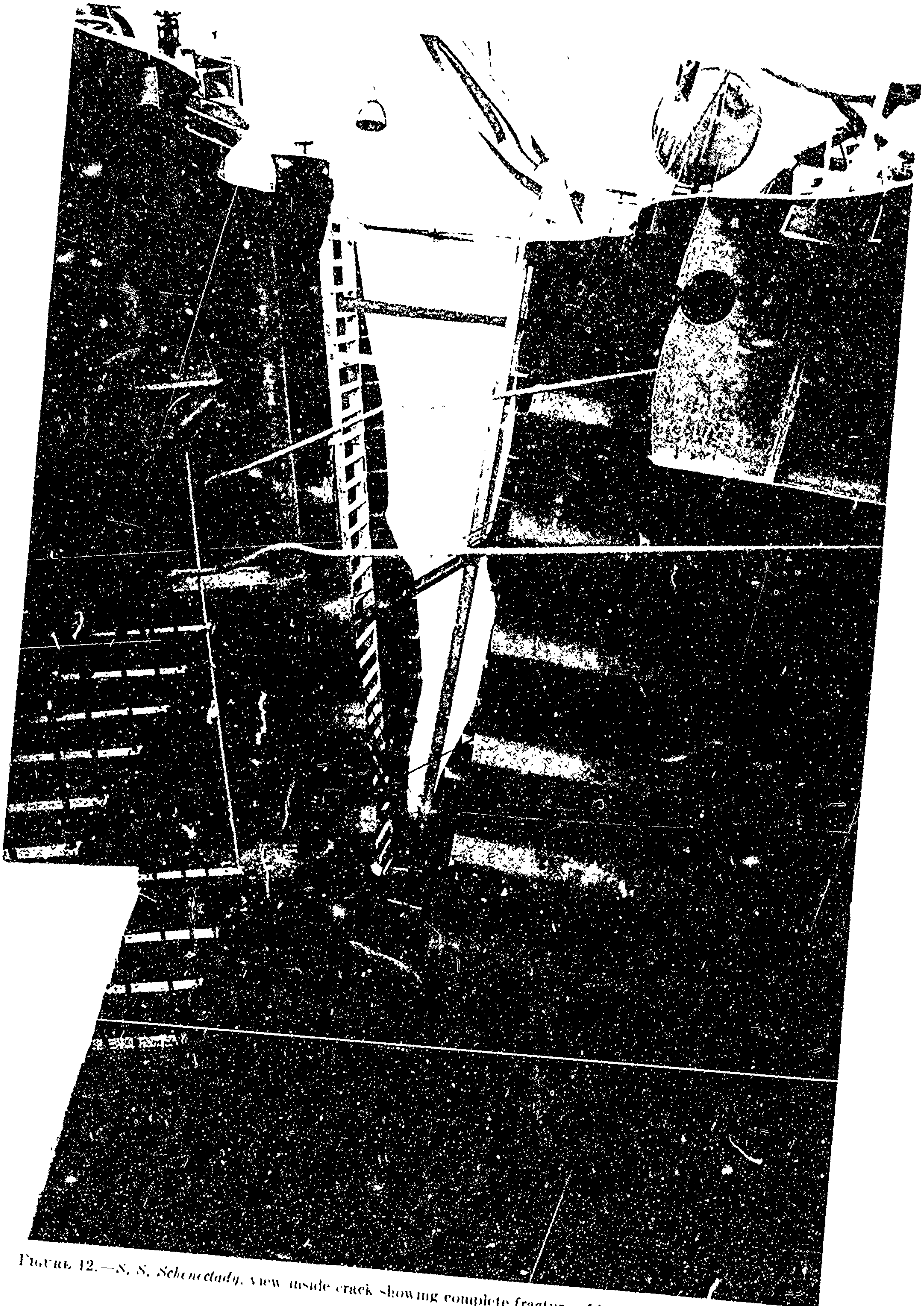


FIGURE 12.—*S. S. Schenectady*, view inside crack showing complete fracture of longitudinal bulkheads.

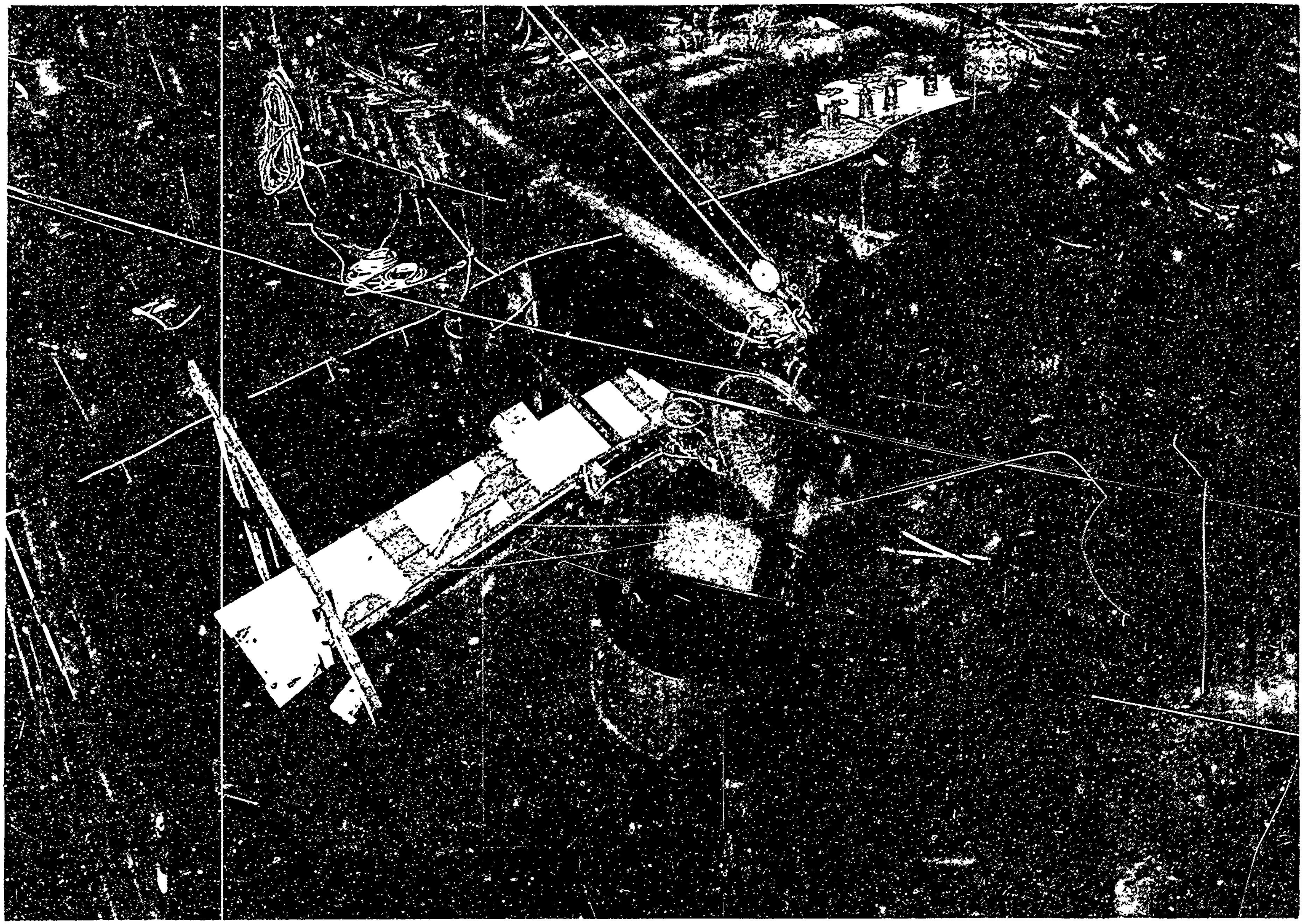


FIGURE 13.—S. S. *Schenectady*, view looking down at inside of crack across deck.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Apr., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
SCHENECTADY	242620	Tank Vessel	T2-SE-A1
BUILDER: Kaiser Co., Inc., Portland, Oregon		BUILDER'S HULL NO.: 1	DATE COMPLETED: 31 Dec., '43
OWNER: War Shipping Administration		OPERATOR: Deconhill Shipping Company	

EXTENT OF WELDING

Hull all welded
No inner bottom

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	-	INNER BOTTOM SEAMS	Yes	DECK BUTTS
Yes	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	-	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	-	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE

(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
16 Jan., 1943	2230 PWT	Tied up at fitting out pier, Swan Island		
SHIP'S SPEED: 0	COURSE: -		DRAFT FWD.: 6'-4"	DRAFT AFT: 17'-0"
SEA CONDITION: Still Water	WEATHER: Clear	DIRECTION OF WAVES WITH RESPECT TO SHIP: No waves		
WIND FORCE: Light	WIND DIRECTION: East wind	AIR TEMPERATURE: 26° F	WATER TEMPERATURE: 40°F	

DESCRIPTION OF FAILURE

(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

The fracture started at the juncture of the fashion plate at the aft starboard corner of the bridge superstructure and the sheer strake.

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS.

Without warning and with a report which was heard for at least a mile, the deck and sides of the vessel fractured just aft of the bridge superstructure. The fracture extended almost instantaneously to the turn of the bilge port and starboard. The deck side shell, longitudinal bulkheads and bottom girders fractured. Only the bottom plating held. The vessel jack-knifed and the center portion rose so that no water entered the hull. The bow and stern settled into the silt of the river bottom. Sounding taken around the vessel eliminated the alleged possibility of the vessel having grounded amidships to a drop in water level.
Bending moment in still water = 184,000 Ft. x Tons Hog amidships.
Stress in crown of deck = 9900 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL

(Repaired, lost, etc.)

Vessel repaired and put in service.

SIGNED (Name and Title)	DISTRICT

701292—47—3

Figure 14.

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Apr., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE (Dry Cargo, Passenger, etc.)	M.C. DESIGN
ESSO MANHATTAN	242157	Tank Vessel	T2-SE-A1

BUILDER	BUILDER'S HULL NO.	DATE COMPLETED
Sun Shipbuilding & Drydock Company	267	22 Aug.,'42

OWNER	OPERATOR
Standard Oil Co. of New Jersey	Standard Oil Co. of New Jersey

EXTENT OF WELDING

Hull all welded
No inner bottom

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	-	INNER BOTTOM SEAMS	Yes	DECK BUTTS
Yes	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	-	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	-	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE

(attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION	
29 March, 1943	1205 EWT	40 fathoms of water 3/4 mile inshore buoy 3, Ambrose Channel, N.Y.	

SHIP'S SPEED	COURSE	DRAFT FWD.	DRAFT AFT
14 knots	121° true	12'-1"	18'-7"

SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP
Slight ground swell	Clear	On port bow

WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE
Force 2	Northeast	30° to 40°	Not known

DESCRIPTION OF FAILURE

(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

The fracture started in a butt weld between plates A-9 and A-10 at the crown of the deck.

GENERAL HISTORY AND DESCRIPTION OF FAILURE INCLUDING KNOWN CONTRIBUTORY FACTORS

With a sound described variously as a thump, thud, bang, crash, or explosion, the fracture ran across the deck in way of #6 tank, and down both sides, progressing to the bilge port and starboard. The vessel jack-knifed and the bow dug under an oncoming wave. The crew abandoned in the boats and were picked up by the USCG KIMBALL. The bottom fractured later and the two portions drifted apart. The butt weld in which the crack started contained oxide, slag and porous areas.
Bending moment in still water = 225,800 Ft. x Tons. Hog amidships.
Stress in crown of deck = 12,200 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL

(Repaired, lost, etc.)

Repaired on drydock at Todd Erie Basin and returned to service.

SIGNED (Name and Title)	DISTRICT

Figure 15.

FIGURE 16.—Aerial view of failure of *S. S. Esso Manhattan* taken from one of two blimps convoying vessel.

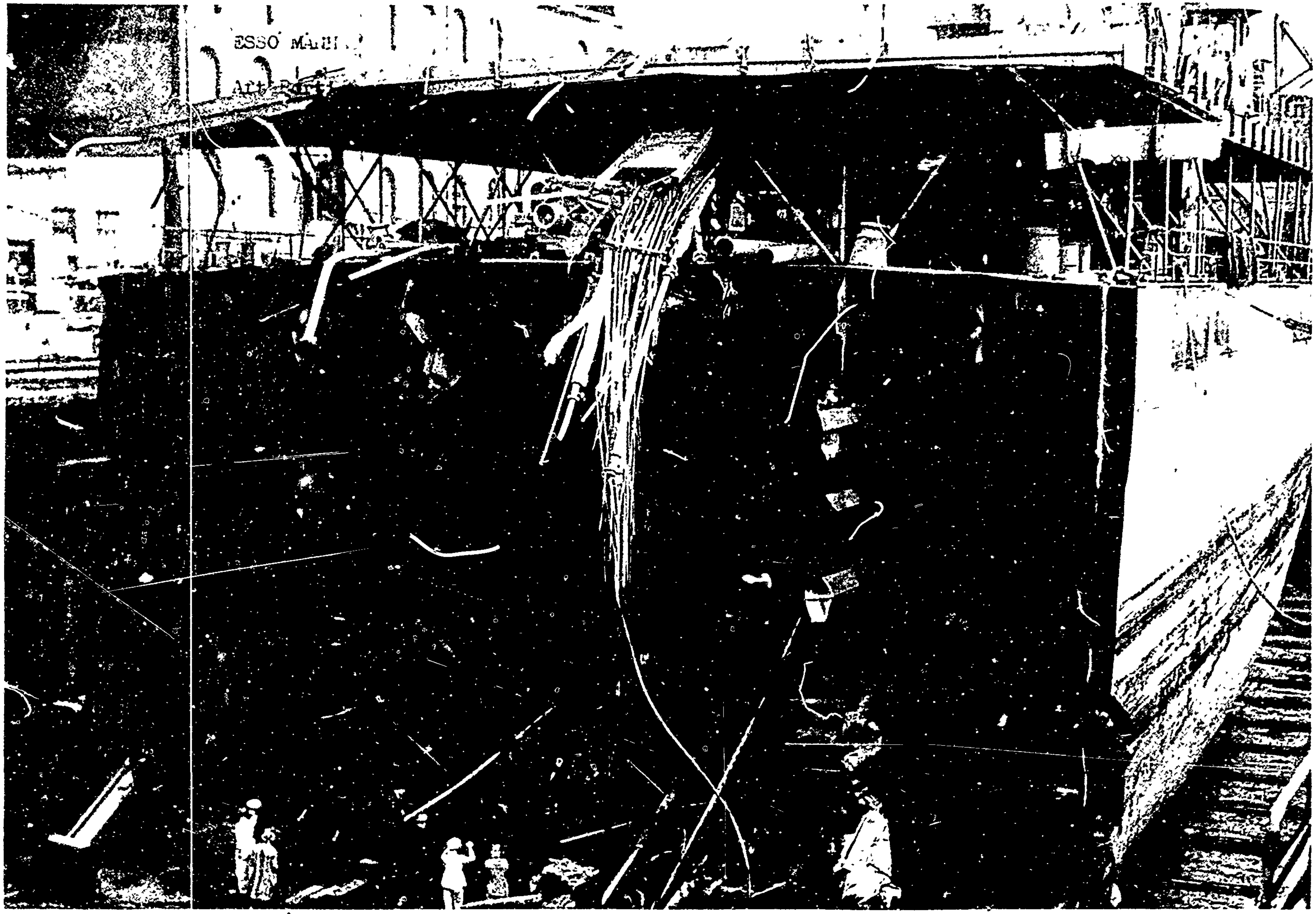


FIGURE 17.—Aft portion *S. S. Esso Manhattan.*

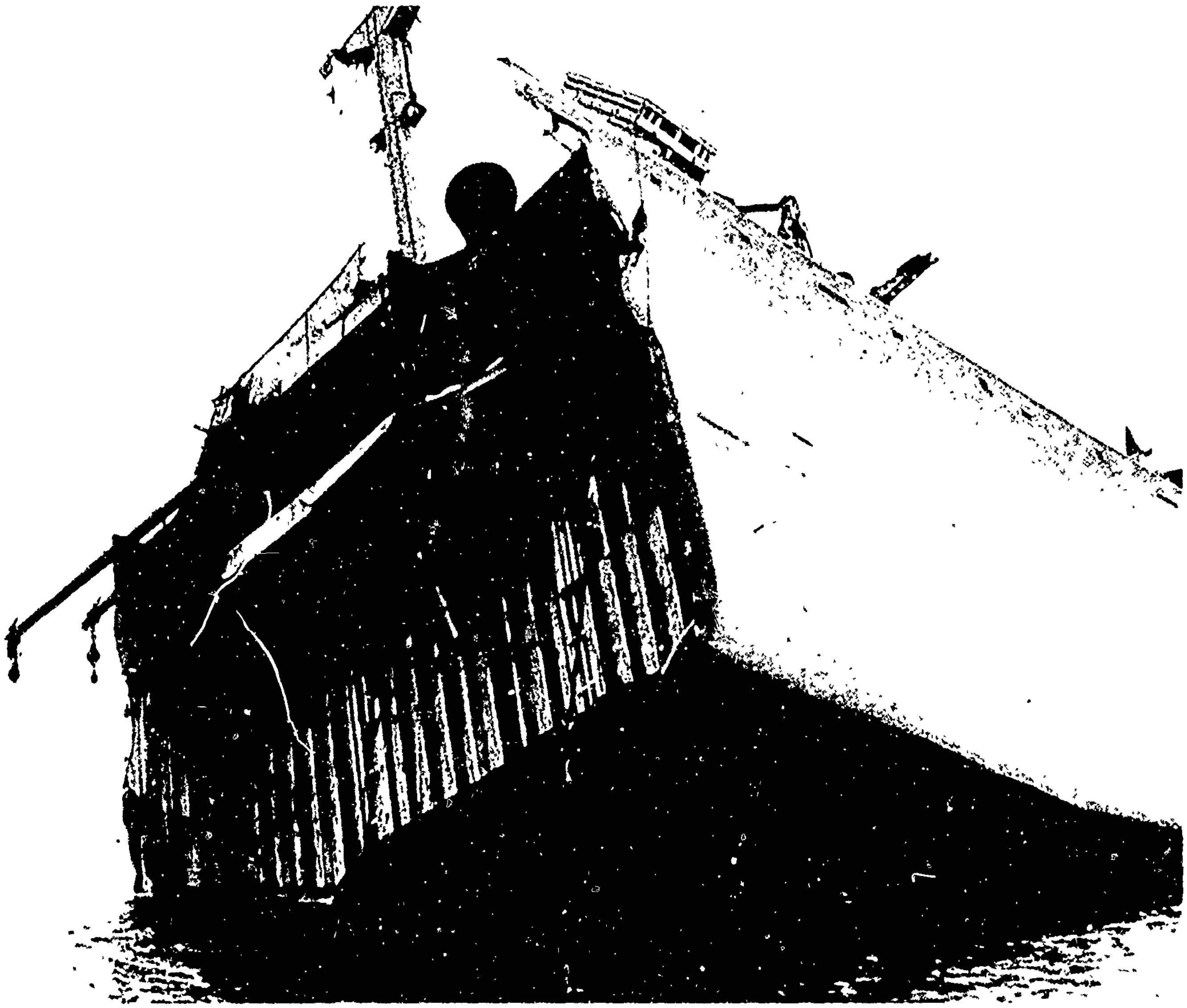


FIGURE 18.—Forward portion of *S. S. Valeri Chkalov*.

FIGURE 19.—Stern portion of *S. S. Valeri Chkalov.*

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 Apr., 1944 (Date)

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO	TYPE (Dry Cargo Passenger etc.)	M.C. DESIGN
VALERI CHKALOV	None	Dry Cargo Vessel	EC2-S-C1
BUILDER: Permanente Metals Corporation Richmond Shipyard No. 2		BUILDER'S HULL NO: 481	DATE COMPLETED: 17 Apr., '43
OWNER: War Shipping Administration		OPERATOR: Union of Soviet Socialist Republics	

EXTENT OF WELDING

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	Yes	INNER BOTTOM SEAMS	Yes	DECK BUTTS
No	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	Yes	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	Yes	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE

(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION		
11 Dec., 1943	1210	Latitude 35° N, Longitude 168° - 25' W		
SHIP'S SPEED	COURSE		DRAFT FWD.	DRAFT AFT
Cut by storm	Sovetskaya Gavan, Siberia to Akutan, Alaska		Unknown	Unknown
SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP		
Heavy	Heavy storm, vis. 0	Apparently a head sea		
WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE	
6 to 8	Unknown	29° - 34°	Unknown	

DESCRIPTION OF FAILURE

(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

The cracks which finally broke the vessel started exactly in the forward corners of #3 hatch, port and starboard.

GENERAL HISTORY AND DESCRIPTION OF FAILURE INCLUDING KNOWN CONTRIBUTORY FACTORS:

The vessel departed from Sovetskaya on 1 Dec., 1943, in ballast. Gales and heavy seas were encountered after departure. At noon on 11 Dec., 1943, a loud report was heard and three cracks were found, one on the port side at Fr. #74, one on stbd. side at Fr. #74; and one on the stbd. side at Fr. #76. The port side crack extended from the hatch corner across the deck and down the shell to the bilge. The stbd. crack at Fr. #74 was in the side shell from the sheer strake to the tween deck. The stbd. crack at Fr. #76 ran down the side shell from the sheer strake halfway down the tween decks. The vessel was taken in tow by the tug "Joseph Stalin" but at 2206 on 13 Dec., she broke completely in two. Both portions were taken in tow by U. S. Navy tugs and brought to anchorage. The crews did not abandon ship. Ballasting details will be made available by the USSR in the near future.

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL

(Repaired lost etc.)

Both portions at anchor in Sand Bay, Great Sitkin Island. Future undetermined.

SIGNED (Name and title)	DISTRICT

Figure 20.

(P)

REPORT OF STRUCTURAL FAILURE OF INSPECTED VESSEL
UNITED STATES COAST GUARD
NAVCG-2752

This report includes all available information up to: 1 June, 1946 *(Date)*

DESCRIPTION OF VESSEL

NAME	OFFICIAL NO.	TYPE *(Dry Cargo, Passenger, etc.)*	M.C. DESIGN
DONBASS III (ex BEACON ROCK	246377	Tanker	T2

BUILDER	BUILDER'S HULL NO.	DATE COMPLETED
Kaiser Co., Inc., Swan Island	84	Sept., 1944

OWNER	OPERATOR
Lend-leased to Russia	Russia - "Nar.omorflot" (U.S. agents - Moore-McCormack)

EXTENT OF WELDING

Hull all welded
No inner bottom

Yes	SIDE SHELL SEAMS					Yes	DECK SEAMS
Yes	SIDE SHELL BUTTS	Yes	BOTTOM SEAMS	-	INNER BOTTOM SEAMS	Yes	DECK BUTTS
Yes	FRAMES TO SIDE SHELL	Yes	BOTTOM BUTTS	-	INNER BOTTOM BUTTS	Yes	BEAMS TO DECK
Yes	BULKHEADS	Yes	FLOORS TO SHELL	-	FLOORS TO INNER BOTTOM	Yes	DECK TO SHELL

CIRCUMSTANCES SURROUNDING FAILURE

(Attach all available details of ship's loading)

DATE OF FAILURE	TIME	SHIP'S LOCATION
17 Feb., 1946	1425	Long. 176° -11'; Lat. 46° -55' N

SHIP'S SPEED	COURSE	DRAFT FWD.	DRAFT AFT
7 knots	About 7.5° South of West	29'-8"	31'-8"

SEA CONDITION	WEATHER	DIRECTION OF WAVES WITH RESPECT TO SHIP	
Heavy	Stormy(?) had been for four days just before.	60° on port bow	(dep.at San Pedro)

WIND FORCE	WIND DIRECTION	AIR TEMPERATURE	WATER TEMPERATURE
9-10 Beaufort	From SSW	37°F	41°-43°F

DESCRIPTION OF FAILURE

(Include sketch of fracture showing starting point and relative location of welds and other structural features)

APPARENT STARTING POINT

The herringbone pattern on the fractured plate edge indicates the origin of fracture to be below the waterline.

GENERAL HISTORY AND DESCRIPTION OF FAILURE, INCLUDING KNOWN CONTRIBUTORY FACTORS:

Fracture occurred in way of #5 tank (the above-water portion of fracture is between Frs. 61 and 62). Vessel broke in two. Stern portion of vessel towed to Port Angeles, Washington; For'd portion towed to Dutch Harbor. The 13th CG District has inspected after above-water portion of hull. Report, photos, etc., have been received at CGHQ. Project underway to procure similar information relative to underwater portion of fracture. According to photos and records, this vessel was fitted with deep I-beam longitudinal strengthening under the main deck transverses. These were apparently of no value in crack prevention or in limiting a crack of bottom origin. Fifteen lives were lost.

Bending moment in still water = 155,200 Ft. x Tons Sag at Fr.#61
Stress in bottom of keel = 7,800 Lbs./in.^{2} Tension.

CLASSIFICATION OF FAILURE: Broke in two

DISPOSITION OF VESSEL

(Repaired, lost, etc.)

SIGNED *(Name and Title)*	DISTRICT

(P)

Figure 21.

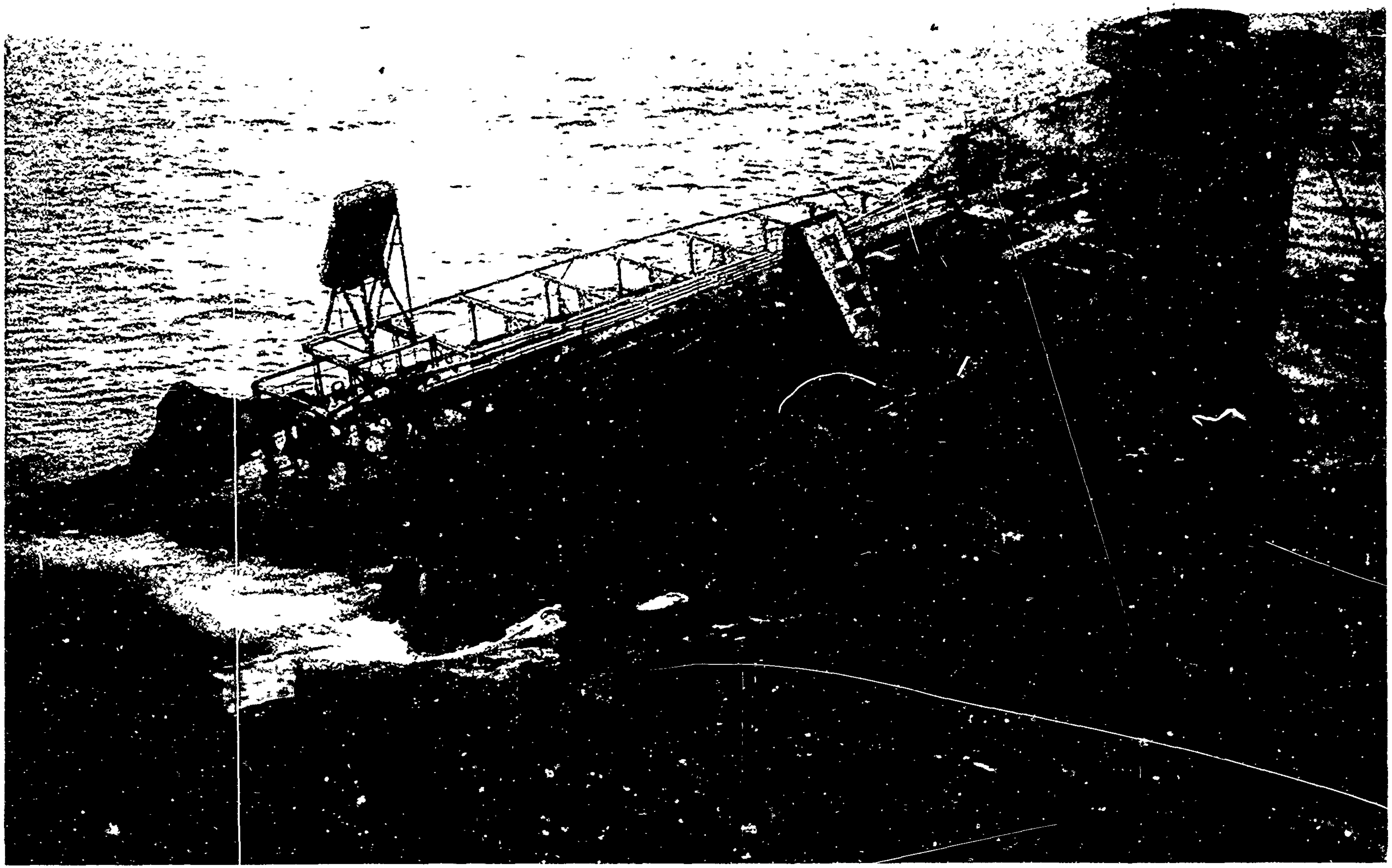


FIGURE 22.—Forward portion of *S. S. Donbass III*.

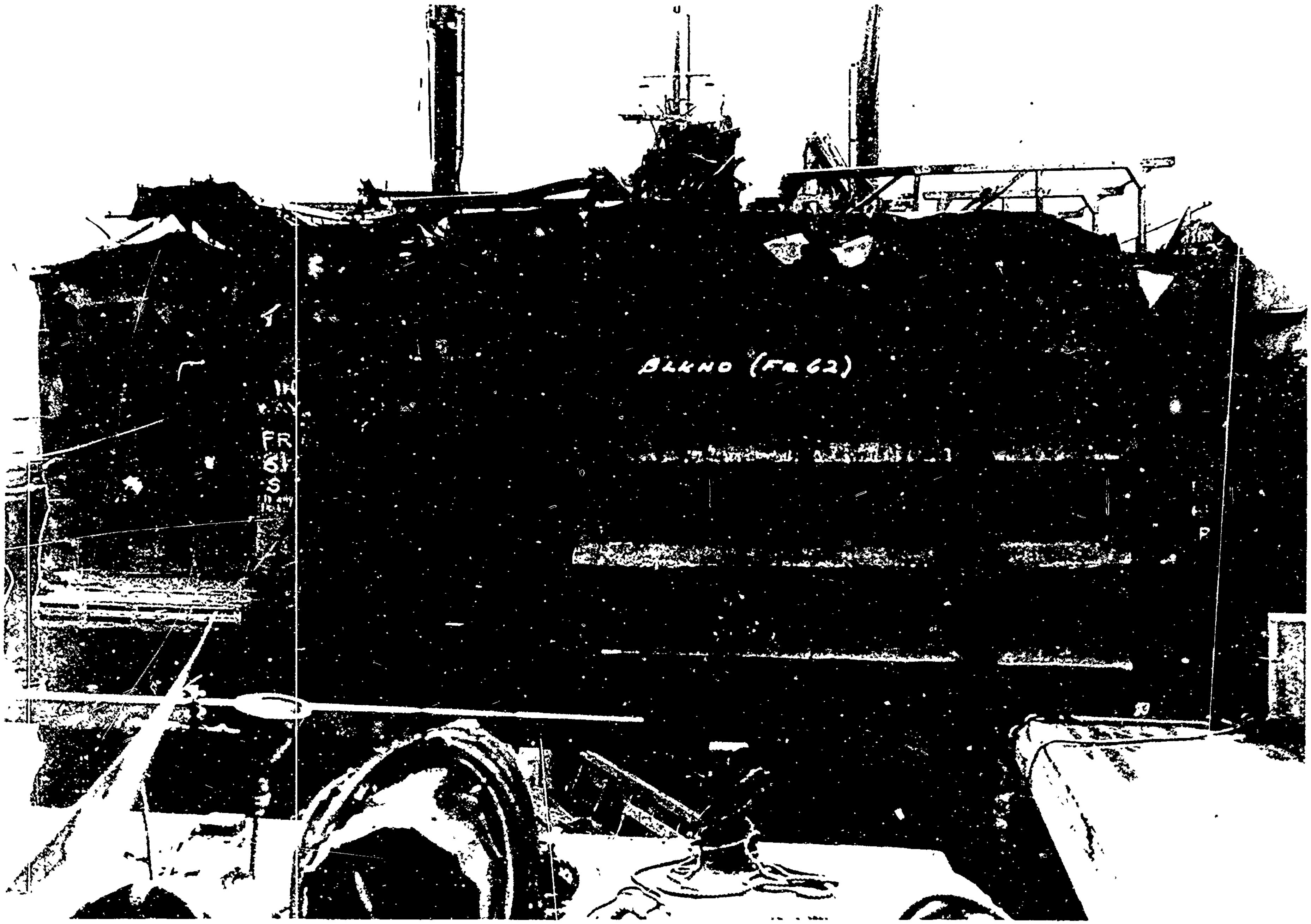


FIGURE 23.—Stern portion of *S. S. Donbass III*.

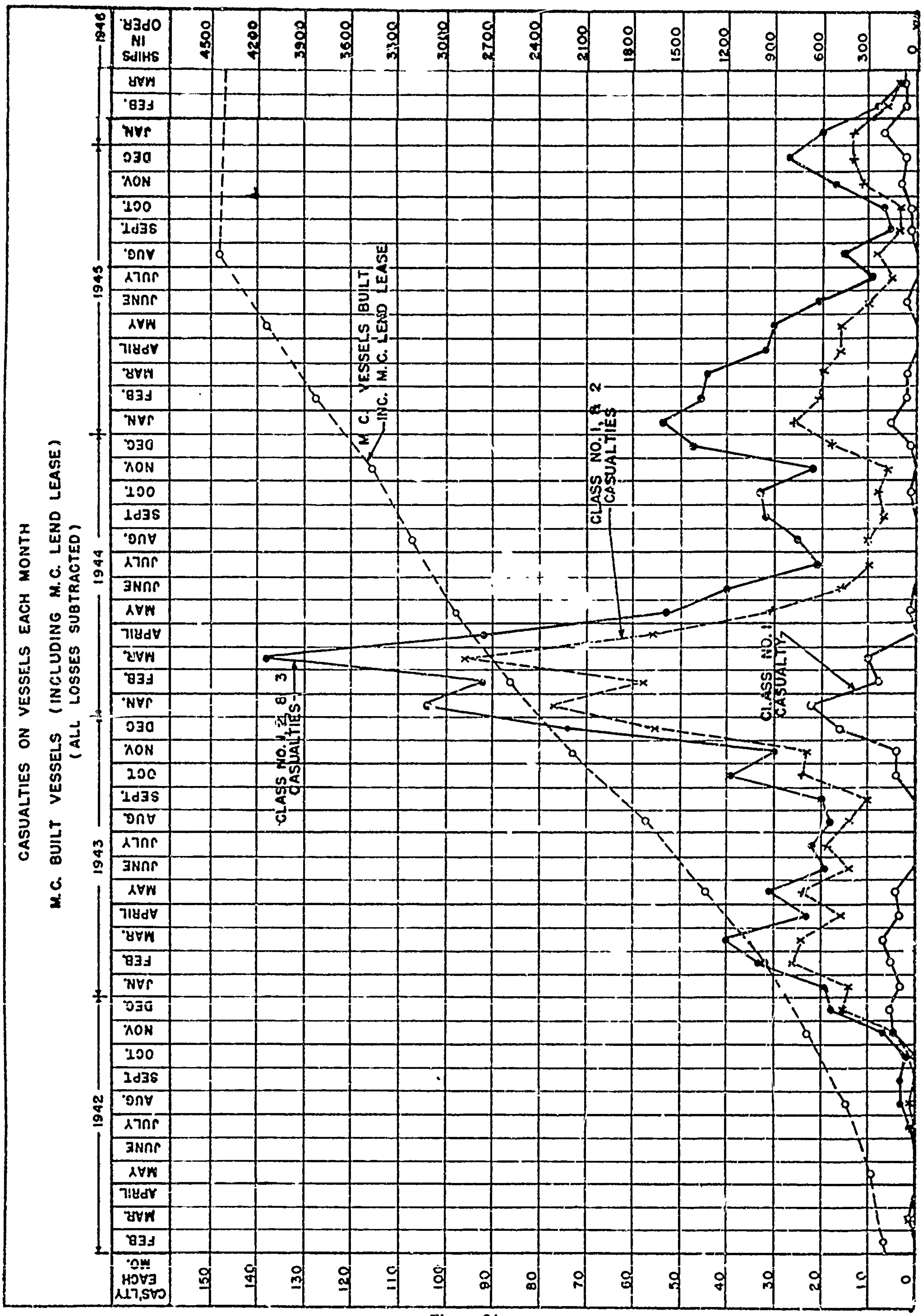

CASUALTIES ON VESSELS EACH MONTH
M.C. BUILT VESSELS (INCLUDING M.C. LEND LEASE)
(ALL LOSSES SUBTRACTED)
SHIPS IN OPER.
4500
4200
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
CAS'LTY EACH MO.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1942
1943
1944
1945
1946
FEB.
MAR.
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
M.C. VESSELS BUILT INC. M.C. LEND LEASE
CLASS NO. 1, 2, & 3 CASUALTIES
CLASS NO. 1 & 2 CASUALTIES
CLASS NO. 1 CASUALTY

Figure 24.

TABLE II

CLASS 1 AND 2 CASUALTIES ON MARITIME COMMISSION-BUILT SHIPS (INCLUDING SHIPS ON LOAN)

Number of Casualties (c) by Age and Calendar Month at Time of Casualty, and Number of Ships (s) Afloat of the Same Age in the Month of Casualty

Age, (Months after launching)	Date of casualty																							
	1941								1942															
	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.	
	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s
0	...	10	...	8	...	10	...	18	...	15	...	25	...	28	...	41	...	56	...	52	...	73	...	84
1	...	3	...	10	...	8	...	10	...	18	...	15	...	25	...	28	...	41	...	56	...	52	...	73
2	...	5	...	3	...	10	...	8	...	10	...	18	...	15	...	25	...	27	...	40	...	55	...	52
3	...	7	...	5	...	3	...	10	...	8	...	10	...	18	...	15	...	25	...	26	...	40	...	55
4	...	7	...	7	...	5	...	3	...	10	...	8	...	10	...	18	...	14	...	24	...	23	...	40
5	...	3	...	7	...	7	...	5	...	3	...	10	...	8	...	10	...	18	...	14	...	21	...	23
6	...	7	...	3	...	7	...	7	...	5	...	3	...	10	...	8	...	10	...	18	...	14	...	21
7	...	1	...	7	...	3	...	7	...	7	...	5	...	3	...	10	...	8	...	10	...	17	...	14
8	...	4	...	1	...	7	...	3	...	7	...	7	...	5	...	3	...	10	...	8	...	9	...	16
9	...	7	...	4	...	1	...	7	...	3	1	7	...	7	...	5	...	3	...	10	...	8	...	9
10	...	10	...	7	...	4	...	1	...	7	...	3	...	7	...	7	...	4	...	3	...	10	...	8
11	...	7	...	10	...	7	...	4	...	1	...	7	...	3	...	7	...	7	...	4	...	3	...	9
12	...	4	...	7	...	10	...	7	...	4	...	1	...	7	...	3	...	7	...	7	...	3	...	3
13	...	9	...	4	...	7	...	9	...	7	...	4	...	1	...	7	...	3	...	7	...	7	...	3
14	...	3	...	9	1	4	...	7	...	9	...	7	...	4	...	1	...	7	...	3	...	6	...	7
15	...	4	...	3	...	9	...	4	...	7	...	9	...	7	...	4	...	1	...	6	...	3	...	5
16	...	0	...	4	...	3	...	9	...	4	...	7	...	9	...	7	...	3	...	1	...	6	...	3
17	...	3	...	0	...	4	...	3	...	9	...	4	...	7	...	9	...	7	...	3	...	1	...	6
18	...	1	...	3	...	0	...	4	...	3	...	9	...	4	...	7	...	9	...	7	...	3	...	1
19	...	2	...	1	...	3	...	0	...	4	...	3	...	9	...	4	...	7	...	9	...	7	...	3
20	...	4	...	2	...	1	...	3	...	0	...	4	...	3	...	9	...	4	...	7	...	9	...	7
21	...	7	...	1	...	2	...	1	...	3	...	0	...	4	...	3	...	9	...	4	...	7	...	9
22	...	2	...	7	...	4	...	2	...	1	...	3	...	0	...	4	...	3	...	9	...	4	...	7
23	...	3	...	2	...	7	...	4	...	2	...	1	...	3	...	0	...	4	...	3	...	9	...	4
24	...	6	...	3	...	2	...	7	...	4	...	2	...	1	...	3	...	0	...	4	...	3	1	9
25	...	1	...	6	...	3	...	2	...	7	...	4	...	2	...	1	...	3	...	0	...	4	...	3
26	...	4	...	1	...	6	...	3	...	2	...	6	...	4	...	2	...	1	...	3	...	0	...	4
27	...	2	...	4	...	1	...	6	...	3	...	2	...	6	...	4	...	2	...	0	...	3	...	0
28	...	3	...	2	...	4	...	1	...	6	...	3	...	2	...	6	...	4	...	2	...	0	...	2
29	...	4	...	3	...	2	...	4	...	1	...	6	...	3	...	2	...	6	...	4	...	2	...	0
30	...	2	...	4	...	3	...	2	...	4	...	1	...	6	...	3	...	2	...	6	...	4	...	2

NOTE:—Data relating to ships exceeding 30 months age are omitted.

Table II—Continued

CLASS 1 AND 2 CASUALTIES ON MARITIME COMMISSION-BUILT SHIPS (INCLUDING SHIPS ON LOAN)

Number of Casualties (c) by Age and Calendar Month at Time of Casualty, and Number of Ships (s) Afloat of the Same Age in the Month of Casualty

Age (Months after launching)	Date of casualty																							
	1942								1943															
	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.	
	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s
0	...	85	...	91	...	106	1	117	1	105	3	106	1	128	...	145	1	164	2	140	1	140	2	143
1	...	84	1	85	...	91	6	106	2	116	7	105	1	104	2	128	1	145	...	163	1	140	...	138
2	...	73	1	84	2	84	3	91	5	105	3	116	4	101	2	101	1	128	1	145	3	161	...	140
3	...	50	...	72	2	82	2	84	4	89	...	104	1	116	2	100	1	101	...	128	...	144	...	161
4	...	55	...	50	2	72	1	82	...	83	2	88	...	103	4	115	3	99	1	100	1	127	1	143
5	...	38	1	54	...	48	4	72	2	81	1	83	3	87	1	103	2	113	2	99		99	...	127
6	...	23	...	38	...	52		48	2	71	3	81	1	81	4	87		103	...	110	1	98	2	96
7	...	21	...	23	...	38	1	52	1	48	3	70	...	80	2	80	1	87	2	103	...	108	1	96
8	...	14	...	21	...	21	...	38	2	50	1	47	3	68	1	80	...	79	1	86	2	103	1	108
9	...	16	1	14	1	21	...	21	...	38	1	50	...	47	...	68	...	80	1	79	1	85	...	103
10	...	9	...	16	...	14	...	21	...	21	...	38	1	49	...	47	...	68	...	80	...	78	...	85
11	...	8	...	9	...	16	...	14	...	21	2	21	1	38	1	49	...	47	1	68	...	79	...	78
12	...	9	...	8	...	9	...	16	2	14	...	21	1	21	...	37	...	49	...	47		68	...	79
13	...	3	1	9	...	7	...	9	...	16	1	13	...	20	...	21	...	37	...	49	1	47	2	68
14	...	3	...	3	...	9	...	7	...	9	1	15	2	11	...	20	...	21		37	1	49	...	47
15	...	7	...	3	...	3	...	8	1	7	...	9	1	15	...	11	...	20	...	20	...	37	...	49
16	...	5	...	7	...	3	1	3	...	7	...	7	1	9	1	15	...	11	1	19	...	19	...	37
17	...	3	...	5	...	7	...	3	...	3	...	7	...	5	1	8	2	15	...	11	...	19	...	19
18	...	6	...	3	...	4	...	7	...	3	2	3	...	7	...	5	...	8	...	15	...	11	...	19
19	...	1	...	6	...	3	...	4	...	7	...	3	...	3	1	7	...	5	1	8	2	15	...	11
20	...	3	...	1	...	6	...	3	...	4	...	7	...	3	1	3	...	7	...	5	1	8	2	15
21	...	7	...	3	...	1	...	6	...	3	...	4	...	7	...	3	...	3	...	7	...	5	...	8
22	...	9	...	7	...	3	...	1	...	6	...	3	2	4	...	7	...	3	1	3	1	7	...	5
23	...	6	...	8	...	7	...	3	...	1	...	6	...	2	...	4	...	7	1	3	1	3	...	7
24	...	4	...	6	...	7	...	7	...	3	...	1	...	6	...	2	...	4	...	7	...	3	...	3
25	...	9	...	4	...	5	...	7	...	7	...	3	...	1	...	6	...	2	...	4	...	7	...	3
26	...	3	...	9	...	4	...	5	...	7	...	7	...	3	...	1	...	6	...	2	...	4	...	7
27	...	4	...	3	...	9	...	4	...	5	...	7	...	7	...	3	...	1	...	6	...	2	...	4
28	...	0	...	4	...	3	1	9	...	3	...	5	...	7	...	7	...	3	...	1	...	6	...	2
29	...	2	...	0	...	4	...	3	...	9	...	3	...	5	1	7	...	7	...	3	...	1	...	6
30	...	0	...	2	...	0	...	4	...	3	...	9	...	3	...	5	...	6	...	7	...	3	...	1

Note:—Data relating to ships exceeding 30 months age are omitted.

Table II—Continued

CLASS 1 AND 2 CASUALTIES ON MARITIME COMMISSION-BUILT SHIPS (INCLUDING SHIPS ON LOAN)

Number of Casualties (c) by Age and Calendar Month at Time of Casualty, and Number of Ships (s) Afloat of the Same Age in the Month of Casualty

Age (Months after launching)	Date of casualty																							
	1943								1944															
	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.	
	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s
0	...	143	1	163	...	160	3	141	1	129	1	116	2	125	...	123	...	117	...	110	...	80	...	90
1	3	143	1	143	2	163	...	158	2	141	4	129	1	116	...	125	1	123	2	117	...	110	...	80
2	3	138	2	143	2	143	2	162	4	158	1	141	...	129	...	116	...	125	...	123	...	117	...	109
3	...	140	1	138	3	143	2	142	...	161	1	158	1	141	...	128	...	116	...	125	...	122	...	117
4	...	159	2	140	2	134	1	143	2	141	2	161	3	158	1	141	...	128	...	116	1	125	...	121
5	...	140	2	159	4	140	2	134	3	143	5	140	...	160	2	158	...	141	...	128	...	115	2	125
6	1	127	1	139	4	159	1	139	2	134	5	143	3	140	2	160	...	158	...	140	...	128	...	115
7	1	97	2	127	3	138	8	158	7	138	4	134	2	143	1	140	...	160	...	157	1	140	...	128
8	1	95	...	97	3	126	7	138	6	156	3	137	2	134	2	141	1	140	1	160	...	157	...	139
9	...	108	2	95	1	97	5	125	3	138	7	156	3	136	1	133	...	141	...	140	1	160	...	157
10	2	103	3	108	4	95	5	97	7	124	2	138	2	156	1	136	2	133	...	140	...	139	1	160
11	1	85	2	103	1	108	...	94	4	97	10	123	4	137	2	156	3	136	...	128	1	139	1	139
12	1	78	...	85	6	103	2	108	5	92	5	96	5	122	3	137	5	155	...	136	...	128	...	139
13	...	79	...	78	...	85	2	102	7	107	4	92	4	95	1	121	2	137	1	154	1	136	1	127
14	...	67	...	79	2	78	3	84	5	102	2	107	6	92	3	95	1	121	...	137	1	154	...	135
15	...	47	1	67	3	79	1	78	1	84	9	101	2	107	5	92	3	95	...	121	1	137	...	154
16	1	49	...	47	1	67	3	79	7	77	7	84	6	99	3	107	...	92	...	94	1	121	...	137
17	...	37	...	49	...	47	3	67	1	78	3	77	6	84	1	99	4	107	...	92	...	94	1	121
18	...	19	...	36	...	49	...	47	5	67	6	78	1	77	2	83	1	99	...	107	...	92	...	94
19	...	19	...	19	...	36	2	49	1	47	1	67	3	78	...	77	...	83	...	97	1	107	1	92
20	...	11	...	19	...	19	1	36	1	49	1	46	1	67	2	78	...	77	...	83	2	97	...	106
21	1	15	...	11	...	19	4	19	3	35	2	49	2	46	1	67	1	78	...	77	2	82	...	97
22	...	8	...	15	...	11	...	19	1	19	...	35	...	49	...	46	...	67	1	78	...	77	...	32
23	...	5	1	8	...	15	1	11	...	18	2	19	1	35	...	49	...	46	1	67	...	78	...	77
24	...	7	...	5	...	8	...	15	1	11	...	18	...	19	2	35	1	49	...	44	1	66	...	77
25	...	3	...	7	...	5	...	8	...	15	...	11	1	17	...	19	1	35	...	49	...	44	...	66
26	...	3	...	3	...	7	...	5	...	8	1	15	...	11	...	17	...	19	...	35	...	49	...	44
27	...	7	...	3	...	3	...	7	...	5	...	8	...	15	1	11	...	17	...	19	...	35	...	49
28	1	4	...	7	...	3	...	3	...	7	...	5	...	8	...	15	...	11	...	17	...	19	...	35
29	...	2	...	4	...	7	...	3	...	3	...	7	...	5	...	8	...	15	...	11	1	17	...	19
30	...	6	...	2	...	4	...	7	2	3	...	3	1	7	...	5	1	8	...	15	...	11	...	17

Note:—Data relating to ships exceeding 30 months age are omitted.

Table II—Continued

CLASS 1 AND 2 CASUALTIES ON MARITIME COMMISSION-BUILT SHIPS (INCLUDING SHIPS ON LOAN)

Number of Casualties (c) by Age and Calendar Month at Time of Casualty, and Number of Ships (s) Afloat of the Same Age in the Month of Casualty

Age (Months after launching)	Date of casualty																							
	1944								1945															
	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.[1]	
	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s
0	...	78	1	89	1	88	1	133	2	124	1	110	...	118	...	111	...	100	...	102	...	102	...	...
1	...	90	...	78	...	89	...	88	...	133	...	124	...	110	...	118	...	111	...	100	...	102	...	...
2	...	80	...	89	...	78	1	89	1	88	...	132	...	124	1	110	...	118	...	111	...	100	...	...
3	...	109	1	80	...	89	1	78	...	89	1	88	...	131	1	122	...	110	1	118	...	111	...	...
4	...	116	...	109	...	80	...	89	...	77	2	89	...	87	...	131	...	122	...	110	...	118	...	...
5	...	121	...	116	...	109	...	80	...	89	...	77	...	89	...	87	...	131	...	122	...	110	...	...
6	...	125	...	121	...	115	1	109	...	80	1	89	...	77	...	89	...	87	...	131	...	122	...	...
7	...	115	...	125	...	121	...	115	...	109	...	80	1	89	1	77	...	89	...	87	...	131	...	...
8	...	127	1	115	...	124	1	121	...	115	...	109	...	80	1	89	...	77	...	89	...	87	...	...
9	1	139	1	126	...	115	1	123	...	121	2	115	...	109	1	80	...	89	...	77	...	89	...	...
10	...	156	...	139	1	126	...	114	...	123	2	120	...	115	1	109	...	80	...	89	...	77	...	...
11	...	160	...	155	...	139	...	126	...	114	...	123	...	119	1	115	...	109	...	80	...	89	...	...
12	...	139	...	160	...	154	1	139	...	126	...	114	...	123	1	119	...	115	...	109	...	80	...	...
13	...	138	...	139	...	160	1	152	...	137	1	126	...	112	...	122	...	119	...	115	...	109	...	...
14	...	127	...	138	...	139	1	159	...	150	1	137	1	126	...	112	...	122	1	118	...	115	...	...
15	...	135	1	126	1	137	1	138	2	158	1	150	...	137	...	126	...	112	...	122	...	118	...	...
16	...	154	1	134	...	126	1	136	2	138	1	158	...	150	...	137	...	126	...	112	...	122	...	...
17	1	137	...	154	...	133	1	126	1	136	1	138	1	157	...	150	...	137	...	126	...	112	...	...
18	...	121	2	137	...	154	...	133	...	126	1	135	1	137	1	157	...	150	...	137	...	126	...	...
19	...	94	...	120	...	137	...	153	1	133	...	126	...	135	...	136	...	157	...	150	1	137	...	...
20	1	92	...	94	...	119	1	136	1	153	...	133	1	126	...	135	1	136	...	157	...	150	...	...
21	1	106	...	92	...	93	3	118	2	135	...	153	2	133	2	126	...	135	...	136	...	157	...	...
22	...	97	...	106	...	92	...	92	1	118	...	135	...	152	1	133	1	126	...	135	...	136	...	...
23	2	82	...	97	...	106	1	91	1	91	1	118	...	135	...	151	...	133	...	126	...	135	...	...
24	...	77	...	82	...	97	...	105	2	91	1	90	1	118	1	135	1	151	...	133	...	126	...	...
25	...	76	...	77	1	82	2	97	3	104	...	90	...	91	3	118	...	135	2	151	...	133	...	...
26	...	66	...	76	2	77	2	82	3	97	1	104	2	90	...	90	...	118	...	135	...	151	...	...
27	...	44	...	66	...	76	...	77	1	82	1	96	...	104	...	90	...	90	...	117	1	135	...	...
28	...	49	...	44	...	66	1	76	...	77	1	81	...	96	2	104	2	90	...	90	...	117	...	...
29	...	35	...	49	...	44	...	66	2	76	...	77	1	80	1	96	...	104	...	90	...	89	...	...
30	...	19	...	35	...	49	...	44	...	66	1	76	...	77	...	79	...	96	...	104	...	89	...	...

Note:—Data relating to ships exceeding 30 months age are omitted.

1—Study Terminated 1 August 1945

PART II

Analysis of Factors Contributing to Structural Failures

A. *Sea and Weather Conditions*

In determining the effects of sea and weather, it was necessary to use extra care to avoid misleading results. Ships of different designs might tend toward exclusive use of specific trade routes. For this reason and because there were so many identical subjects, the Liberty ship was used as the specimen for analysis. Existing orders to modify the hatch corners of vessels headed for regions of severe weather conditions tended to segregate the Liberties on a sea and weather condition scale. For this reason, vessels were eliminated from the study when the hatch corners were modified. For the same reason, the newer vessels with design and workmanship improvements were preferred for the more severe services, and this factor had to be considered. The selection finally narrowed down to the 667 EC2 vessels launched before February 1943. These vessels were completed before any structural design details were altered.

The service life of each vessel was included from date of launching to the present or to the date it was lost, loaned abroad or modified at the hatch corners. The modified vessels were then studied separately.

Each vessel of the group was located from the log entry on 1 February 1943; 1 August 1943; 1 February 1944; 1 August 1944; 1 February 1945; and 1 August 1945. The locations of the ships for each of the six dates were plotted together on one chart, figure 25. Vessels in port were kept separate. The combined picture is representative of the condition over the operating period.

To obtain the data regarding the proportion of service time experienced at various temperatures, the world chart of ship locations was applied to twelve charts of the world including isotherms for the monthly average temperatures. The ship occasions chart, Fig. 25, was considered to represent the distribution of Liberty ships over the world at any instant during the period under study, as it shows the integrating positions based upon six occasions spread over the period of study. The 3,413 ship occasions indicated on the chart were divided between the 10° temperature ranges described by the isotherms on the world charts. The occasions within each temperature range were then summed for the twelve monthly charts. Thus a relative distribution was obtained indicating the experience of the ships in each temperature range based upon monthly isothermal charts.

The isothermal charts show the average monthly temperature. Instantaneous temperatures are above and below the average for a certain percentage of time. Data regarding the average spread distribution corresponding to each average monthly temperature and for various different climates were obtained from the Weather Bureau and the Hydrographic Office. A correction was applied to the accumulated occasions within each temperature range and they were redistributed to represent instantaneous values. This correction was generally not great. The resulting figures indicated the proportionate amount of service time for each temperature range as established with the aid of the ship occasions chart. These relative figures were changed to actual ship months of service by a straight multiplication because the total number of months of service time on the particular group of ships was known.

A similar procedure was followed in the case of both the sea and swell charts but the Hydrographic Office furnished charts which were on a percentage of time per month rather than an average monthly basis. It was therefore not necessary to make the correction for average monthly values.

The number of fractures for the corresponding period of operation were plotted opposite the temperature which was reported with each. When the temperature at time of fracture was not reported, the fracture was not enumerated in this study.

From the assembled data based on the 667 Liberty ships launched before 1 February 1943, an attempt

WORLD CHART SHOWING LOCATION OF THE SELECTED LIBERTY SHIPS ON 3413 OCCASIONS.

2195 OCCASIONS IN PORT (#)
1218 OCCASIONS AT SEA

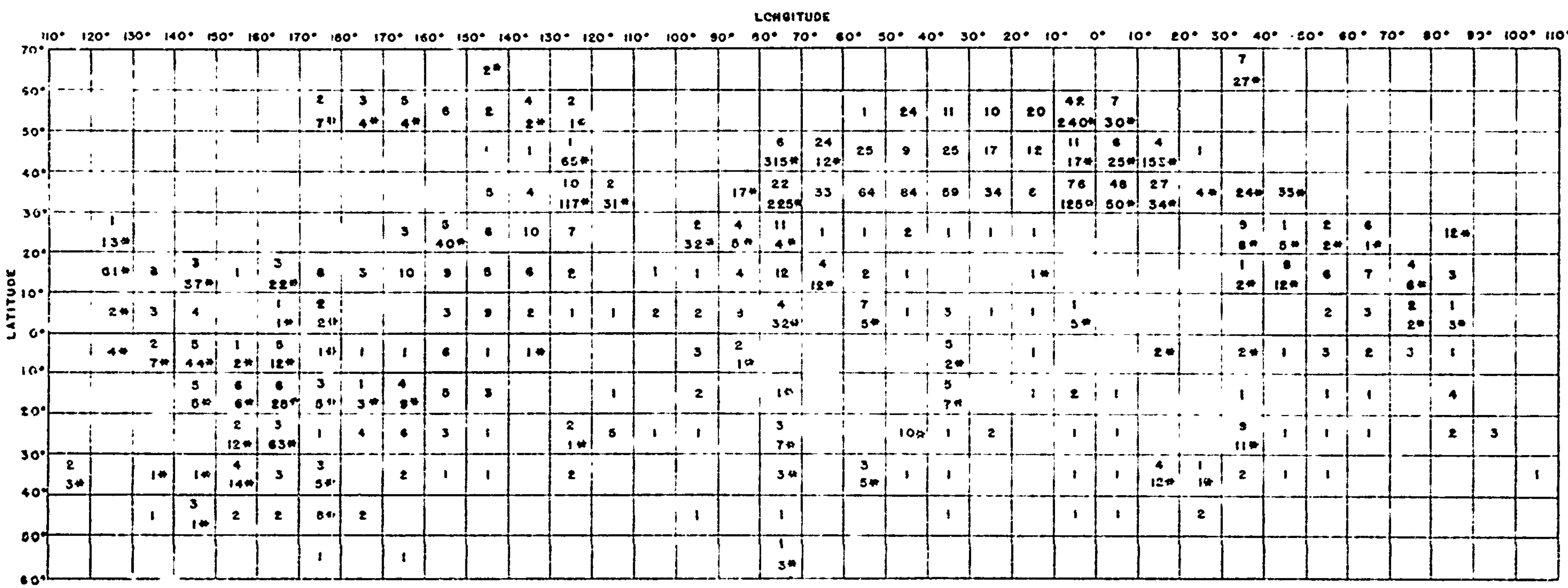


Figure 25.

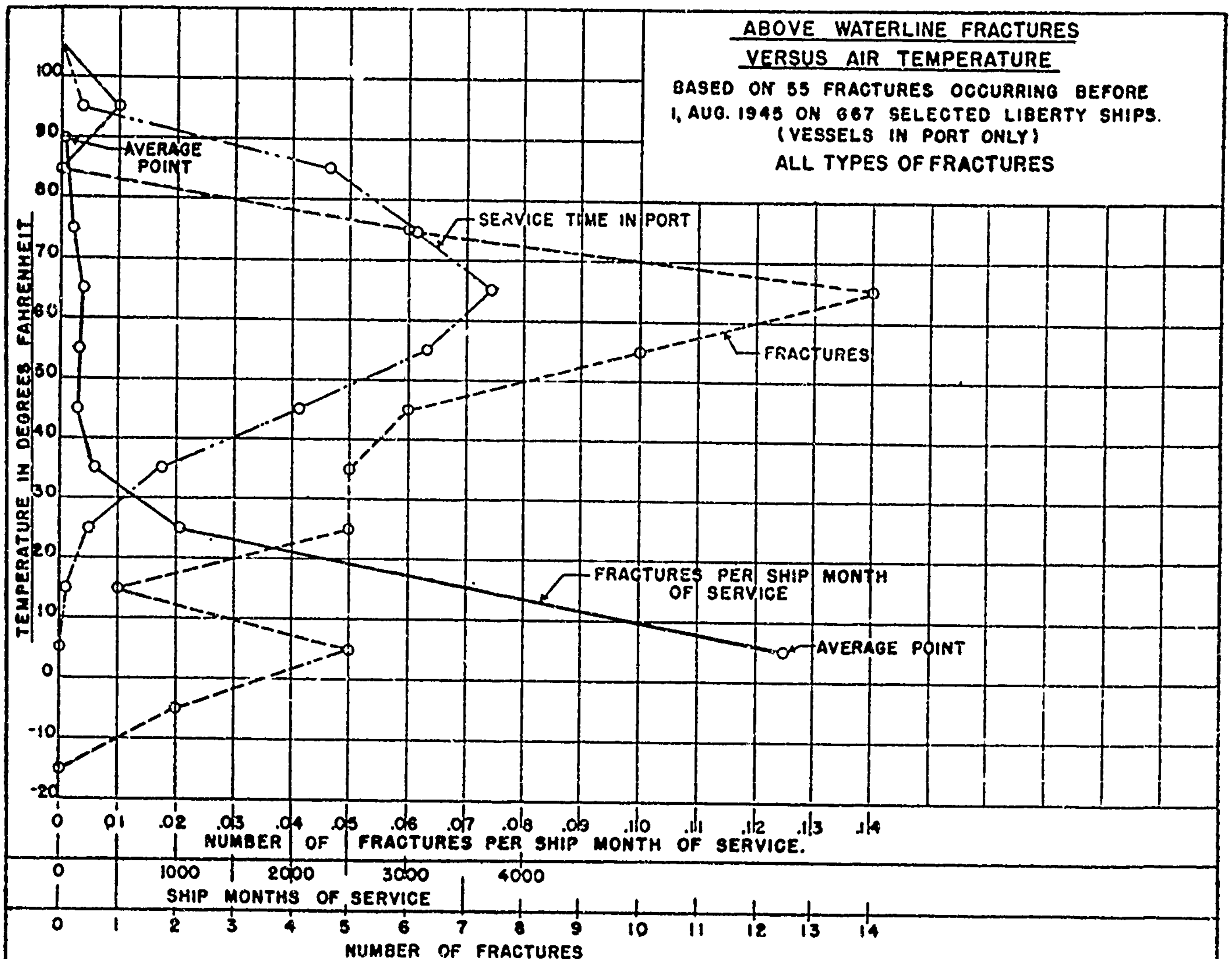


Figure 26.

was made to ascertain the risk of casualty under varying conditions of air temperature and state of the sea. Various plots were made but it was found that the data were not sufficient to establish casualty risks under known combinations of air temperature and state of sea in such a manner that they would withstand a rigorous statistical appraisal. It was possible, however, to eliminate entirely the effect of sea in a study which was made on ships in port only. The results of this study are presented in figure 26

TABLE III

CLASS 1 AND 2 CASUALTIES ON 667 LIBERTIES LAUNCHED BEFORE 1 FEBRUARY 1943

Number of Casualties (c) by Age and Calendar Month at Time of Casualty, and Number of Ships Afloat (s) of the Same Age in the Month of Casualty

Age (Months after launching)	Fall 1941		Winter 1941–42		Spring 1942		Summer 1942		Fall 1942		Winter 1942–43		Spring 1943		Summer 1943		Fall 1943		Winter 1943–44	
	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s	c	s
1, 2, 3		10		58		163		324	2	507	23	692	9	250						
4, 5, 6				10		57		144	1	307	10	494	18	669	5	241				
7, 8, 9						10		54	1	136	5	297	10	476	8	650	1	233		
10, 11, 12								9		52	1	135	4	288	2	471	10	646	10	221
13, 14, 15										7		48	3	125		286	5	468	21	590
16, 17, 18												6	2	40	1	121		282	19	442
19, 20, 21														6	1	39	1	119	11	262
22, 23, 24																6	1	39	2	112
25, 26, 27																		6	1	35
28, 29, 30																				5

TABLE III—*Continued*

Age (Months after launching)	Spring 1944 c	Spring 1944 s	Summer 1944 c	Summer 1944 s	Fall 1944 c	Fall 1944 s	Winter 1944-45 c	Winter 1944-45 s	Spring 1945 c	Spring 1945 s	Summer 1945 c	Summer 1945 s	Fall 1945 c	Fall 1945 s	Winter 1945-46 c	Winter 1945-46 s
13, 14, 15	15	184	....	....	....	....	....	....	....	....	....	....	....	....	....	....
16, 17, 18	22	484	1	135	....	....	....	....	....	....	....	....	....	....	....	....
19, 20, 21	10	355	2	349	1	104	....	....	....	....	....	....	....	....	....	....
22, 23, 24	5	203	1	251	....	239	....	69	....	....	....	....	....	....	....	....
25, 26, 27	1	90	1	139	....	175	....	167	....	59	....	....	....	....	....	....
28, 29, 30	....	27	1	65	....	97	1	92	....	129	....	52	....	....	....	....
31, 32, 33	....	3	....	18	....	46	....	58	....	80	....	121	....	46	....	....
34, 35, 36	....	....	....	2	....	13	....	37	....	33	....	72	....	101	....	39
37, 38, 39	....	....	....	....	....	2	....	12	....	31	....	28	....	56	....	91
40, 41, 42	....	....	....	....	....	....	....	2	....	12	....	29	....	14	....	42
43, 44, 45	....	....	....	....	....	....	....	....	....	2	....	12	....	21	....	9
46, 47, 48	....	....	....	....	....	....	....	....	....	....	....	2	....	12	....	17
49, 50, 51	....	....	....	....	....	....	....	....	....	....	....	....	....	2	....	9
52, 53, 54	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0

and show the distribution of service time and fractures for various air temperature ranges. This plot includes Class 1, 2 and 3 fractures for the above water line portion of the hull as well as an indication of the risk of casualty in terms of casualty per ship months of service time; all curves are plotted against air temperature ranges.

Although the number of fractures did not permit a complete subdivision on the basis of both sea and weather, it was possible to get a rough idea of what the combined effect of these two items would be. From the approximations made, it would appear that the risk of casualty at the lower operating temperatures and rough seas is many times the risk of fracture in very warm weather and in port. These are extremes of operation, however, and it is fortunate that there are few ships operating in cold weather and heavy seas. Although it was not possible to obtain the actual risk under any given condition, it is possible to make a comparison of the overall contribution of the two variables on the fracture problem and with respect to the 667 Liberty ships. For this purpose, the operating time of these ships was divided into four equal parts and it has been possible to separate the 620 fractures (Class 1, 2 and 3) into corresponding groups.

	Fractures	Ratio
Temperature high in port	11	1
Temperature low in port	37	3
Temperature high at sea [1]	53	5
Temperature low at sea [1]	519	47

[1] It must be realized that two-thirds of the operating time was spent in port, consequently the service time in the two "at sea" quadrants includes not only the data in heavy seas, and in normal and calm seas, but also a certain amount of time in port.

All reported air and sea temperatures and sea conditions are tabulated in the alphabetical index of casualties in the appendix of this report.

B. *Age of Vessel*

The date and age data, table II, permit study in many different ways. A sample plotting of winter casualties, figure 27, shows that casualty rate is not appreciably affected by age. Summer casualties are very few and show no anomalies. Other divisions by season may be plotted ad lib but most of the casualties were in winter.

The effects of structural alterations on the "667 Liberties" are eliminated by deleting each ship from the list at the time the alterations were made, table III. Thus greater homogeneity of the date and age data on these ships permits further analysis. Although the curves, figure 28, show risk diminishing as age increases, such a conclusion would be hasty. This trend might be explained in several different ways; as by decreasing quality in ship construction practices, increasing notch sensitivity in the steel, or the selective assignment of missions to different categories of ships, there is no way of disentangling these influences. In any case, it is not to be regarded as an effect of elimination from the category of ships especially subject to casualty (lemons).

One conclusion which might be drawn from the curves for winters 1942-43 and 1943-44 is that the conditions to which the ships were exposed in the second of these were notably more severe than in the first.

The upper and lower dispersion limits are shown on figures 27 and 28. These limits are established on the basis of probability so that 99 out of 100 sir r findings could be expected to fall between them.

CASUALTIES PER 3 MONTH PERIOD (Winter 1943-44)
Divided by SHIP-MONTHS SERVICE IN SAME PERIOD
MERCHANT VESSELS BUILT BY MARITIME COMMISSION (See Table I.)
(BY TRIMESTER AGE GROUPS)

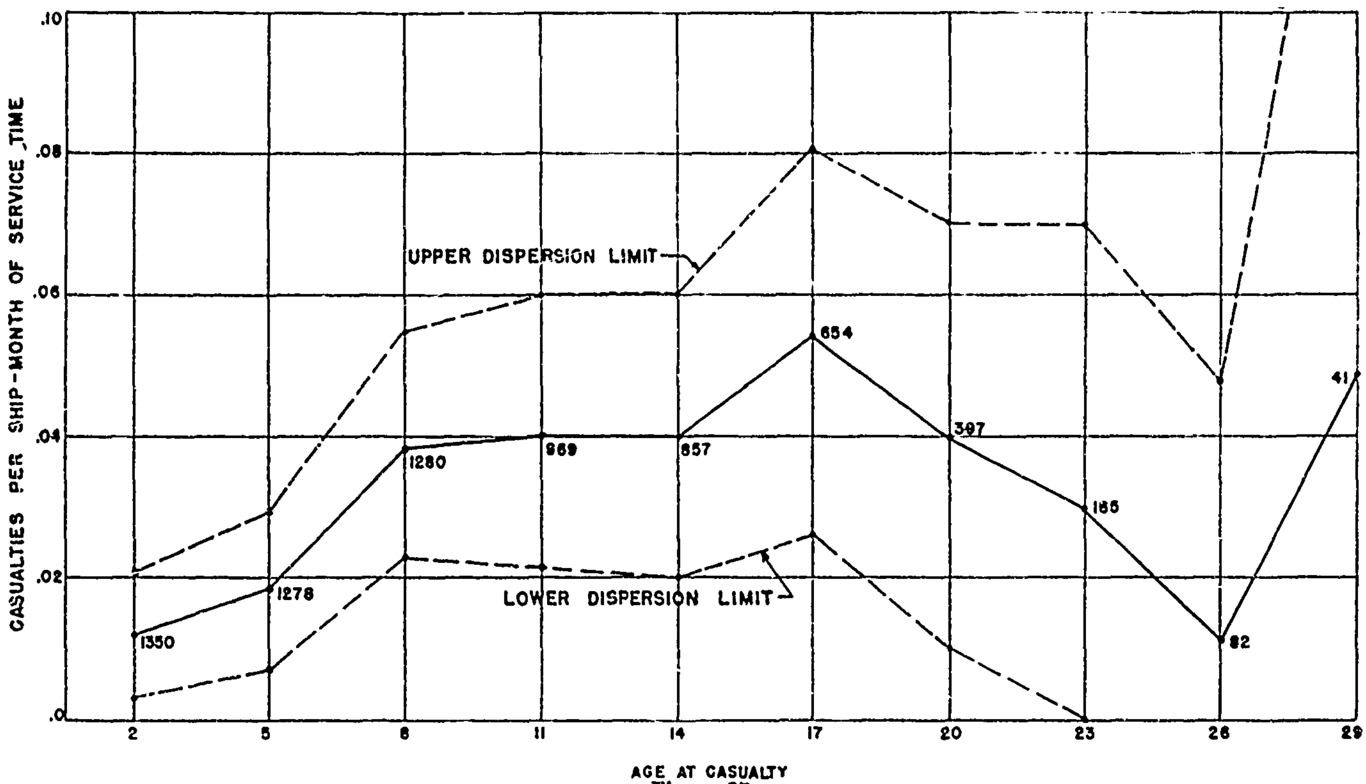


Figure 27.

CASUALTIES PER 3 MONTH PERIOD (Winters 1942-43 & 1943-44)
Divided by SHIP-MONTHS SERVICE IN SAME PERIOD
LIBERTY SHIPS LAUNCHED PRIOR FEB. 1, 1943. (See Table III.)
(BY TRIMESTER AGE GROUPS)

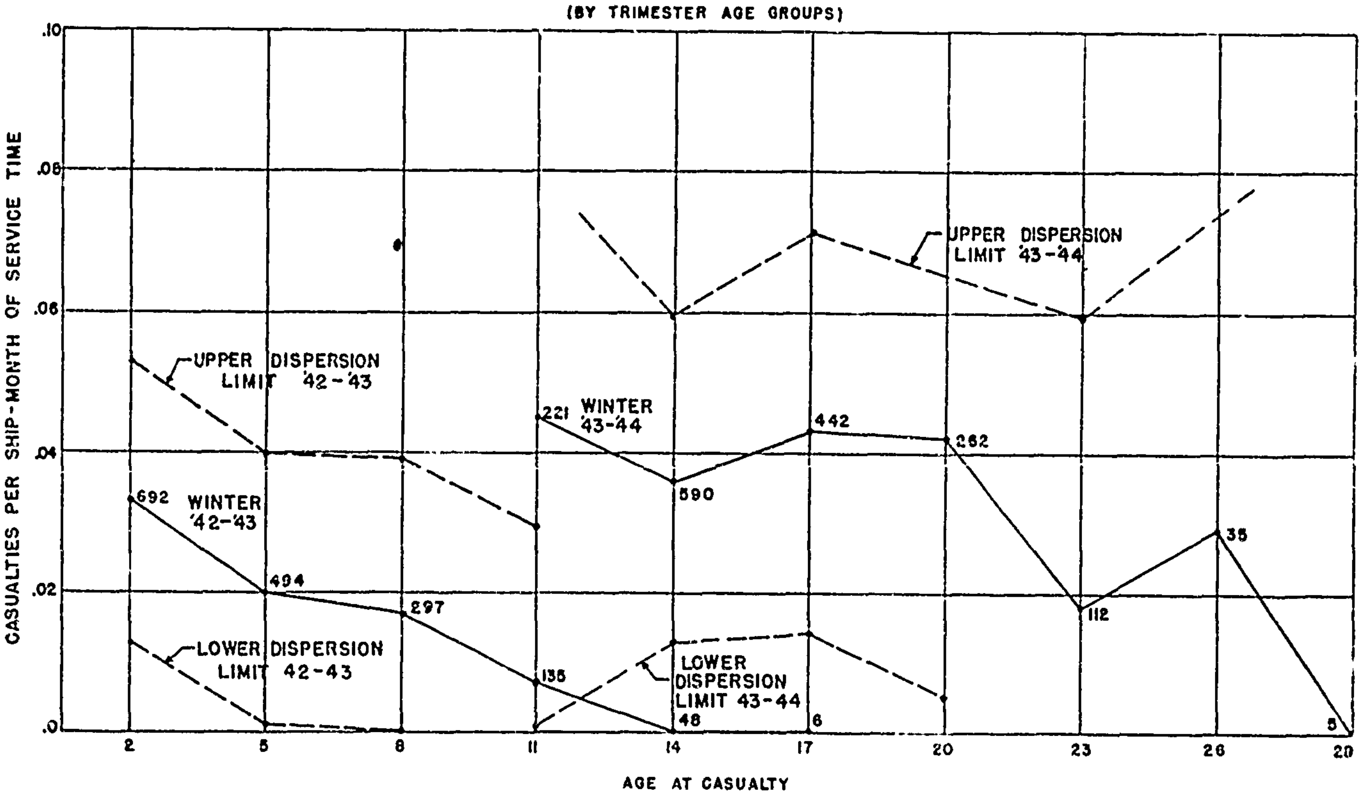


Figure 28.

C. *Loading of Vessel*

It was early suspected that poorly distributed cargo loading, under the pressure of wartime necessity, had been responsible for many of the structural failures. It was therefore decided to embark upon a study of the effect of cargo loading and in this regard, information was solicited from Merchant Marine inspectors and supplemented by data from the logs of many merchant vessels. The information on the dry cargo Liberty ships presented a great variety of loadings and no rational method for reducing this mass of data was evolved. It was noted from a rough survey that the details of the loading were considerably different, but the fore and aft distribution varied within relatively narrow limits insofar as bending moment on the hull was concerned.

In order to obtain a base line to which comparisons could be made, calculations were made on the Liberty ships at several different drafts with a loading which was uniformly distributed so that the trim was representative of typical operating conditions. Typical trim conditions at various drafts were obtained by recording the fore and aft drafts of 216 ships from the log books. The trim used in the calculation was the average of the scattered plots. From these bending moment calculations, the maximum tensile stress in the crown of the deck amidships was determined and is indicated in figure 29 by triangles and a solid line. The maximum nominal stress value in the deck with this type of loading was about 7,600 pounds per square inch tension at 24 feet mean draft. Comparison between the uniform loading used for this calculation and the numerous loading charts forwarded to Coast Guard Headquarters indicates that the uniform loading was practically typical and can be considered so.

For further comparison, stresses from bending moment calculations performed by the University of California on two Liberties have been plotted as hollow circles. It will be noted that the scatter of points follows the general trend of the line of uniform load distributions. In addition, a calculation was made on a condition representative of the most severe hogging load likely to occur in normal service and the deck stress was found to be 13,750 pounds per square inch tension under this abnormal bending load.

Finally, calculations were made on several vessels which had cracked. The nominal stress at the point of fracture is plotted with solid circles. The scatter again centers around the line of uniform loading. This indicates that the loading on the vessels which fractured was apparently not abnormal even though the stress from loading is appreciable.

Although a wide range of cargo distributions can be produced, it can be seen that the actual difference in bending moment between typical normal distributions is not great and little would be gained by attempting to prescribe cargo loading distributions. On the other hand, ballasting presents a possibility for a wider range of variations without interference with good operating conditions. Prescriptions were therefore made up for standard ballasting distributions and are now in use on Liberty ships in the North Atlantic. The nominal deck stresses with the various standard ballasting plans are indicated by boxes on the illustration, figure 29. The box indicated as London and Glasgow ballasting represents the ballasting system used before the longitudinal bending moment was a consideration and failures became a problem. The Maritime Commission 1,500-ton ballasting schedule is now in use. The weight distributions in the standard ballasting conditions is shown on Table IV.

A similar but less extensive study was done on the cargo loading on the T2 Tankers. It was found that a much wider possible range existed for the cargo loading conditions with nominal deck stresses reaching 14,540 pounds per square inch tension under an abnormal load condition. Stresses from uniform loading, however, were even lower than those in the Liberty. They varied in a smooth curve from 6,000 pounds per square inch tension in the light condition to 600 pounds per square inch compression with a uniform full load, the deck stress in lightship condition being the maximum value for a uniformly distributed loading. Loading calculations have been made on two T2 casualties and the nominal stresses at the points of fracture in the sheer strake in one case and in the deck in another was found to be 9,900 pounds per square inch tension for the *SS Schenectady* and 12,150 pounds per square inch tension for the *SS Esso Manhattan*. It is clear that in the case of tankers, abnormal loading can contribute to the failures but that it can be avoided with greater ease than on the Liberties.

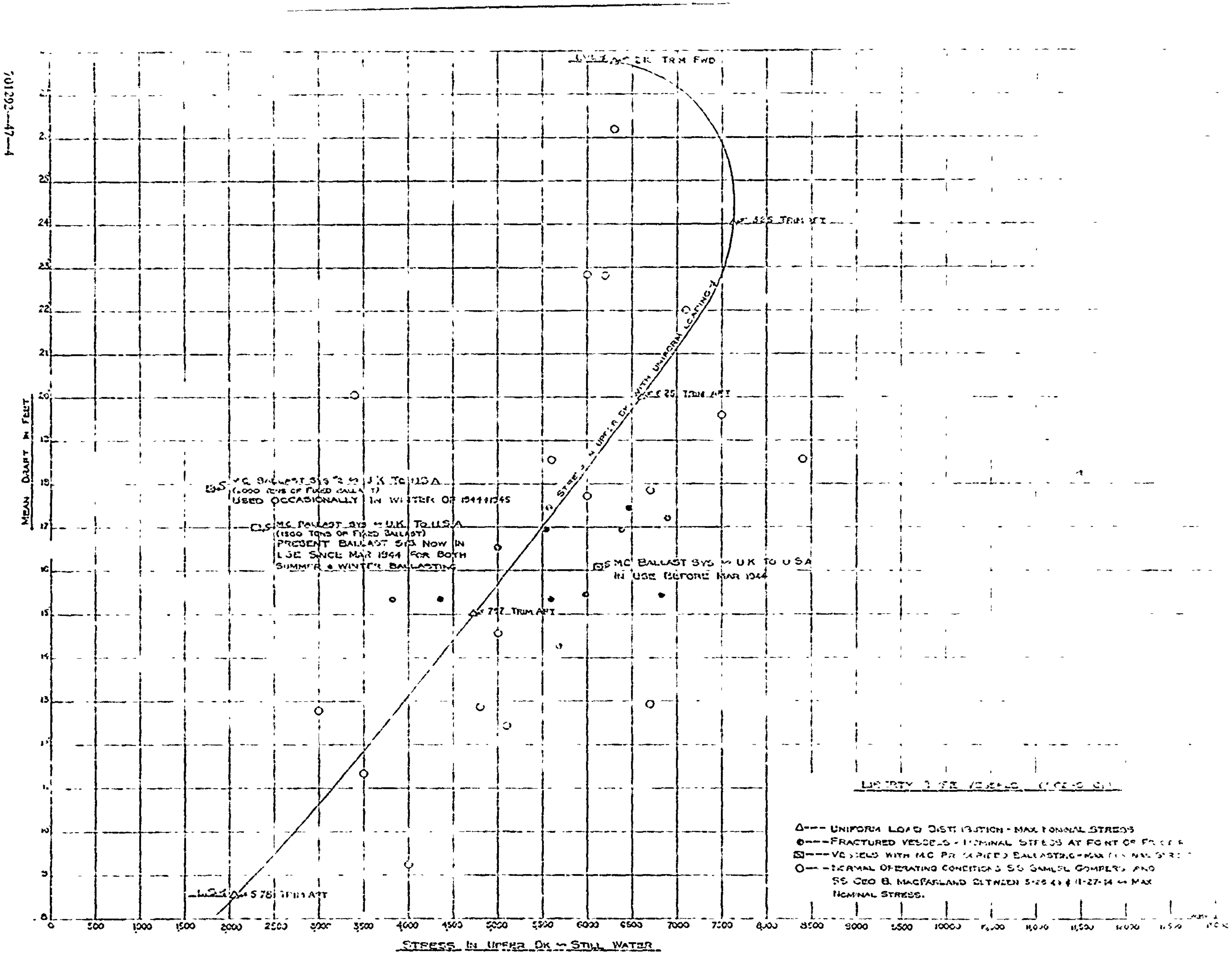

TRIM FWD
TRIM AFT
STRESS IN UPPER DK WITH UNIFORM LOADING
MEAN DRAFT IN FEET
M.C. BALLAST SYS #2 UK TO USA
(2000 TONS OF FIXED BALLAST)
USED OCCASIONALLY IN WINTER OF 1944-1945
M.C. BALLAST SYS UK TO USA
(1500 TONS OF FIXED BALLAST)
PRESENT BALLAST SYS NOW IN
USE SINCE MAR 1944 FOR BOTH
SUMMER & WINTER BALLASTING
M.C. BALLAST SYS UK TO USA
IN USE BEFORE MAR 1944
7.77 TRIM AFT
STRESS IN UPPER DK — STILL WATER
UNIFORM LOAD DISTRIBUTION - MAX NOMINAL STRESS
FRACTURED VESSELS - NOMINAL STRESS AT POINT OF FRACTURE
NORMAL OPERATING CONDITIONS SS SAMUEL GOMPERS AND
SS GEO B. MACFARLAND BETWEEN
NOMINAL STRESS.

Figure 29.

TABLE IV

Summary Sheet—Loading Conditions

(Liberty EC2-S-C1)

	M. C. ballast of 1500 tons; return from United Kingdom	M. C. ballast from London, Leith, and Glasgow
Lightship	3,670	3,670
Crew and stores	30	0
Potable water	56	54
Inner bottom No. 1	144	144
Inner bottom No. 2	340	346
Inner bottom No. 3	234	254
Inner bottom No. 4	132	134
Inner bottom No. 5	236	256
Inner bottom No. 6	110	120
Forepeak	145	138
Deep tank No. 1	0	228
Deep tank No. 2	420	424
Settling tanks	100	100
Deep tank No. 3	760	0
Aftpeak	155	152
Cargo space No. 1	0	0
Cargo space No. 2	360	300
Cargo space No. 3	615	300
Cargo space No. 4	525	450
Cargo space No. 5	0	450
Lazarette	0	0
Tons displacement	8,032	7,520
Per cent of full load	57	53
Ft. tons still water moment	22,485	53,290
P. s. i. stress in deck	2,292	5,900

D. *Repeated Casualties*

Certain vessels have incurred more than one casualty. When a ship suffers two or more failures, there is a tendency to dub her "a lemon". This frequent reaction to repeated failures implies that certain ships by virtue of inherent characteristics are more liable to suffer structural failures. It would be practically impossible to separate the causes of such additional casualties and point to workmanship, fabrication practices, material or to some mysterious unknown factor as the culprit. An attempt was made, however, to get some idea as to whether such "lemons" actually exist.

A probability calculation has been made to determine the number of repeated failures which would result from a random scattering of 922 casualties among a corresponding group of 2,580 ships on the assumption that all units are equally likely to attract trouble.

TABLE V

Theoretical Versus Actual Distribution, Repeated Casualties

EC2-S-C1 Casualties Up to 1 August 1945

Based on 922 Class 1, 2 and 3 Casualties

	According to theory of probability[1]	Actually reported
EC2's which suffered no casualties	1,806	1,932
EC2's which suffered 1 casualty only	644	454
EC2's which suffered 2 casualties only	115	140
EC2's which suffered 3 casualties only	14	33
EC2's which suffered 4 casualties only	1	17
EC2's which suffered 5 casualties only	0	3
EC2's which suffered 6 casualties only	0	1
Total ships involved	2,580	2,580

The indication is that after a ship has had a casualty, it is somewhat more liable to a casualty than before the first.

[1]The Poisson distribution formula was used in this computation:

$$p(x) = \frac{e^{-m} m^x}{!x}$$

where e is the base of natural logarithms.
x is the order, or the integral number of repetitions considered.
p(x) is the fraction of the whole number of casualties for each order "x".
m is the average value of casualties per ship, i.e., 922 ÷ 2580.

PART III

Susceptibility to Fracture of Different Ship Designs and Structural Details

A. *Shipbuilder and Type of Vessel*

The various Maritime Commission designs have been divided to show the susceptibility of each design to structural casualties. In addition, the EC2s and T2 Tankers have been listed by shipyard because the number of vessels built by each yard was sufficient to permit a picture of their relative performance. The figures in Table VI show the number of ships launched in each group, the ship months of service time up to 1 April 1946, the number of casualties of all classes which were reported up to that time, and the Class 1 casualties.

A study of the figures shows that no real conclusion can be drawn. Considering only those groups which accumulated more than 3,000 ship months of service, it will be seen that the best record with the Liberty ships was in Permanente Yards 1 and 2, and second best was Bethlehem-Fairfield, which was the only yard where shell seams were riveted. Considering the Class 1 casualties only. however, it will be noted that the best yard is Bethlehem-Fairfield and second best is New England.

It is difficult to rationalize these results on the basis of workmanship because Bethlehem-Fairfield did not exhibit remarkably good appearance in the Welding Advisory Committee's workmanship report and other reliable reports indicate that the quality of hull structure produced by Permanente varied from fair to good as systematic controls were introduced. At the other extreme, Oregon received a poor report from the Welding Advisory Committee and has a correspondingly poor casualty record. Calship is intermediate with a moderately poor casualty record and a good report by the Welding Advisory Committee.

A feeling of confidence in the vessels with riveted shell seams resulted in their assignment to routes where severe weather conditions were anticipated. In light of this and the good performance record under such adverse circumstances, the beneficial influences of riveted seams cannot be denied.

In connection with the Class 1 casualties, the good record of New England is difficult to explain but it should be noted that this yard riveted the bulwark to the top of the sheer strake, thereby eliminating many serious fractures which might have emanated from the bulwark. A similar lack of alignment between serious class and all class casualty results exists in almost the entire table and cannot be explained.

The casualty result on the T2 Tankers is even more difficult to rationalize but it is interesting to note that Marinship, where great care was taken in the structural details and where gamma ray inspection was used, has a measurably superior record to the other three shipyards. This yard received about the most favorable report of any yard visited by the Welding Advisory Committee.

Sixteen of the 78 Marinship tankers were delivered directly to the Navy. This is a somewhat higher proportion than for the other yards, but the good record of Marinship cannot be greatly affected by this factor because reports of major difficulties on Navy operated vessels did not include any Class 1 casualties for Marinship.

It is gratifying to see the record of the Victory ships as compared to the others. Their record indicates quite clearly that it is possible to eliminate most of the fractures by improving design details including riveted gunwales and using more careful workmanship.

Previous reports have mentioned the high casualty rate of the C2 refrigerated ships. These casualties were invariably in the tween decks inside of the insulated holds. The numerous repairs have included rounded corners for the hatches and in several cases, the introduction of riveted seams around the margins of the tween decks. In recent months, the number of failures reported for these ships has dropped markedly indicating that the alterations have been effective. *(For other designs see Table VII.)*

TABLE VI

Shipbuilder and Type of [illegible]

Comparison of Casualty Incidence Based on Casualties R[illegible]

Type of vessel and shipbuilder	Number ships launched	Ship months of service	All [illegible] casualties		[illegible] one casualties	
			Number	Casualties per ship month	Number	Casualties per ship month
EC2-S-C1						
Alabama	20	704	21	0.0293	2	0.0028
Bethlehem-Fairfield	281	10,821	90	0.0083	2	0.0002
Calship	306	10.619	164	0.0154	1[illegible]	0.0018
Delta	132	549	57	0.0161	12	0.003[illegible]
Jones Brunswick	65	1[illegible]15	27	0.0141	[illegible]	0.0005
Jones Panama	66	1[illegible]95	14	0.0094	1	0.0007
Kaiser Vancouver	10	[illegible]9	8	0.0217	1	0.0027
Marinship	15	512	7	0.0129	0	0
New England	236	5,70[illegible]	72	0.012[illegible]	2	0.0004
North Carolina	126	4,085	60	0.0147	5	0.0012
Oregon	322	11,011	215	0.0195	20	0.0018
Permanente	489	15.557	100	0.0064	14	0.0009
Rheem	1	41	0	0	0	0
St. Johns	82	1,908	26	0.0136	1	0.0005
Southeastern	88	2,196	23	0.0105	1	00.005
Todd-Houston	208	5,542	74	0.0134	18	0.0032
Walsh-Kaiser	10	309	7	0.0227	0	0
Total EC2-S-C1	2,530	76,396	964	0.0126	99	0.0013
T2 TANKERS						
Alabama	102	2,147	22	0.0125	6	0.0027
Kaiser Swan	147	3,283	66	0.0201	6	0.0018
Marinship	78	1,611	4	0.0025	0	0
Sun	203	4,991	101	0.0202	[illegible]	0.0008
Total T2 tankers	530	12,032	193	0.0160	16	0.0013
TOTAL VICTORIES	414	5,940	33	0.0056	0	0
All Maritime Comission Ships	4,687	125,985	1,441	0.0114	127	0.0010

B. *Liberty Ships*

A plot, figure 30, has been prepared showing the longitudinal and vertical location of all classes of fractures on the Liberty ships. This chart indicates that the fractures peak up near amidships in the upper deck and in the bottom with few fractures in the tween decks, indicating that longitudinal bending stresses play an important part in their distribution. The tabulation also shows the magnifying effect of certain design features such as the hatch corners which were responsible for 612 fractures or 24.4 percent. The sketch of the EC2-S-C1 vessel indicates the effect quite clearly, figure 31.

The distribution of the fractures in the 89 serious casualties occurring up to 1 August 1945, is somewhat different, figure 32. In many cases, the damage was so extensive that the starting point was not located. For this reason, it is only possible to identify positively the starting point of 31 casualties involving 42 fractures. Ten of these fractures or 24 percent started in the sheer strake cut for the gangway ladder. 22 or 52 percent started in the hatch corner including 48 percent at No. 3 hatch.

Figure 33 shows the original design of the hatch corner and indicates the three most important sources of fractures. The greatest number of hatch corner fractures occurred in the manner indicated as A, second greatest as B, and there were several of type C. In the case of the type B fractures, there was involved a combination of design and workmanship. The abrupt end of the 51-pound doubler beneath the

TABLE VII

Casualties Occurring on Various Designs

		Before 1 Aug 1945	1 Aug 45-1 Apr 1946	Before 1 Apr 1946
Liberty	EC2-S-C1	922	43	965
	Z-ET1-S-C3	53	9	62
	Z-EC2-S-C2	...	...	...
	Z-EC2-S-C5	3	1	4
	EC2-S-AW1	...	...	...
Tanker	T1	1	0	1
	T2	178	15	193
	T3	18	0	18
Standard Cargo	C1A & C1B	38	3	41
	C2	31	2	33
	C2 Refrig.	40	1	41
	C3	8	3	11
	C4	2	1	3
Combination	P & C	...	...	...
	C2 P & C	4	0	4
	C3 P & C	...	...	...
Miscellaneous	C1-M-AV1	4	0	4
	L6	13	0	13
	N3	13	1	14
	V4	0	1	1
Victory	VC2-S-AP2, 3, & 4	14	19	33
Total		1,342	99	1,441

deck was probably sufficient in itself to start a fracture at so critical a location but in many cases, this was supplemented by a saddle weld in the butt of the deck plating at this point. It was common practice in some shipyards to weld with a Unionmelt machine to within a few inches of the hatch coaming where the automatic equipment had to be stopped. The remainder of the seam was completed by hand welding without further preparation and a saddle weld resulted because of failure of the welding to penetrate the square edged butt.

Many fractures occur at the sheer strake cut for the gangway ladder and the square ending of the boat deck plate stanchions, figures 34 and 35.

It has been noted that the fractures at the centerline stanchion of the second deck almost always occurred as a result of rough weather. The second deck at the edge of the hatch is under high tension whenever there is cargo loaded in the tween decks because the heavy supporting H stanchion is just beneath. Most of these fractures have occurred in the forward end of No. 2 hold and the aft end of No. 1 hold. This is just about where maximum pounding would be expected. The thrust of the bottom force overcoming the inertia of the tween deck cargo produces high stresses in the deck over the H column. In addition, notches around the sole plate of the tween deck stanchion and the ends of brow plates magnify the stress, figure 36.

Bending tests on the Liberties indicate that the bending stresses in the hull are only slightly reduced by the presence of the deck house. The number of amidship bulwark fractures and shell fractures at the gangway support this. It is curious to note that up to 1 August 1945, the corners of the machinery casings which are similar in design to the other hatch corners suffered less than 13 fractures. Hatch No. 3 suffered 377 fractures and No. 4 110 fractures and the beneficial influence of the warmth in the casing is hard to contest.

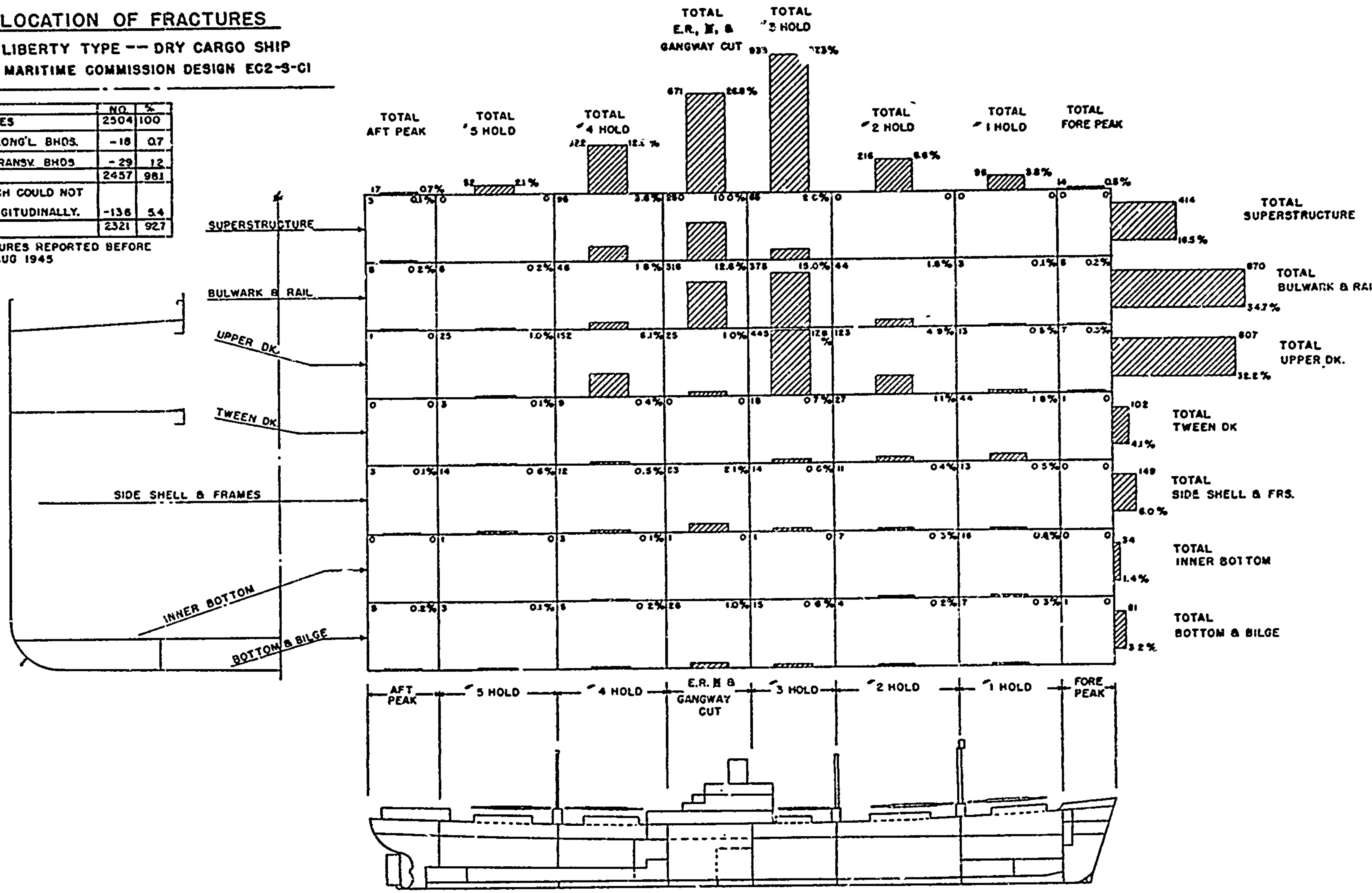
It has frequently been held that the hatch corners were not the serious offenders but that many of the fractures emanated at the bulwark or gunwale and ran inboard to the hatch corner. A fracture running

LOCATION OF FRACTURES

LIBERTY TYPE — DRY CARGO SHIP
MARITIME COMMISSION DESIGN EC2-S-C1

	NO.	%
*TOTAL FRACTURES	2504	100
FRACTURES IN LONG'L BHDS.	-18	0.7
FRACTURES IN TRANSV. BHDS	-29	1.2
	2457	98.1
FRACTURES WHICH COULD NOT BE LOCATED LONGITUDINALLY.	-136	5.4
	2321	92.7

*BASED ON FRACTURES REPORTED BEFORE 1, AUG 1945



NOTE: NUMBER IN THE UPPER LEFT CORNER OF EACH SQUARE INDICATES THE NUMBER OF FRACTURES THAT HAVE OCCURRED IN THAT PARTICULAR SECTION OF VESSEL. THE NUMERAL IN THE UPPER RIGHT CORNER INDICATES THE PER CENT OF THE TOTAL FRACTURES OF ALL SECTIONS (2504)

Figure 30.

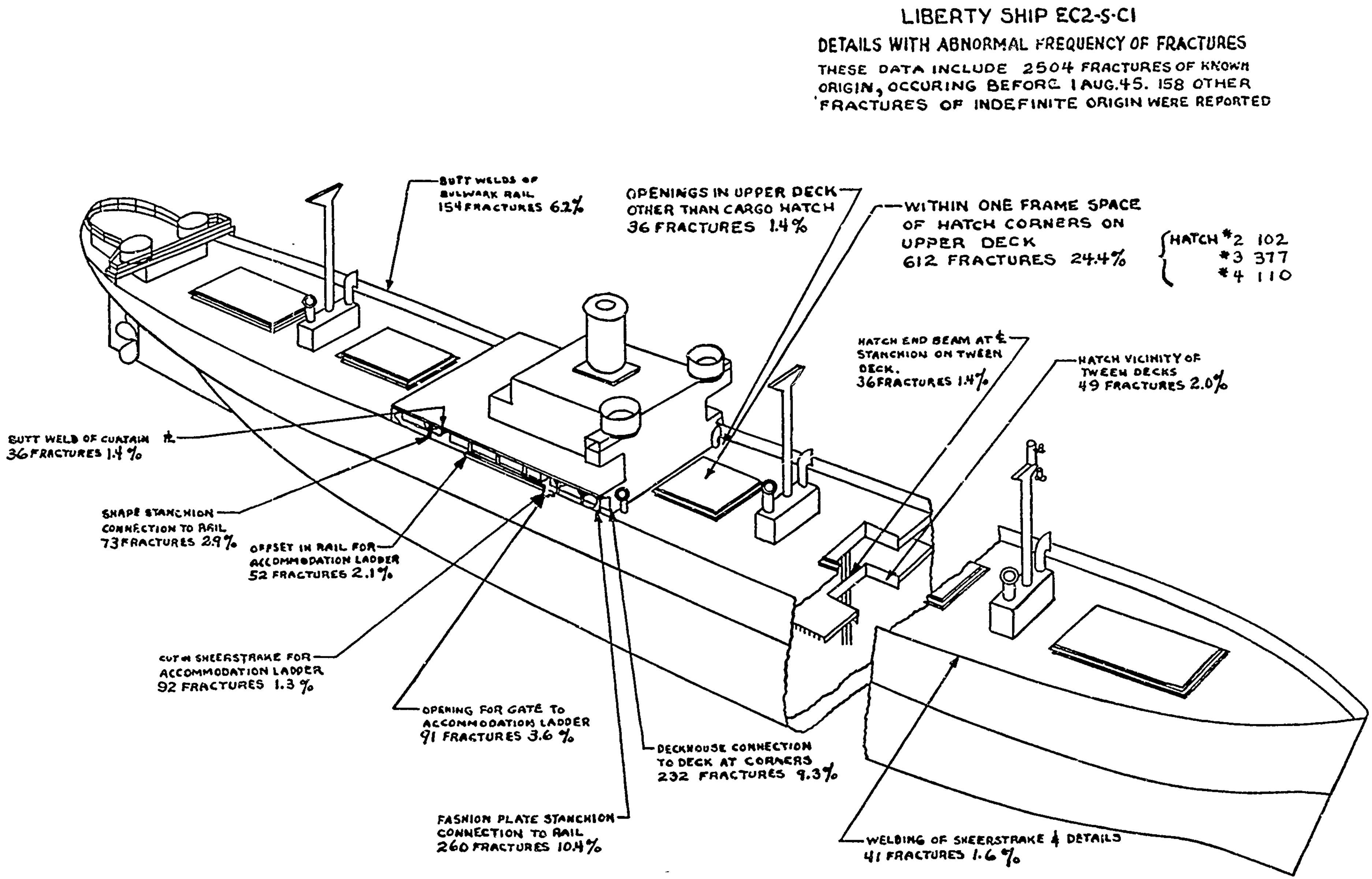

LIBERTY SHIP EC2-S-C1
DETAILS WITH ABNORMAL FREQUENCY OF FRACTURES
THESE DATA INCLUDE 2504 FRACTURES OF KNOWN ORIGIN, OCCURING BEFORE 1 AUG.45. 158 OTHER FRACTURES OF INDEFINITE ORIGIN WERE REPORTED
BUTT WELDS OF BULWARK RAIL 154 FRACTURES 6.2%
OPENINGS IN UPPER DECK OTHER THAN CARGO HATCH 36 FRACTURES 1.4%
WITHIN ONE FRAME SPACE OF HATCH CORNERS ON UPPER DECK 612 FRACTURES 24.4%
HATCH #2 102
#3 377
#4 110
HATCH END BEAM AT ℄ STANCHION ON TWEEN DECK. 36 FRACTURES 1.4%
HATCH VICINITY OF TWEEN DECKS 49 FRACTURES 2.0%
BUTT WELD OF CURTAIN ℄ 36 FRACTURES 1.4%
SHAPE STANCHION CONNECTION TO RAIL 73 FRACTURES 2.9%
OFFSET IN RAIL FOR ACCOMMODATION LADDER 52 FRACTURES 2.1%
CUT IN SHEERSTRAKE FOR ACCOMMODATION LADDER 92 FRACTURES 1.3%
OPENING FOR GATE TO ACCOMMODATION LADDER 91 FRACTURES 3.6%
DECKHOUSE CONNECTION TO DECK AT CORNERS 232 FRACTURES 9.3%
FASHION PLATE STANCHION CONNECTION TO RAIL 260 FRACTURES 10.4%
WELDING OF SHEERSTRAKE & DETAILS 41 FRACTURES 1.6%

Figure 31.

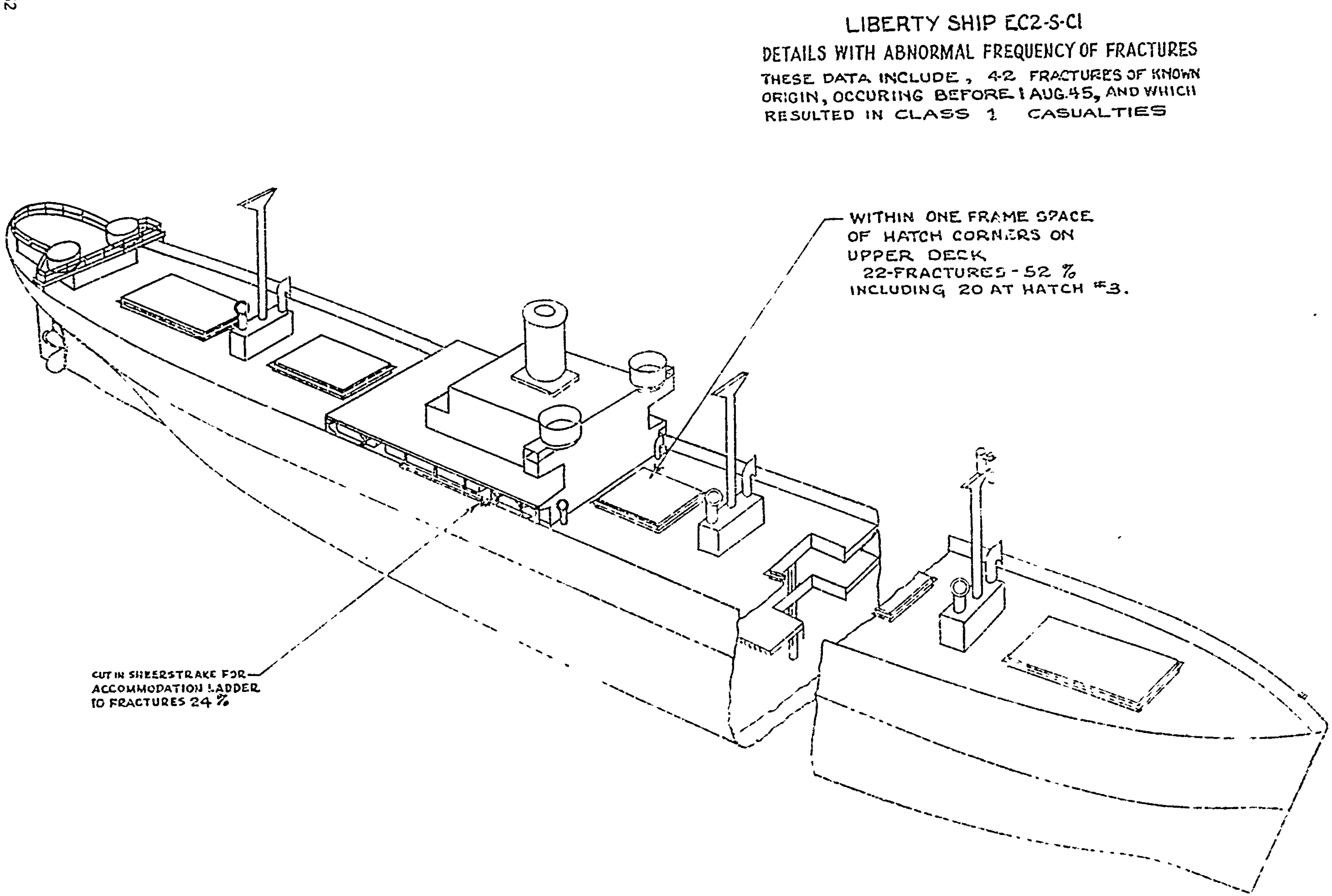
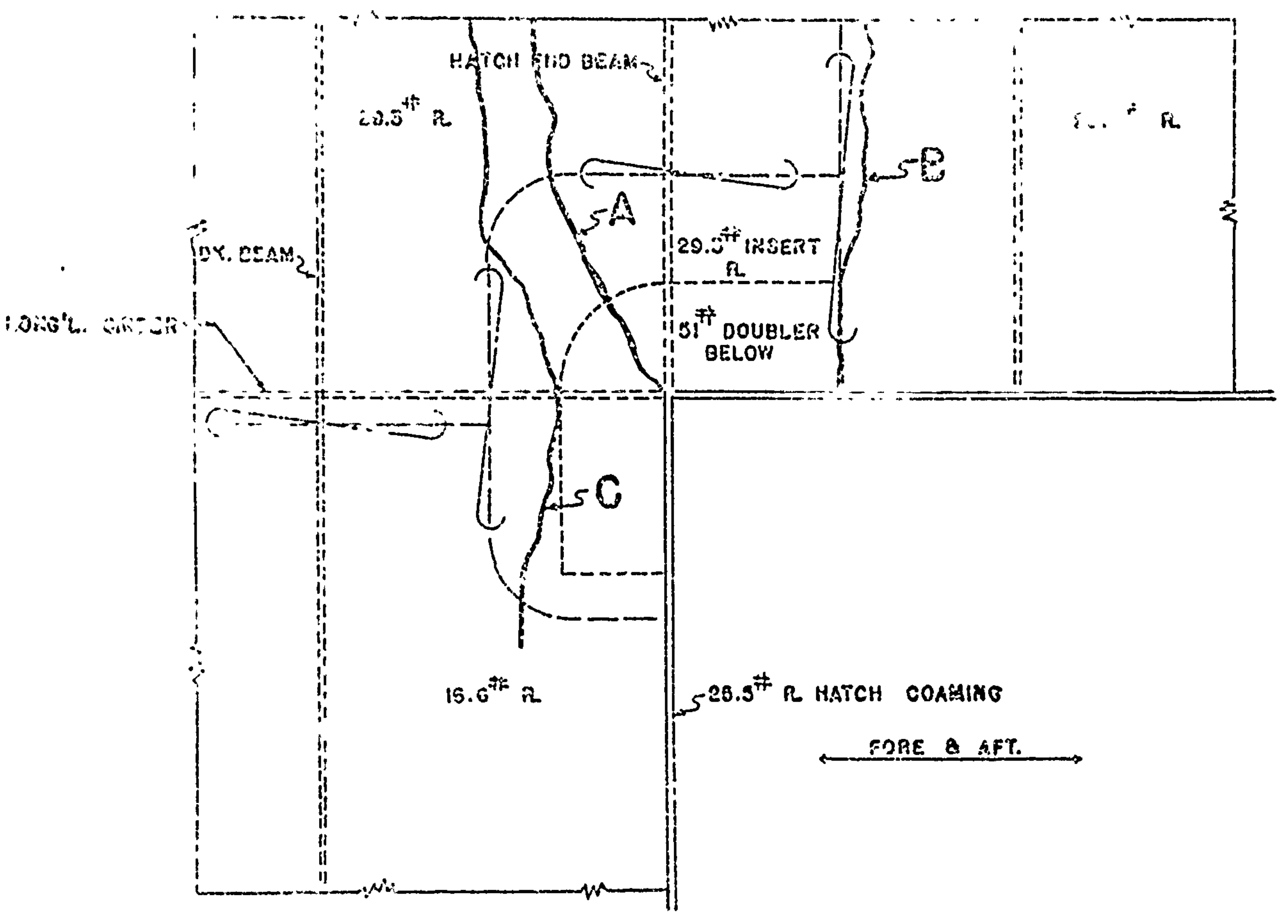

LIBERTY SHIP EC2-S-C1
DETAILS WITH ABNORMAL FREQUENCY OF FRACTURES
THESE DATA INCLUDE , 42 FRACTURES OF KNOWN ORIGIN, OCCURING BEFORE 1 AUG.45, AND WHICH RESULTED IN CLASS 1 CASUALTIES
WITHIN ONE FRAME SPACE OF HATCH CORNERS ON UPPER DECK
22-FRACTURES - 52 %
INCLUDING 20 AT HATCH #3.
CUT IN SHEERSTRAKE FOR ACCOMMODATION LADDER
10 FRACTURES 24 %

Figure 32



SQUARE HATCH CORNER REINFORCED WITH DOUBLER

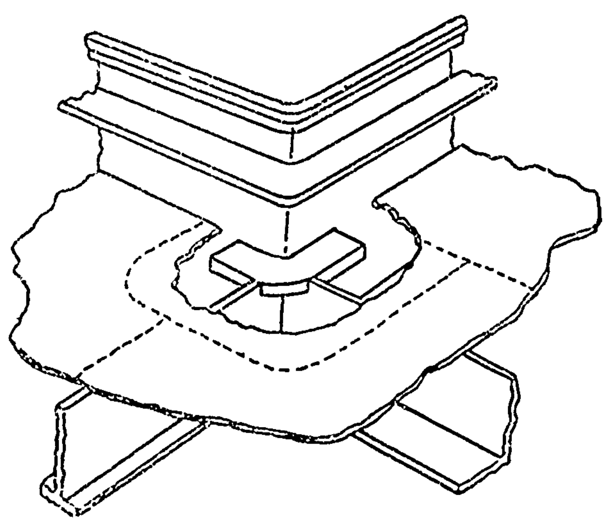
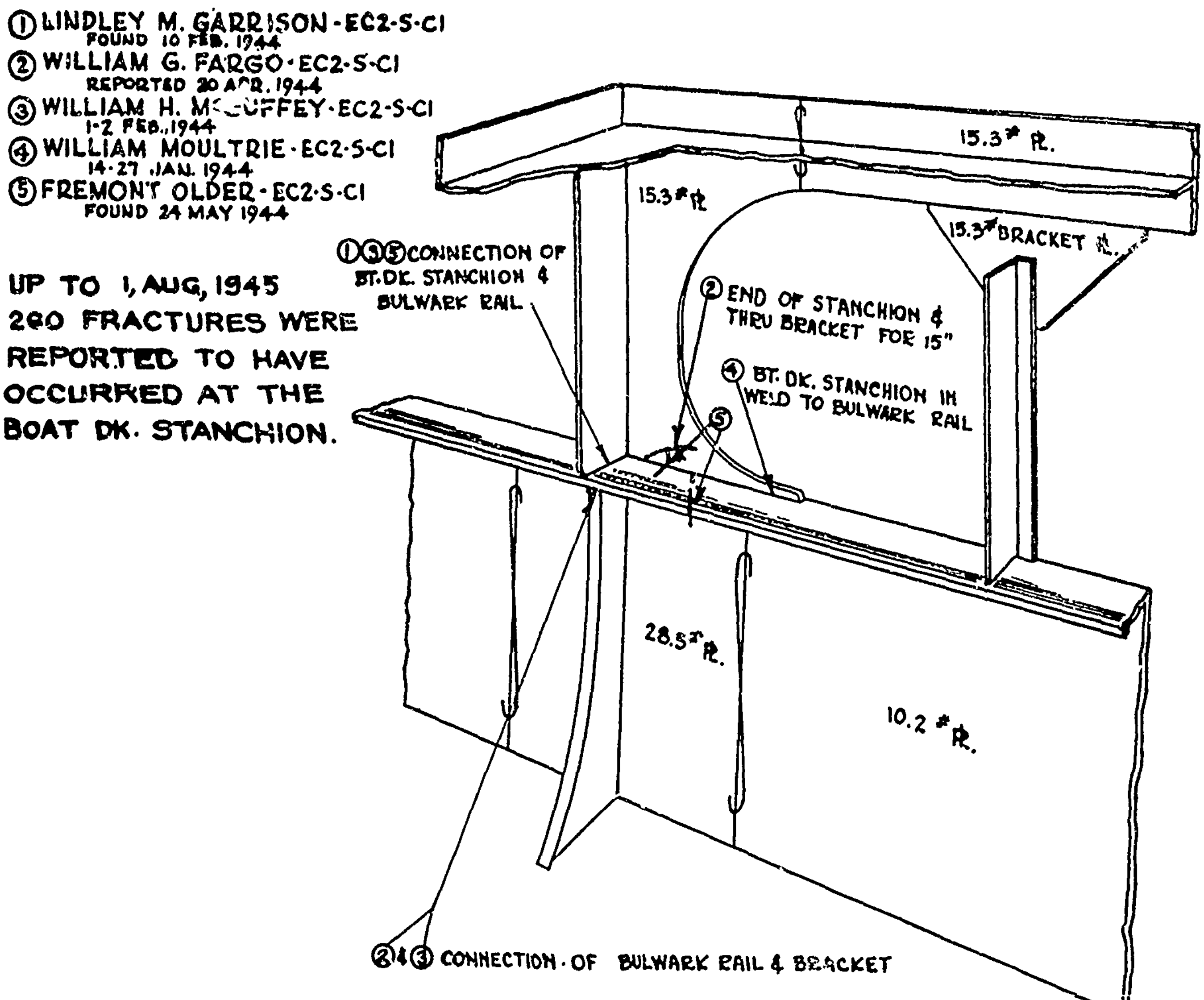


Figure 33.

from hatch corner to gunwale would warrant grading the casualty Class 1. The Class 1 EC2 casualties include 67 fractures involving the hatch corner vicinity. Thirty-nine of these fractures are known to have originated in the hatch corner. A simple proportion indicates that 5 or 6 of the 28 fractures of indefinite origin probably can be attributed to the details of the gunwale or bulwark. The reported 612 hatch corner fractures do not include these 5 or 6, nor do they include the remaining 22 or 23 which probably originated in the hatch corners.

LIBERTY VESSEL

COMPOSITE SKETCH OF FRACTURES AT FORWARD BOAT DECK STANCHION



NOTE:

FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 34.

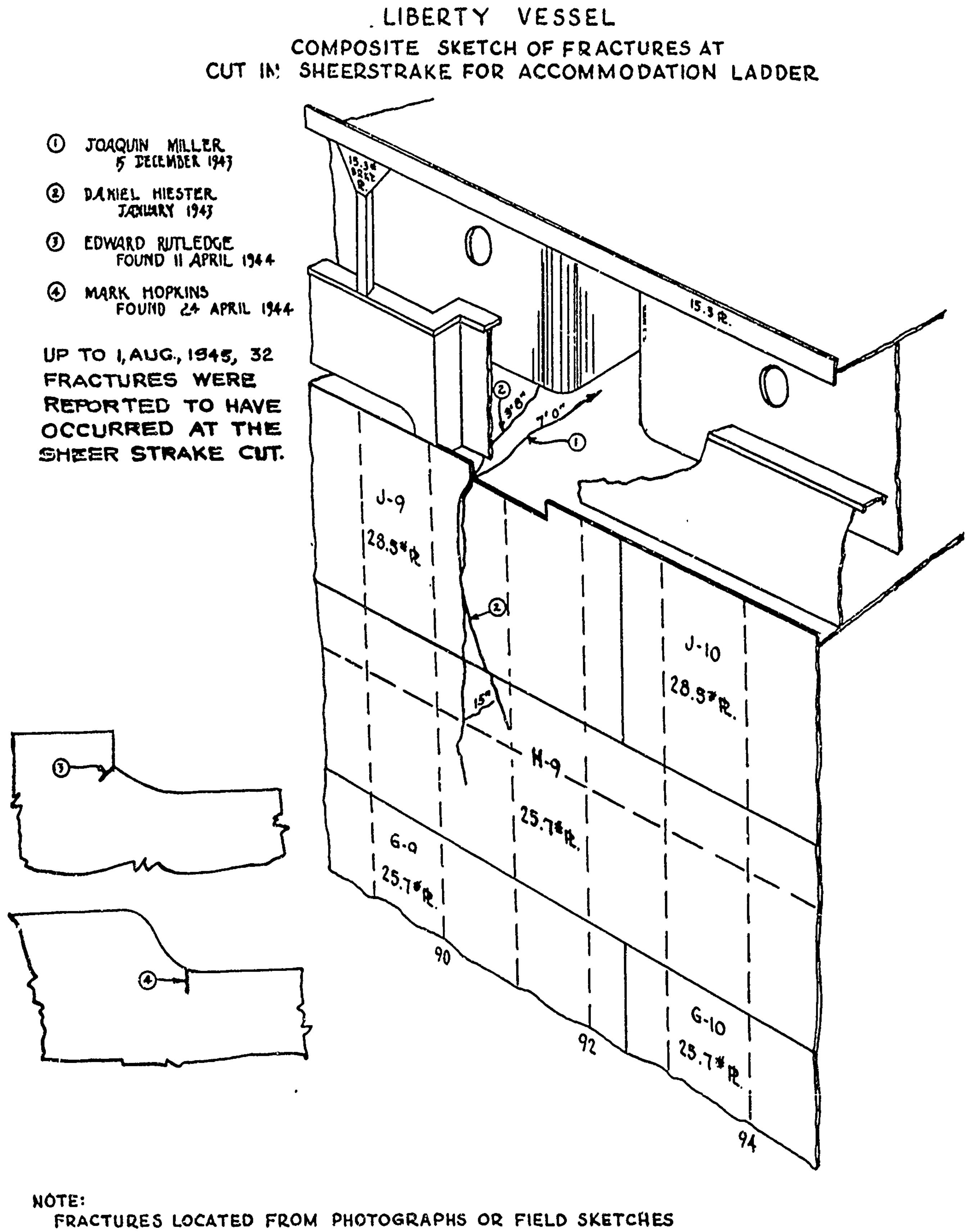

LIBERTY VESSEL
COMPOSITE SKETCH OF FRACTURES AT
CUT IN SHEERSTRAKE FOR ACCOMMODATION LADDER
① JOAQUIN MILLER 15 DECEMBER 1943
② DANIEL HIESTER JANUARY 1943
③ EDWARD RUTLEDGE FOUND 11 APRIL 1944
④ MARK HOPKINS FOUND 24 APRIL 1944
UP TO 1, AUG., 1945, 32 FRACTURES WERE REPORTED TO HAVE OCCURRED AT THE SHEER STRAKE CUT.
15.3 ℞.
7'0"
3'6"
J-9
28.5# ℞
J-10
28.5# ℞.
15°
H-9
25.7# ℞.
G-9
25.7# ℞.
G-10
25.7# ℞.
90
92
94
NOTE:
FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 35.

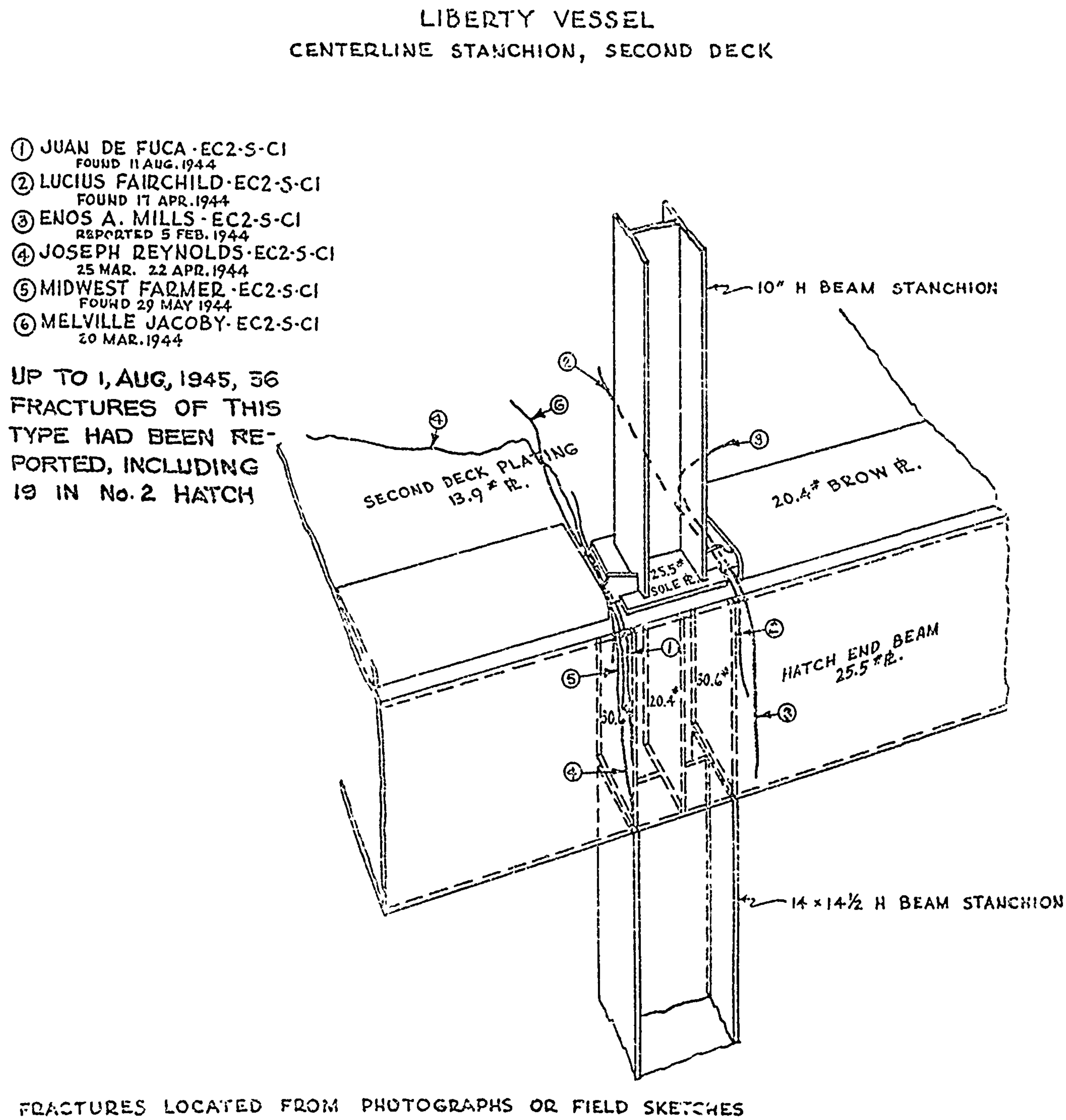

LIBERTY VESSEL
CENTERLINE STANCHION, SECOND DECK
① JUAN DE FUCA · EC2-S-C1
FOUND 11 AUG. 1944
② LUCIUS FAIRCHILD · EC2-S-C1
FOUND 17 APR. 1944
③ ENOS A. MILLS · EC2-S-C1
REPORTED 5 FEB. 1944
④ JOSEPH REYNOLDS · EC2-S-C1
25 MAR. 22 APR. 1944
⑤ MIDWEST FARMER · EC2-S-C1
FOUND 29 MAY 1944
⑥ MELVILLE JACOBY · EC2-S-C1
20 MAR. 1944
UP TO 1, AUG, 1945, 36 FRACTURES OF THIS TYPE HAD BEEN REPORTED, INCLUDING 19 IN No. 2 HATCH
10" H BEAM STANCHION
SECOND DECK PLATING 13.9# PL.
20.4# BROW PL.
25.5# SOLE PL.
HATCH END BEAM 25.5# PL.
30.6#
20.4#
30.6#
14 × 14½ H BEAM STANCHION
FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 36.

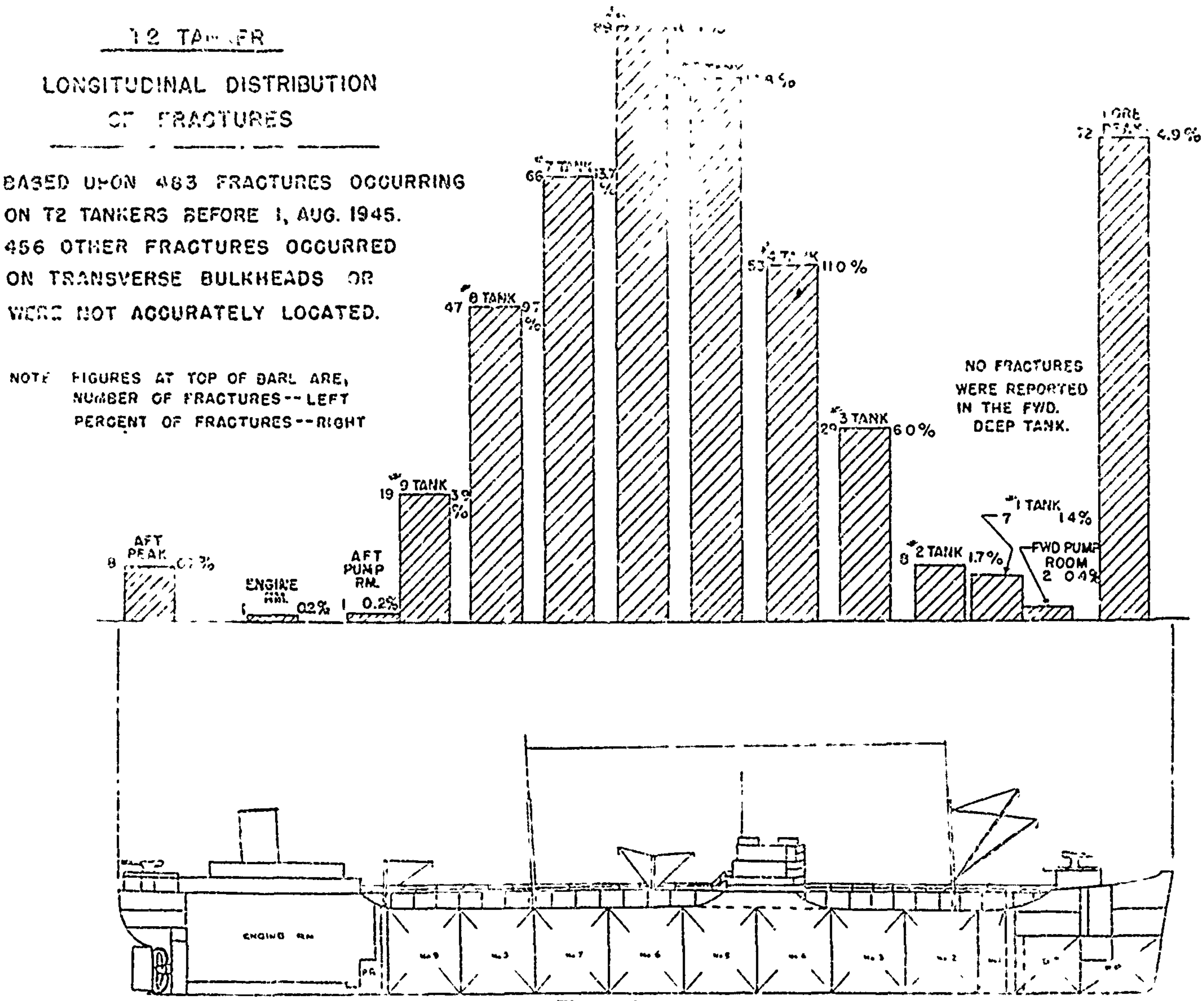


Figure 37.

C. T2 Tankers

The longitudinal distribution of the fractures on the T2 Tankers also shows a peak amidships indicating that bending of the hull is partly responsible for their occurrence, figure 37. All of the nine serious casualties occurred in Nos. 3, 4, 5, 6, and 7 tanks.

The source of the failure has been located on two of the ships which broke in two. In the case of the *SS Esso Manhattan*, a defective butt weld was the source and in the case of the *SS Schenectady*, it was a notch resulting from the combined effect of a design detail and a defective weld. The source of trouble on the two recent T2 Tanker catastrophes is not yet known.

Most of the Class 3 fractures occurred in a detail at the juncture of the transverse and longitudinal bulkheads, figure 39. Three hundred twenty-five fractures reported before 1 August 1945, at these intersections have been traced to design details which cause a stress concentration under the influence of both hull bending and local hydrostatic loads. It would appear from the longitudinal distribution of these fractures that the hull bending stresses have considerably more to do with the failures than local hydrostatic loading, either static or dynamic.

The sources of these fractures have been located by calculation and test and a satisfactory measure has been devised to ease the offending detail.

One hundred and seventy fractures occurred at the toe of a bracket on the transverse bulkheads, figure 40. This is a design detail which can easily be cured and improved arrangements have been fitted in several vessels. A check on the longitudinal distribu-

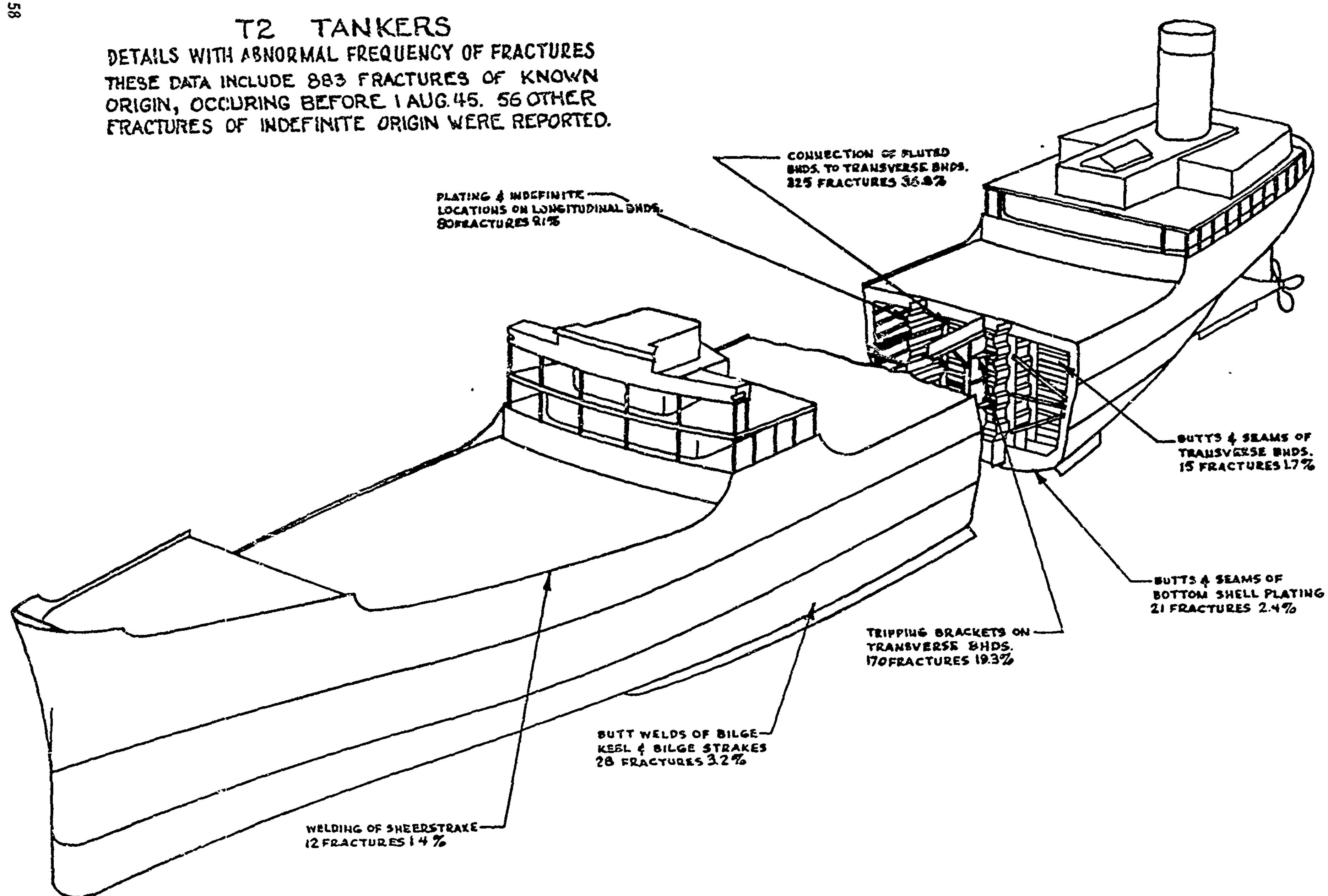
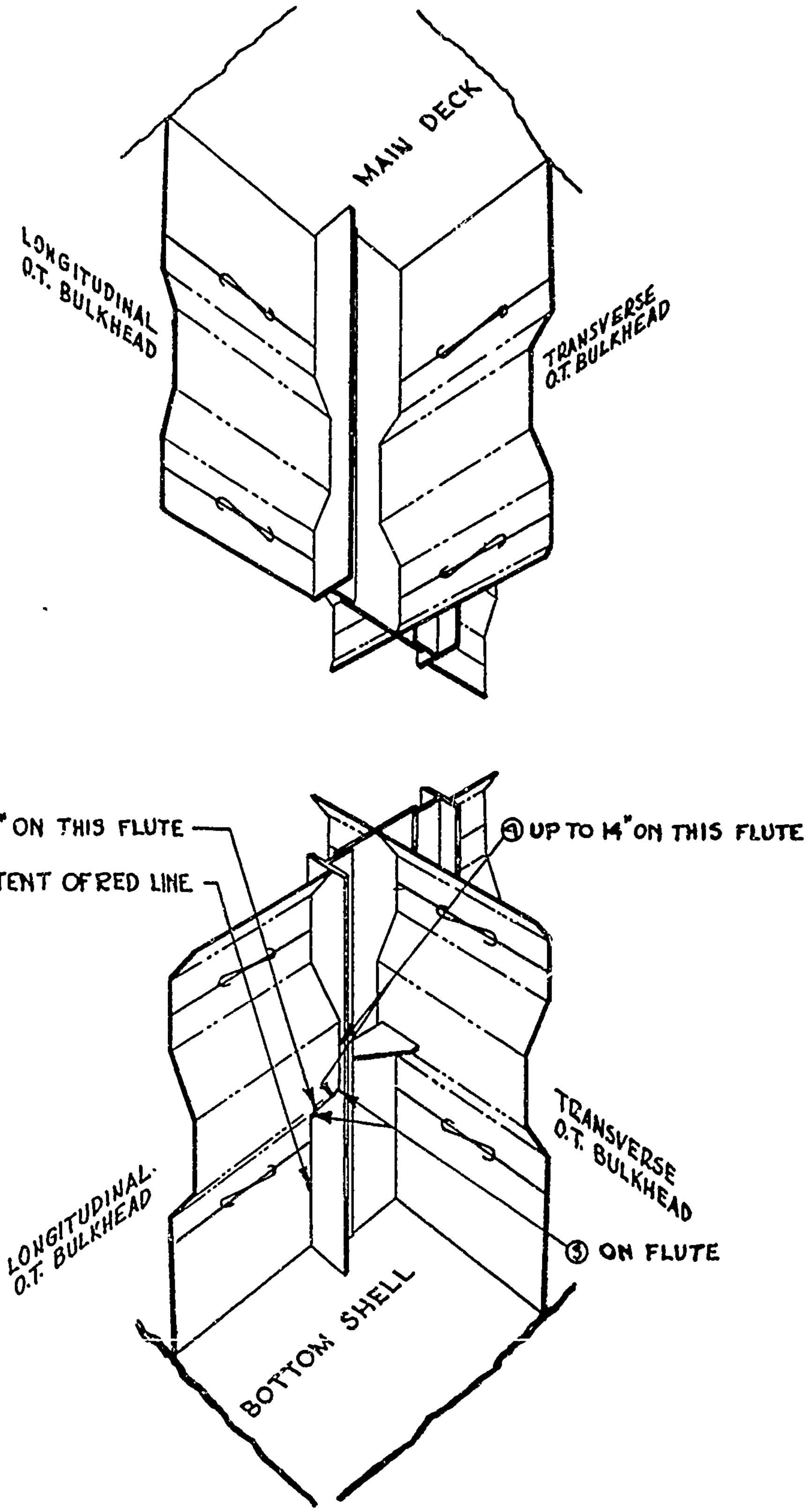

T2 TANKERS
DETAILS WITH ABNORMAL FREQUENCY OF FRACTURES
THESE DATA INCLUDE 883 FRACTURES OF KNOWN ORIGIN, OCCURING BEFORE 1 AUG. 45. 56 OTHER FRACTURES OF INDEFINITE ORIGIN WERE REPORTED.
CONNECTION OF FLUTED BHDS. TO TRANSVERSE BHDS. 325 FRACTURES 36.8%
PLATING & INDEFINITE LOCATIONS ON LONGITUDINAL BHDS. 80 FRACTURES 9.1%
BUTTS & SEAMS OF TRANSVERSE BHDS. 15 FRACTURES 1.7%
BUTTS & SEAMS OF BOTTOM SHELL PLATING 21 FRACTURES 2.4%
TRIPPING BRACKETS ON TRANSVERSE BHDS. 170 FRACTURES 19.3%
BUTT WELDS OF BILGE KEEL & BILGE STRAKES 28 FRACTURES 3.2%
WELDING OF SHEERSTRAKE 12 FRACTURES 1.4%

Figure 38.

T2-SE-A1 TYPE
COMPOSITE SKETCH OF FRACTURES
CONNECTION OF FLUTED LONGITUDINAL BULKHEADS TO TRANSVERSE BULKHEADS

① NEW LONDON
REPORTED 26 JUNE, 1944
② NORTHFIELD
FOUND 12 SEPT., 1943
③ CHURUBUSCO
REPORTED 12 JUNE, 1944
④ RIVER RAISIN
REPORTED 7 JULY, 1944

UP TO 1 AUG. 1945 325 FRACTURES WERE REPORTED AT THESE BULKHEAD INTERSECTIONS.



NOTE:
FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 39.

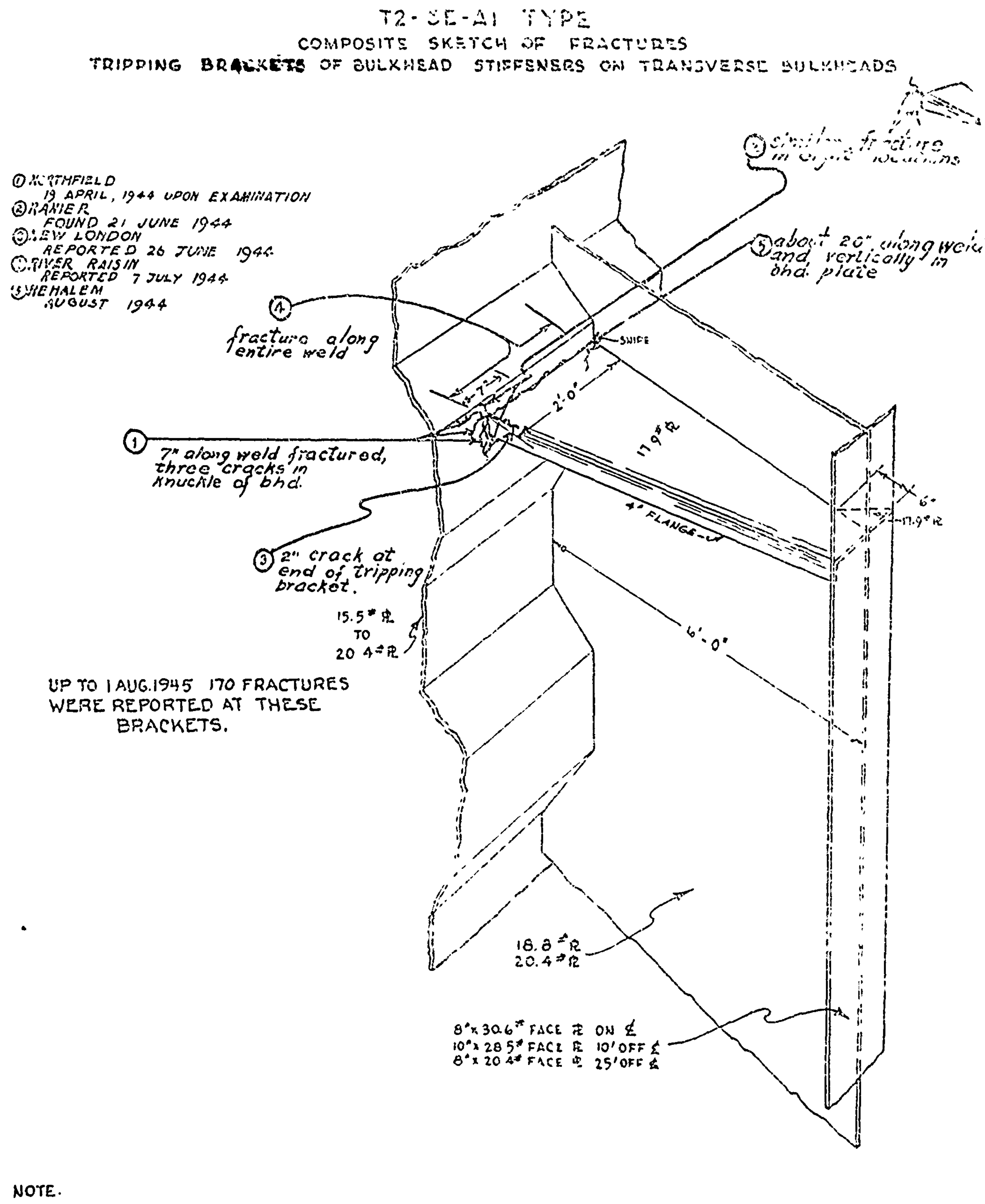

T2-SE-A1 TYPE
COMPOSITE SKETCH OF FRACTURES
TRIPPING BRACKETS OF BULKHEAD STIFFENERS ON TRANSVERSE BULKHEADS
① NORTHFIELD
19 APRIL, 1944 UPON EXAMINATION
② RANIER
FOUND 21 JUNE 1944
③ NEW LONDON
REPORTED 26 JUNE 1944
④ RIVER RAISIN
REPORTED 7 JULY 1944
⑤ NEHALEM
AUGUST 1944
② fracture
⑤ about 20" along weld and vertically in bhd. plate
④ fracture along entire weld
SNIPE
2'-0"
17.9# ℞
① 7" along weld fractured, three cracks in knuckle of bhd.
4" FLANGE
6"
17.9# ℞
③ 2" crack at end of tripping bracket.
15.5# ℞ TO 20.4# ℞
6'-0"
UP TO 1 AUG.1945 170 FRACTURES WERE REPORTED AT THESE BRACKETS.
18.8# ℞
20.4# ℞
8"x 30.6# FACE ℞ ON ℄
10"x 28.5# FACE ℞ 10' OFF ℄
8"x 20.4# FACE ℞ 25' OFF ℄
NOTE.
FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 40.

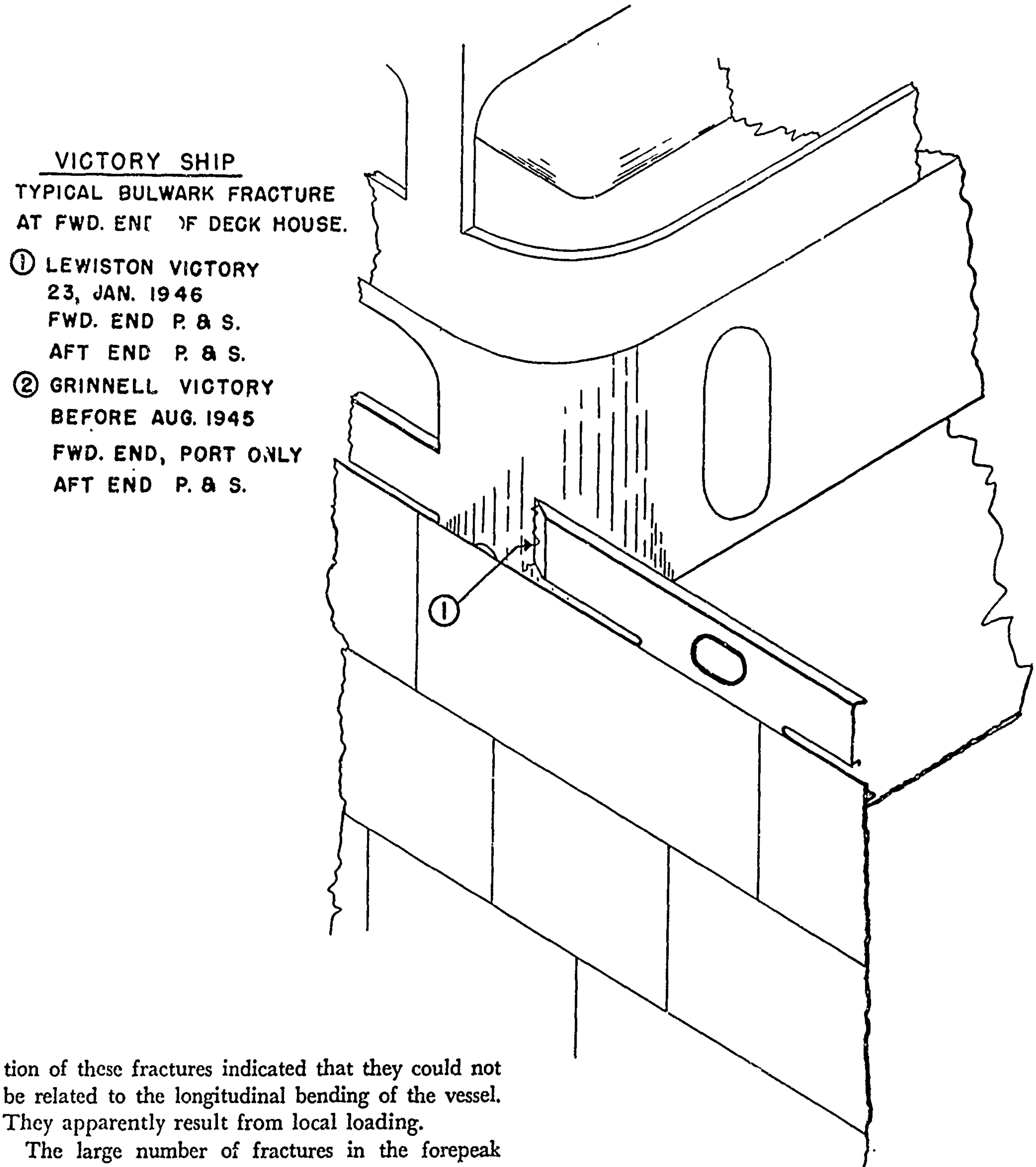


Figure 41.

tion of these fractures indicated that they could not be related to the longitudinal bending of the vessel. They apparently result from local loading.

The large number of fractures in the forepeak indicated in figure 37 have involved many details of the internal structure. They are local in nature.

D. *Victory Ships*

Practically all of the casualties on the Victory ships have been Class 3. The fractures reported before 1 August 1945, indicate two principal sources of trouble: the bulwark cap rail and plating and the bulwark braces. The casualties occurring before 1 August 1945, included 53 fractures. Eighteen, or 30 percent, occurred in butts of the bulwark and 27, or 51 percent, occurred at the toes of the bulwark braces.

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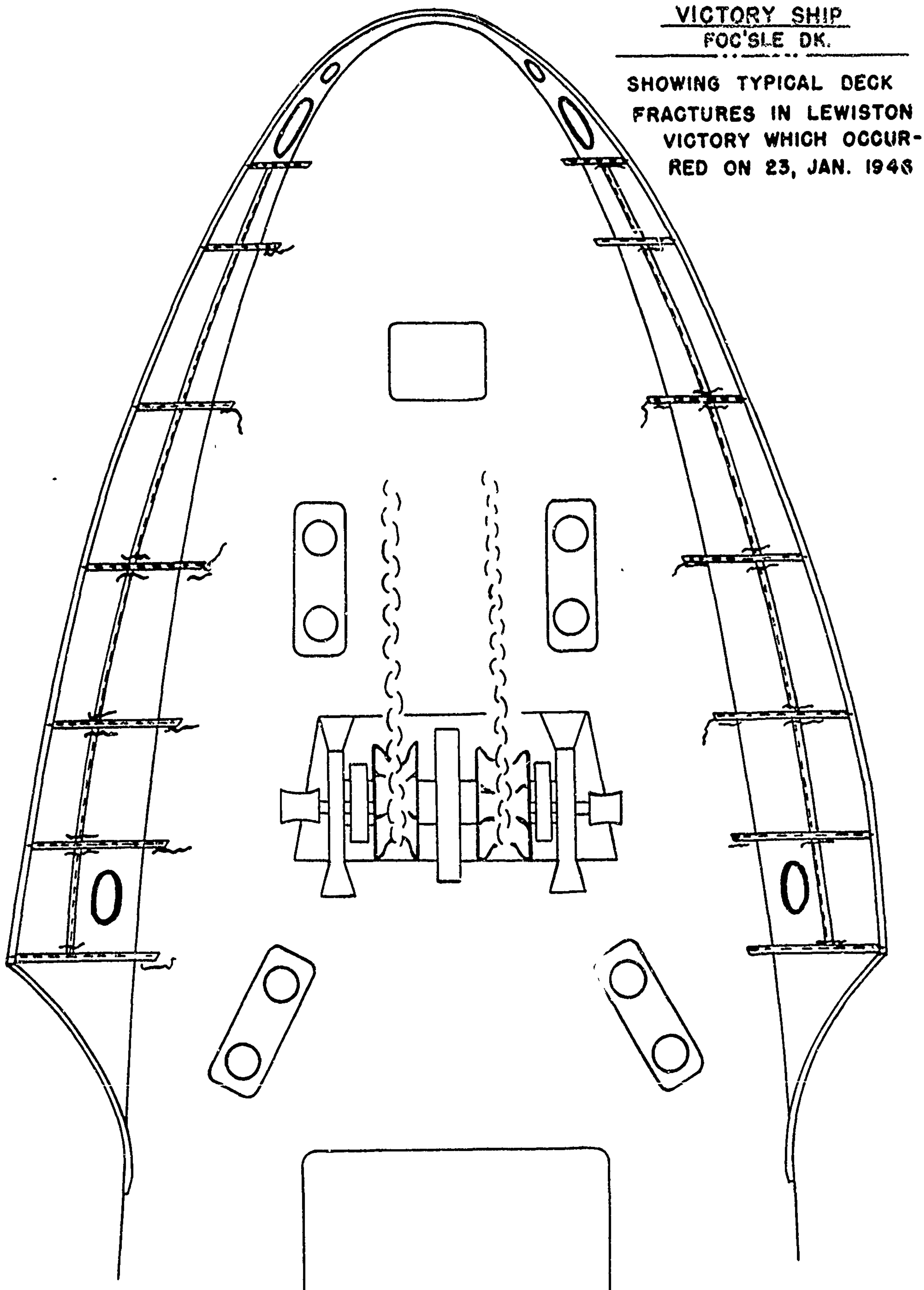

VICTORY SHIP
FOC'SLE DK.
SHOWING TYPICAL DECK FRACTURES IN LEWISTON VICTORY WHICH OCCURRED ON 23, JAN. 1946

Figure 42.

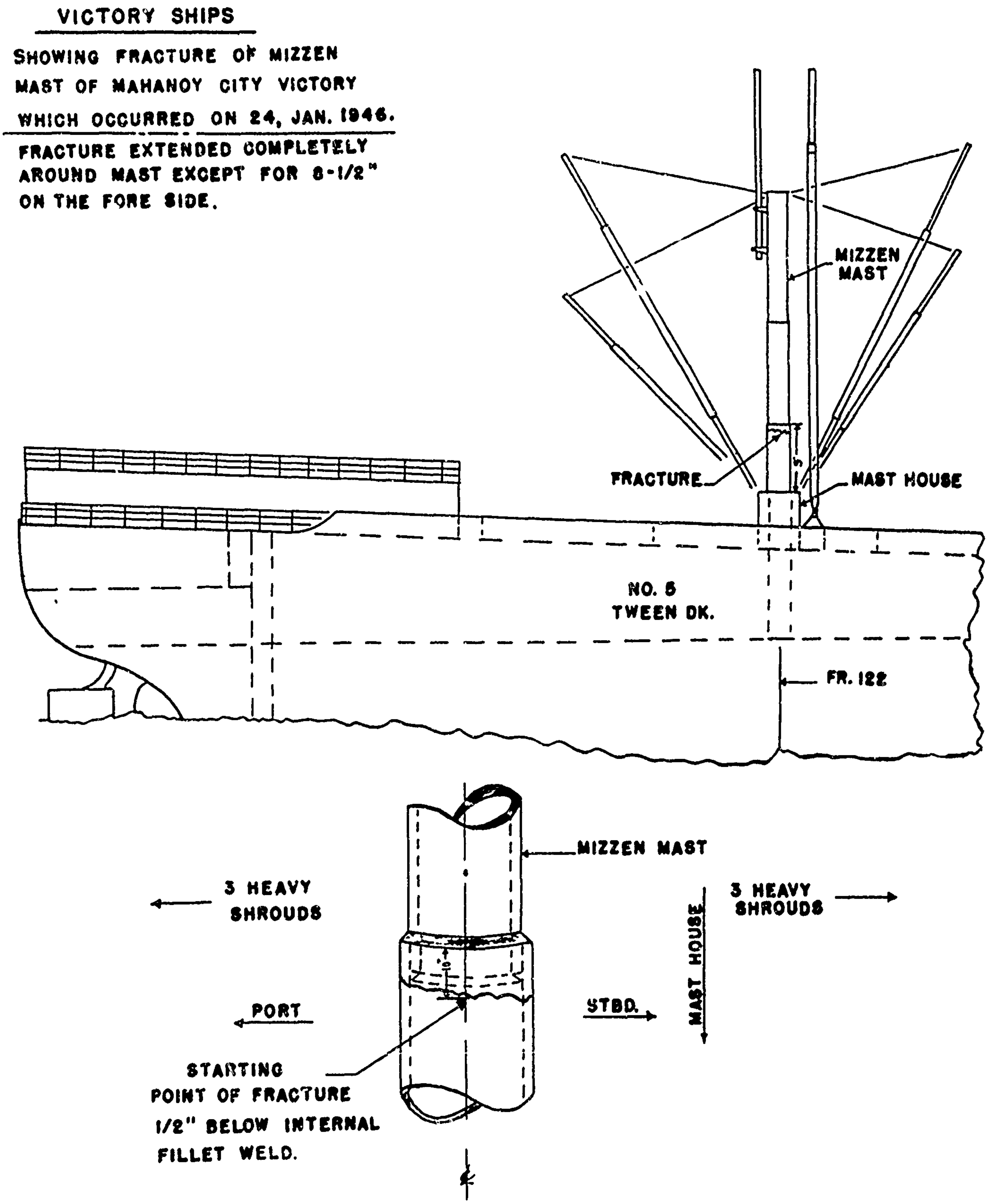

VICTORY SHIPS
SHOWING FRACTURE OF MIZZEN MAST OF MAHANOY CITY VICTORY WHICH OCCURRED ON 24, JAN. 1946.
FRACTURE EXTENDED COMPLETELY AROUND MAST EXCEPT FOR 8-1/2" ON THE FORE SIDE.
MIZZEN MAST
FRACTURE
MAST HOUSE
NO. 5
TWEEN DK.
FR. 122
MIZZEN MAST
3 HEAVY SHROUDS
3 HEAVY SHROUDS
MAST HOUSE
PORT
STBD.
STARTING POINT OF FRACTURE 1/2" BELOW INTERNAL FILLET WELD.

Figure 43.

Most of the bulwark failures occur at the forward and aft end of the deck house where the bulwark is flanged to land perpendicular to the rounded house front, figure 41. This is a poor design detail but is not a dangerous feature because experience with the Liberties led to constructing the Victory bulwarks free of the top of the sheer strake. This freedom prevents the cracks from propagating into the hull.

Most of the bulwark brace failures occurred on the forecastle, figure 42. It appears that the load of water resulting from plowing into a wave bends the widely flared bulwarks outward and causes the braces to fail. Sometimes the weld between the brace and deck plating cracks but frequently the deck itself is torn or cracked. This is not serious on the forecastle but it sometimes occurs nearer amidships. Most of the Class 2 Victory ship casualties involve this type of fracture.

Since 1 August 1945, there have been reported five new and curious failures, figure 43. The masts have broken on five new ships as follows:

ANTIOCH VICTORY.....	Foremast.....	Bethlehem-Fairfield.
MAHANOY CITY VICTORY	Mizzen Mast..	Bethlehem-Fairfield.
BROWN VICTORY......	Mainmast....	Oregon.
WAYCROSS VICTORY...	Mainmast....	Bethlehem-Fairfield.
ST. LAWRENCE VICTORY.	Mainmast....	Permanente.

The cause of these failures has not been determined but the sources of the steel are being checked.

E. *Relative Contribution of Design and Workmanship*

The fractures occurring on the EC2-S-C1 design have been grouped to determine the proportionate contribution of design and workmanship to the number of fractures which occurred. It is impossible to make a breakdown with a clear line of demarkation between the groups because in many cases, poor design details and poor workmanship went hand in hand in their contribution to the fracture. In other cases awkward design resulted in defective welds because of the difficulty in performing the welding.

Using reported casualty data supplemented by the findings of the research projects for guidance, it has been possible to make a reasonably reliable judgment regarding the part played by workmanship in 1,800 of the 2,504 fractures reported occurring on the *EC2-S-C1* vessels before 1 August 1945. It was found that in 25 percent of these cases, no fracture would have resulted had good workmanship been used. In 20 percent of the cases, there was some question but it was believed that the failure might have been avoided had the workmanship been good. In the remaining 55 percent, the design conditions created such severe notches that perfect workmanship could have done little to prevent the failures.

The 25 percent fractures which could have been avoided by good workmanship include welded butts in the bulb bars in the bulwark and bilge keel. These defective butt welds might have been avoided in the design stage by the use of some other member instead of the bulb bar. The 20 percent which might have been avoided by good workmanship were practically all at the end of the hatch corner doubler where the participation of perfect workmanship is questionable. It can be seen from this that design contributed to a large proportion of the casualties, far greater than did workmanship.

This should not be taken as an excuse for relaxing the standards of workmanship because many serious failures including the *Esso Manhattan* which broke in two were traced to defective butt welds where poor design played no part whatsoever.

F. *Discussion*

Almost all of the fractures could be traced to a notch of some sort. This notch might be a design geometry or a defective weld but in practically every case, a real notch could be found. There were a few cases, however, where geometry did not participate. In most of these, the fracture commenced at a longitudinal welded seam and spread to port and starboard. In the five Victory ship mast failures, the fractures have occurred near but not in geometrical configurations. In each case, however, they were near welds. The welds in some cases appear to affect the structure apart from creating geometrical discontinuities.

PART IV

Effectiveness of Certain Structural Alterations

A. *Summary of Alterations Performed on Liberty Ships*

Table IX shows the numbers of vessels of various types which have been altered in accordance with requirements which have been issued. It will be seen that hatch corner reinforcements have been fitted on practically all of the vessels and that riveted crack arrestors have been fitted on a great many. Compliance with current requirements involves immediate addition of hatch corner reinforcements, deck and gunwale crack arrestors on all passenger-carrying Liberties. Cargo ships must have hatch corner reinforcements and gunwale crack arrestors before issuance of the annual inspection certificate beginning 30 June 1946. All alterations will therefore be completed by 30 June 1947.

Type of Liberty Ship

SHIPS CONVERTED TO CARRY TROOPS

- AP —Dry cargo ship completely converted for troops operated by Navy.
- APK —Dry cargo ship partially converted for troops operated by Navy.
- XAP —Dry cargo ship completely converted for troops operated by WSA.
- XAPK —Dry cargo ship partially converted for troops.
- XAH —Dry cargo ship converted to hospital ship.

DRY CARGO SHIPS

- XAK-1 —General cargo not converted EC2-S-C1 (except Navy operated).
- XAK-2 —General cargo converted to cable ship.
- XAK-3 —General cargo converted to mule carrier.
- XAK-4 —Tank (motorized equipment) carrier Z-EC2-S-C2.
- XAK-5 —Tank and airplane carrier Z-EC2-S-C5.
- AK —General cargo not converted EC2-S-C1 operated by Navy.
- XAC —Colliers, EC2-S-AW1.

LIQUID CARGO SHIPS

- XAO —Tank vessels Z-ET1-S-C3 (except Navy operated).
- AO —Tank vessels Z-ET1-S-C3 operated by Navy.

MISC. VESSELS OPERATED BY ARMY AND NAVY

- Army: MA—MA repair ships, etc.
- Navy: MN—M, AG, AK, AKN, AKS, ARG, ARV, and IX (unclassified).

B. *Hatch Corner Reinforcements on Liberty Ships*

Figures have been prepared to show the relative effectiveness of the various types of hatch corner reinforcements prescribed for the Liberty ships. The results up to 1 August 1945, are tabulated below:

TABLE VIII

Type of hatch corner reinforcement	Ship months of service	Casualties involving hatch corners	Casualties per ship month
Unreinforced	22,146	210	0.0095
Reinforced in service, Codes 5, 6, and 7	17,115	37	.0022
Reinforced during construction, Codes 1 and 2	7,722	0	0
Hatch codes 3, 4, and 8, (not approved)	5,403	8	.0015
Approved codes 1, 2, 5, 6, 7	24,993	37	.0015

The above table should not be considered a true statistical presentation of the relative merits of the hatch corner reinforcement designs because it is impossible to determine the weather and sea service conditions to which the various groups of ships were subjected. The comparison of casualty rates used above is a sound method of approach provided the

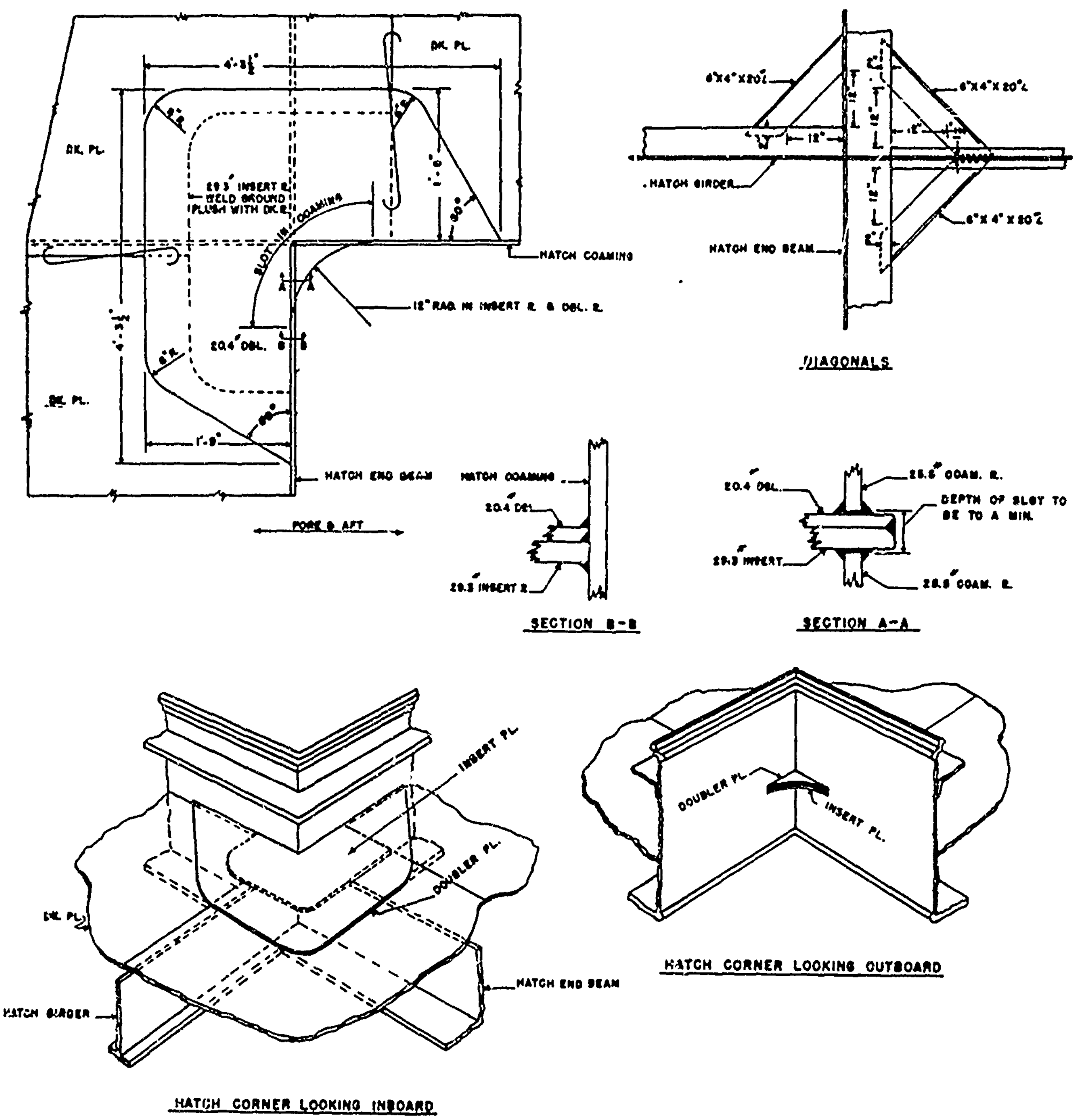
Table IX

SUMMARY OF STRUCTURAL ALTERATIONS ON LIBERTY SHIPS 1, FEBRUARY 1946

U.S. OPERATED VESSELS ONLY

SHIPS IN OPERATION = 2212 LOST -- WAR = 193 LOST - MARINE = 42 LOANED = 264 TOTAL LAUNCHED = 2711		CODE NO.	TYPE OF VESSEL: TROOPSHIPS & CARRIERS: AP	XAP	XAPK	XAH	DRY CARGO SHIPS: XAK-1	XAK-2	XAK-3	XAK-4	XAK-5	AK	XAC	LIQUID CARGO SHIPS: XAO	AO	MISC.: IX	GRAND TOTALS
NUMBER OF SHIPS				17	281	4	1704			1	36	35	24	39	19	52	= 2212
HATCH CORNER REINF'T		1			3		494				36	5	1			23	562
		2												2	9		11
		3					165										165
		4					48										48
		5		16	264		870					10				19	1179
		6												25			25
		7										1					1
		8			10		20			1		3		12	10		56
	TOTAL =			16	277		1597			1	36	19	1	39	19	42	= 2047
DK. ALTER.		1			21		363				6	6		7	1	31	435
		2		12	7	1	3				1						20
		3		2		3											5
		4											24				24
	TOTAL =			14	24	4	366				7	6	24	7	1	31	= 484
GUNWALE ALTERATION		1			[illegible]		376				35		24			13	454
		2			12		40					6		3		7	68
		3		4	2	4	3									1	14
		4		9	4		10							3			26
		5			8		153					9					170
		6					12										12
		7			12		662			1	1	13		29	19	20	757
		8		1	182		159							3			345
		9		1	2		3				1			1			8
	TOTAL 5, 6 & 7 =			0	20	0	827			1	1	22	0	29	19	20	= 939
	TOTAL ARRESTORS =			15	203	4	591			0	36	6	24	10	0	26	= 915
	TOTAL =			15	223	4	1418			1	37	28	24	39	19	46	= 1854
L.B. GIRD.		1		14	4	4	11					1		2			= 36
BILGE KEEL		1		1	51		992			1	36	13	24	39	19	33	1209
		2			86		87					4				2	179
		3		11	3	4	72										90
	TOTAL =			12	140	4	1151			1	36	17	24	39	19	35	= 1478
REINF'T. COMPL.		1		11	126	4	586				36	6	24	10		32	835
		2		3	115		162									3	283
	TOTAL =			14	241	4	748				36	6	24	10		35	= 1118

HATCH REINFORCEMENT
CODE NUMBER 1, 2 & 3



CODE NUMBER 1 --- HATCHES 2, 3, & 4 IN UPPER DK.

U.S. MARITIME COMMISSION MC PLAN EC2-S-C1-S16-2-3, DETS 2 & 3
U.S. MARITIME COMMISSION MC PLAN EC2-S-C1-S11-6-6 DETS. 2 & 3
MOORE DRY DOCK PLAN 9997, DETS. 2 & 3
BETHLEHEM STEEL CO. S.B. DIV. 56TH ST. BKLYN PLAN T-398 DET. 2 & DIAG
GIBBS & COX, CALSHIP MCE PLAN 1-312-S11-6-4A ALT. XV DETS. 5A & 6A
GIBBS & COX, DELTA MCE PLAN 1-312-S11-6-4 ALT. A DET. 9 (NO DIAG.)
J.A. JONES CONST. CO. INC. PANAMA CITY (SK-S11-6-4E DETS. 2 & 3)(2-SK-S11-6-4B DET. 2)

CODE NUMBER 2 ---NO DIAGONALS, APPLIES TO TRUNKS 3, 4, 5, 6 & 7 IN UPPER DK (HATCHES 2, 3, & 4)

U.S. MARITIME COMMISSION MC PLAN Z-ET1-S-C3-S16-2-3 DET 2

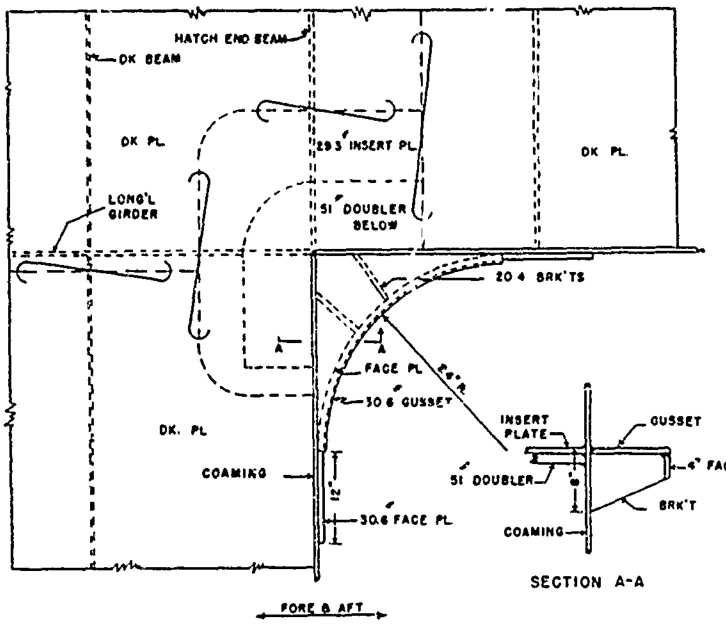
CODE NUMBER 3 ---HATCHES 2, 3 & 4 IN UPPER DK.

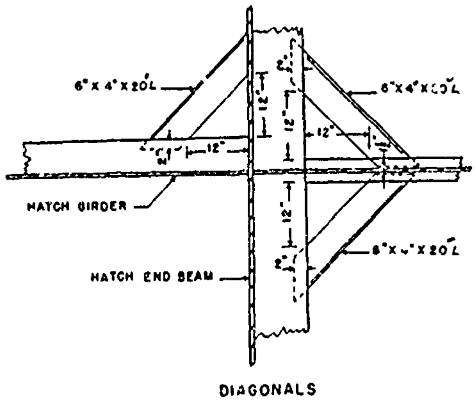
PERMANENTE METALS CORP. RICH. 2 PLAN RS16-2-3-1
30.6# DOUBLER & DIAGONALS, NO INSERT PL.
OREGON S.B. CORP. SIMILAR BUT EARLY HULLS HAD 20.4# DBL.

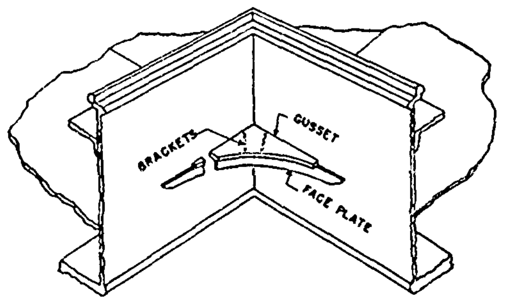
Figure 44.

HATCH REINFORCEMENT

CODE NUMBER 5, 6 & 7







HATCH CORNER LOOKING OUTBOARD

CODE NUMBER 5 --- HATCHES 2, 3 & 4 IN UPPER DK
- *U. S. MARITIME COMMISSION MC PLAN EC2-S-C1-S16-2-3 DETAILS 1 & 3
- U. S. COAST GUARD PLAN EMM 17-S11-17-1 ALTERATION "A"
- U. S. COAST GUARD PLAN M1 15-S11-17-1 DETAIL A
- (NOTE: THE U S C.G PLANS, DETAIL A DO NOT INCLUDE DIAGONALS AT THE LOWER FLANGES OF THE BEAMS & GIRDERS)
- MOORE DRYDOCK CO. PLAN 9997 DETAILS 1 & 3
- *BETHLEHEM STEEL CO. S B DIV. 56TH ST BKLYN PLAN T-398 DETAIL 1 & DIAGONALS
- *ARTHUR G BLAIR INC. PLAN DGA-95 DETAIL A & 3
- J. A. JONES CONST CO. INC., PANAMA CITY (SK-S11-6-4E DETAILS 1 & 3 & Z-SK-S11-0-4B DETAILS 1 & 3
- (JONES PLAN SHOWS 51# DOUBLER PLACED ABOVE INSERT PL)

CODE NUMBER 6 --- NO DIAGONALS, APPLIES TO TRUNKS 3, 4, 5, 6 & 7 IN UPPER DK (HATCHES 2, 3 & 4)
- U. S. MARITIME COMMISSION MC PLAN Z-ET1-S-C3-S16-2-3 DETAIL 1

CODE NUMBER 7 --- SIMILAR BUT NO DIAGONALS
- HURLEY MARINE WORKS INC. PLAN EC2-38 DOES NOT STATE CORNERS TO BE REINFORCED
- NAVY DEPT. BU. OF SHIPS PLAN 017699 " " " " " " "
- NORFOLK NAVY YARD PLAN AK114-S1.06-297875, UPPER DK. HATCHES 1 TO 5 INC.

NOTES

♠ SOME LIBERTY SHIPS HAVE NO INSERT PLATES AT THE HATCH CORNER.

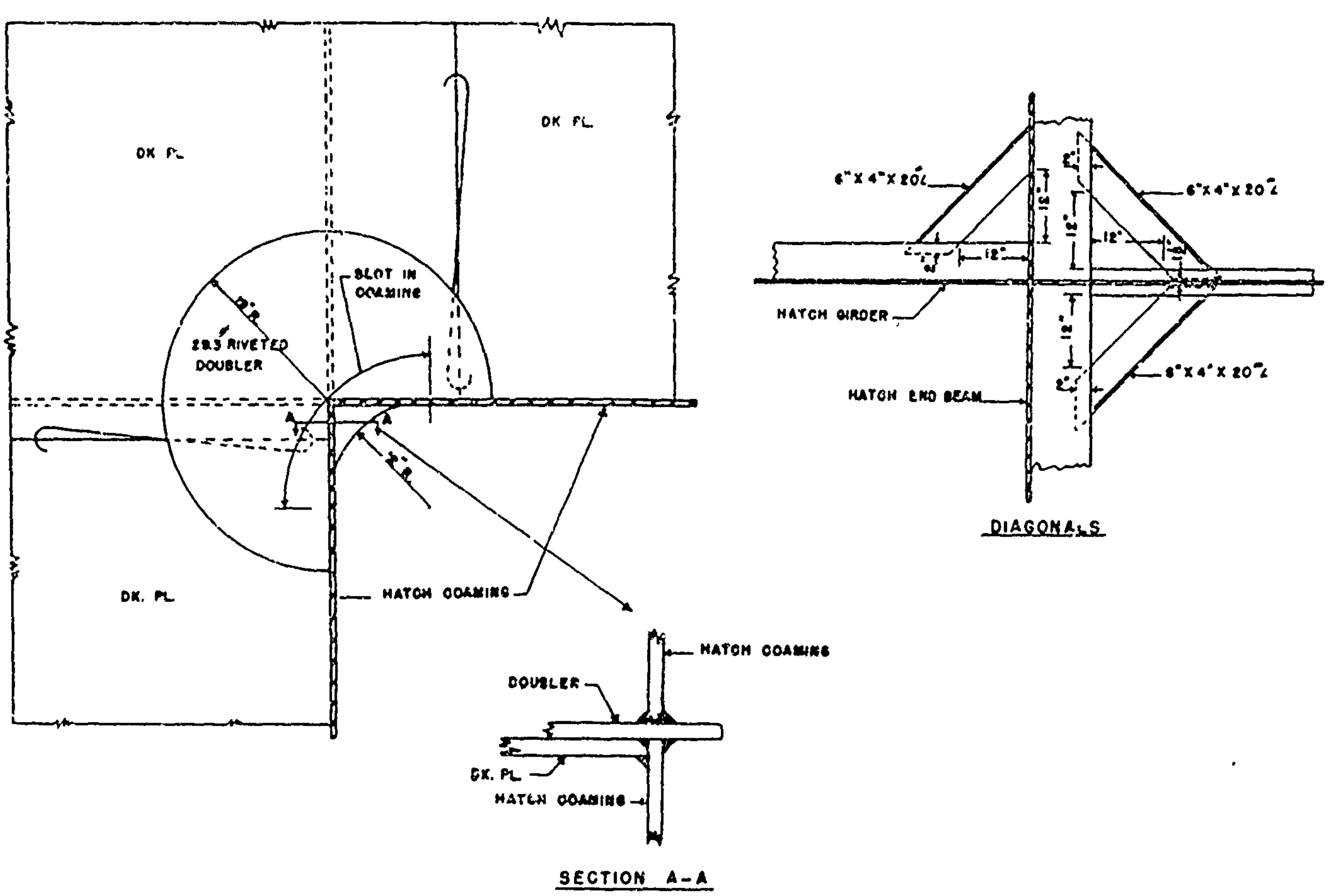
♣ SOME LIBERTY SHIPS HAVE THE 51# DOUBLER ABOVE DK.

* CODE NO. 5 EXACTLY AS SHOWN

Figure 45.

HATCH REINFORCEMENT

CODE NUMBER 4



CODE NUMBER 4 --- HATCHES 2, 3, & 4 IN UPPER DK

NEW ENGLAND S.B CORP. MCE PLAN 2I6-2-3-102

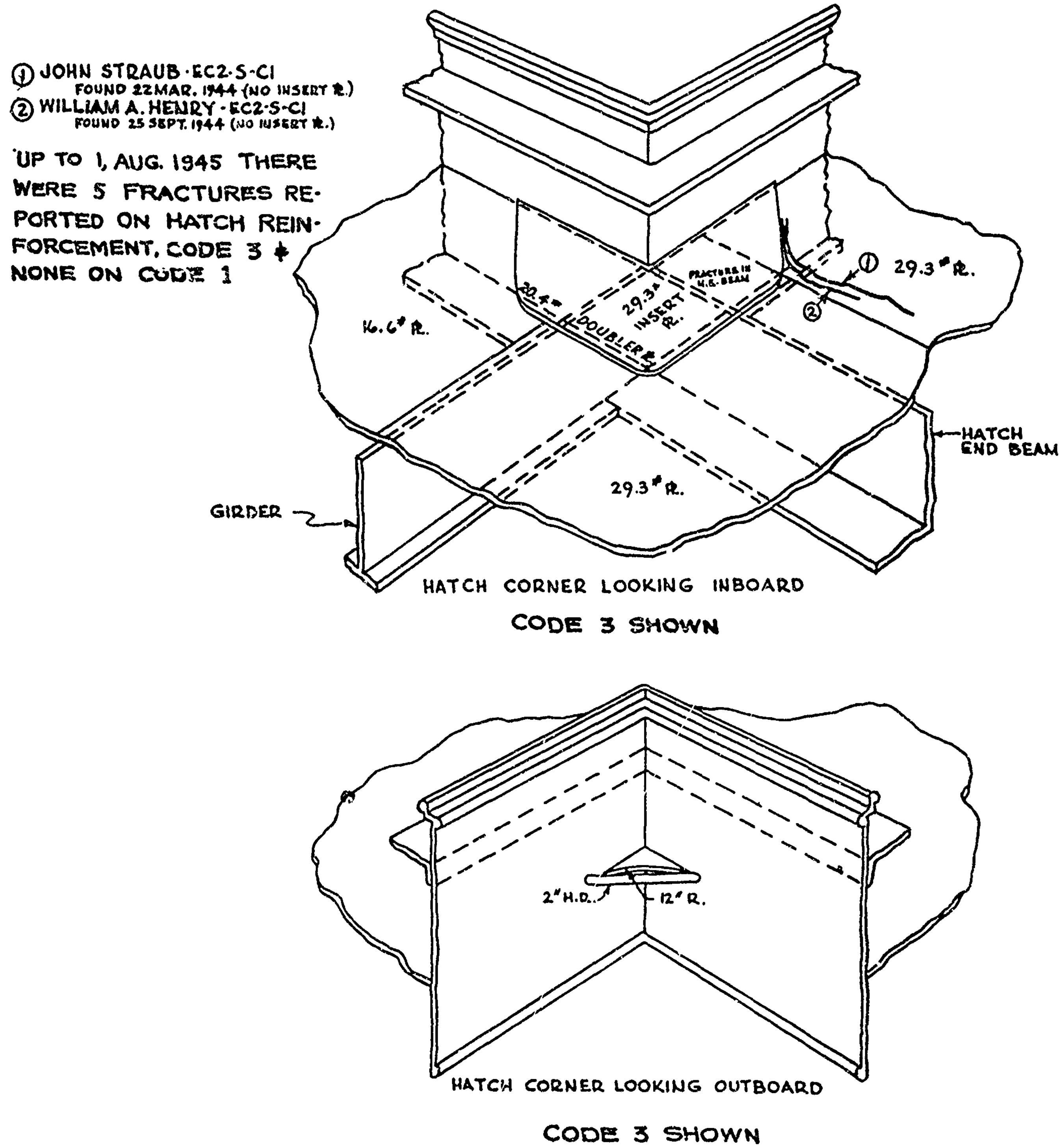
Figure 46.

service conditions are identical and the number of cases are sufficient for sampling purposes. Failing this, the traditional method of judging the benefit of alterations by impressions gained in service and as recorded in making up this table must be used. In this connection, we know that the service conditions to which the ships with reinforced hatch corners were subject were more severe than those to which the ships with unreinforced hatch corners were subjected. The comparisons set forth above are therefore conservative. The effective performance of the prescribed hatch corner reinforcements is both gratifying and reassuring. It is reassuring because it demonstrates that reasonable care and practicable designs are capable of easing points in the structure which are known to be sources of trouble.

C. *Crack Arrestors on Liberty Ships*

The crack arrestors fitted on various designs have proved very effective. They were found to have stopped cracks in 17 instances on 15 vessels which suffered normal structural casualties. In addition there have been reports on four other ships subjected to war and marine casualties where fractures occurred indirectly from grounding or torpedo and mine damage. The crack arrestors stopped eight cracks on these four vessels and the influence of the crack arrestors was questionable in the case of two other cracks. In the case of one other vessel, which ran aground off the coast of California, it is claimed that the crack arrestors were responsible for delaying the complete failure of the vessel and permitting

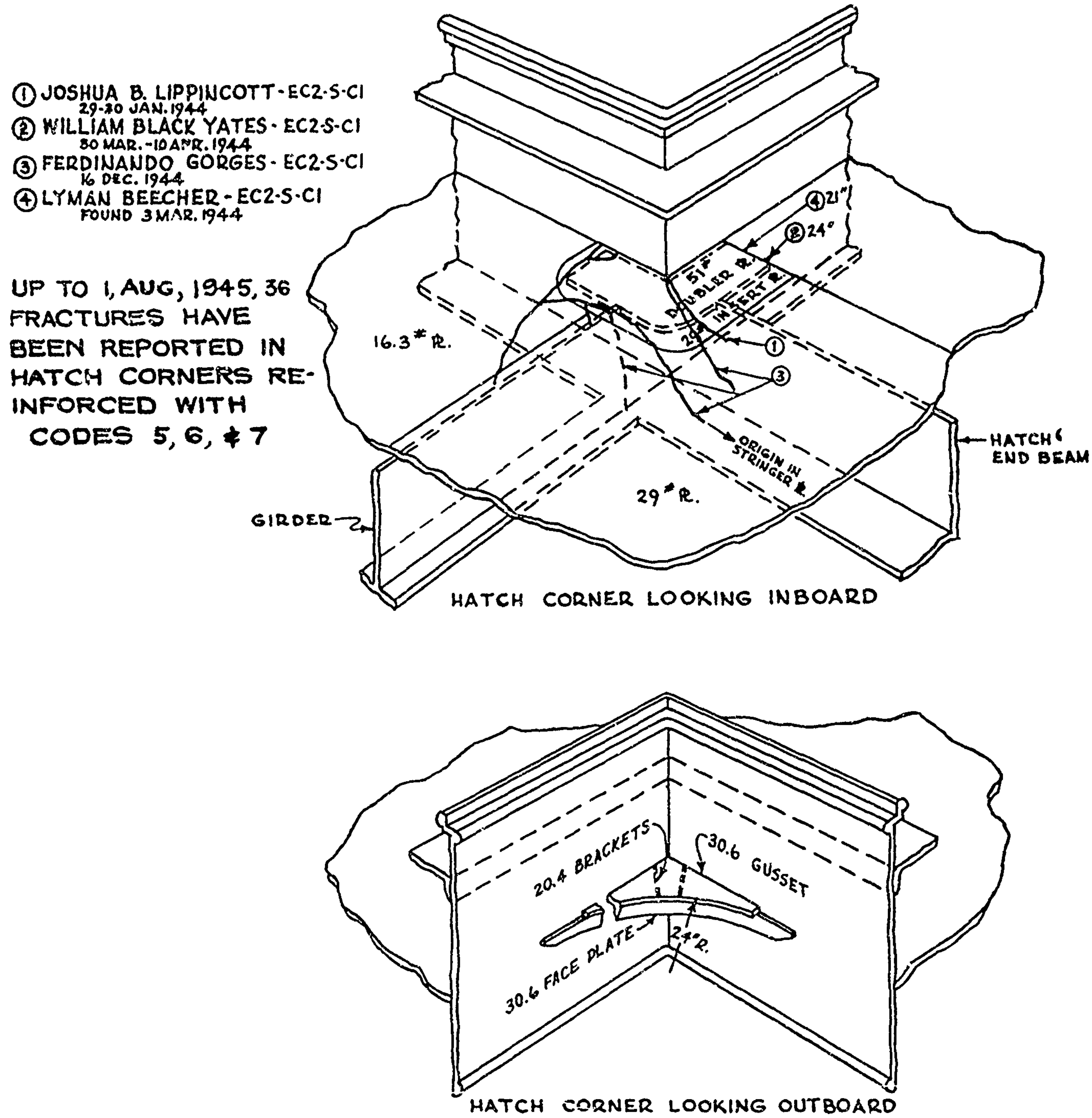
LIBERTY VESSEL
COMPOSITE SKETCH OF FRACTURES AT #2, #3, OR #4 HATCH CORNERS, UPPER DECK
HATCH MODIFICATION 1 MARITIME COMMISSION PLAN No. EC2-S-C1-S16-2-3, DET. 243
HATCH MODIFICATION 3 AS ABOVE EXCEPT NO INSERT PLATE............



NOTE:
FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 47.

LIBERTY VESSEL
COMPOSITE SKETCH OF FRACTURES AT #2, #3, OR #4 HATCH CORNERS, UPPER DECK
HATCH MODIFICATION 5, 6 & 7
MARITIME COMMISSION PLAN No. EC2-S-C1-S16-2-3
DETAIL 1 & 3



NOTE:
FRACTURES LOCATED FROM PHOTOGRAPHS OR FIELD SKETCHES

Figure 48.

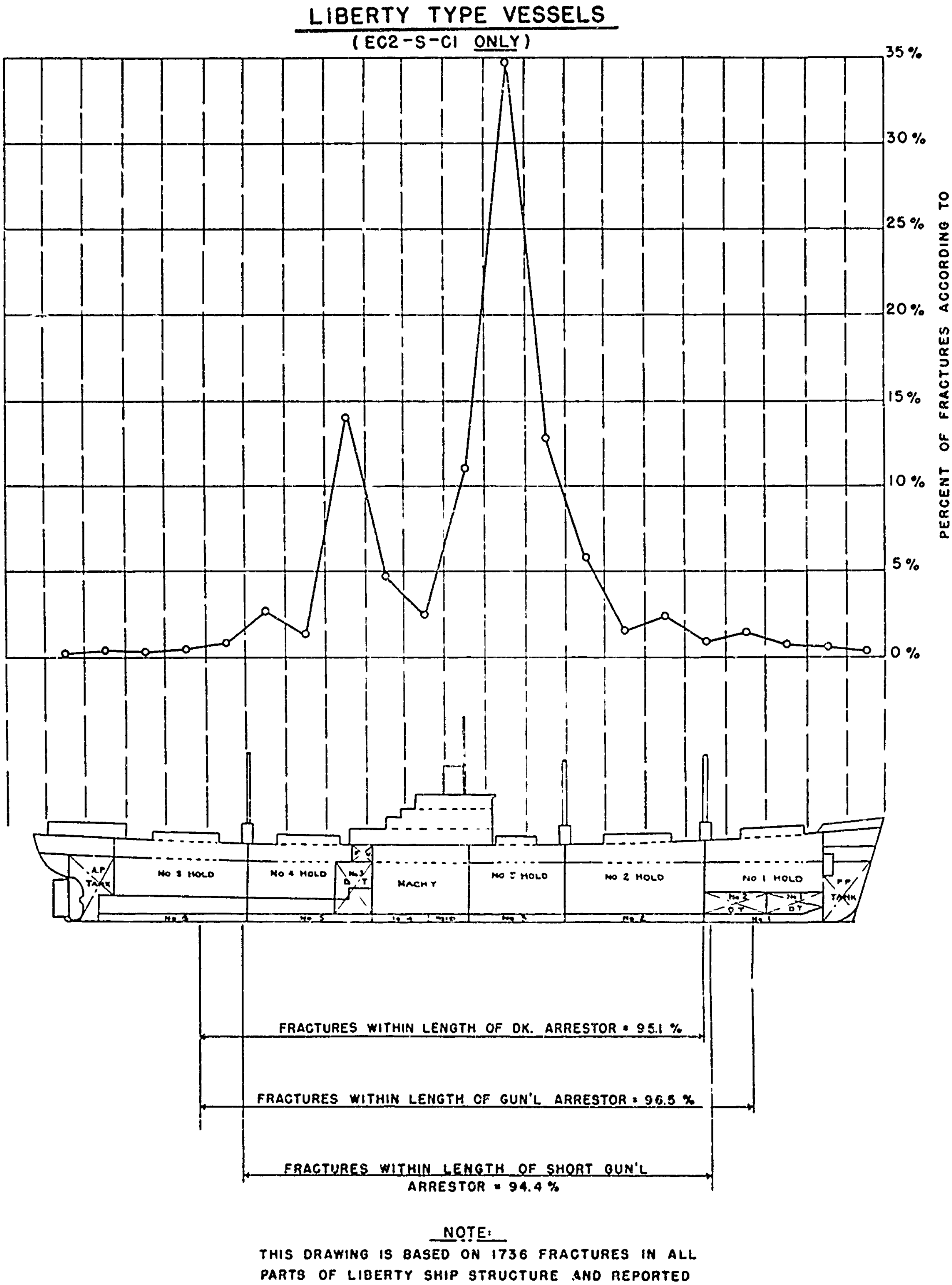
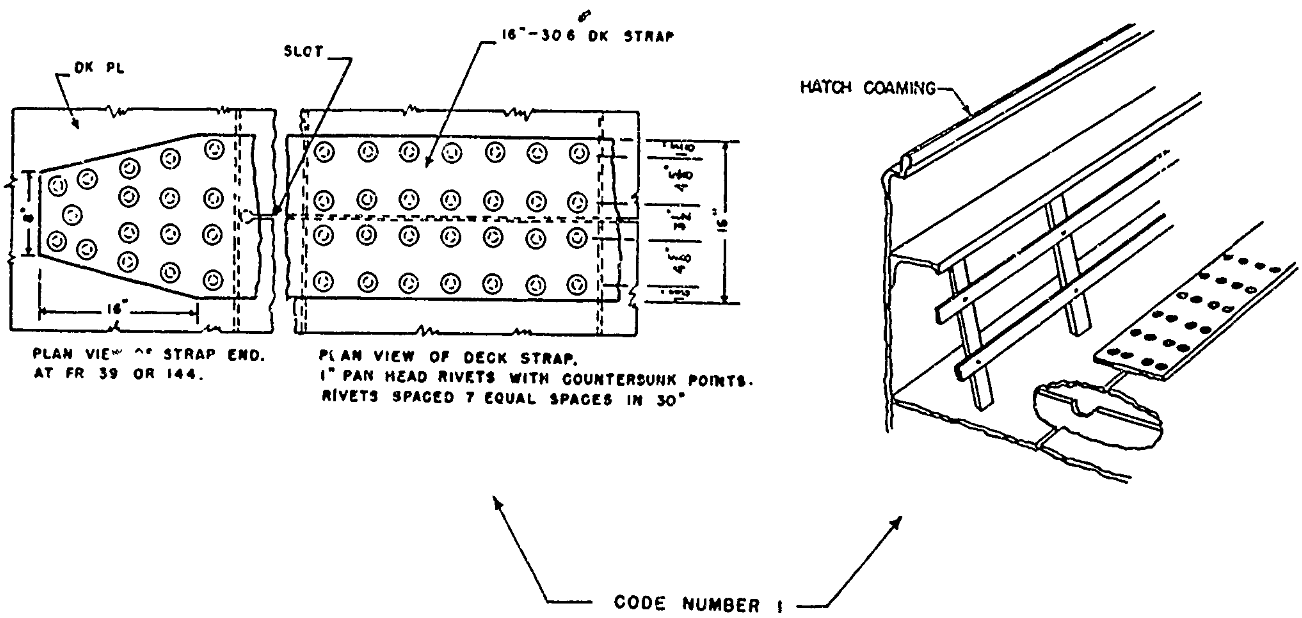
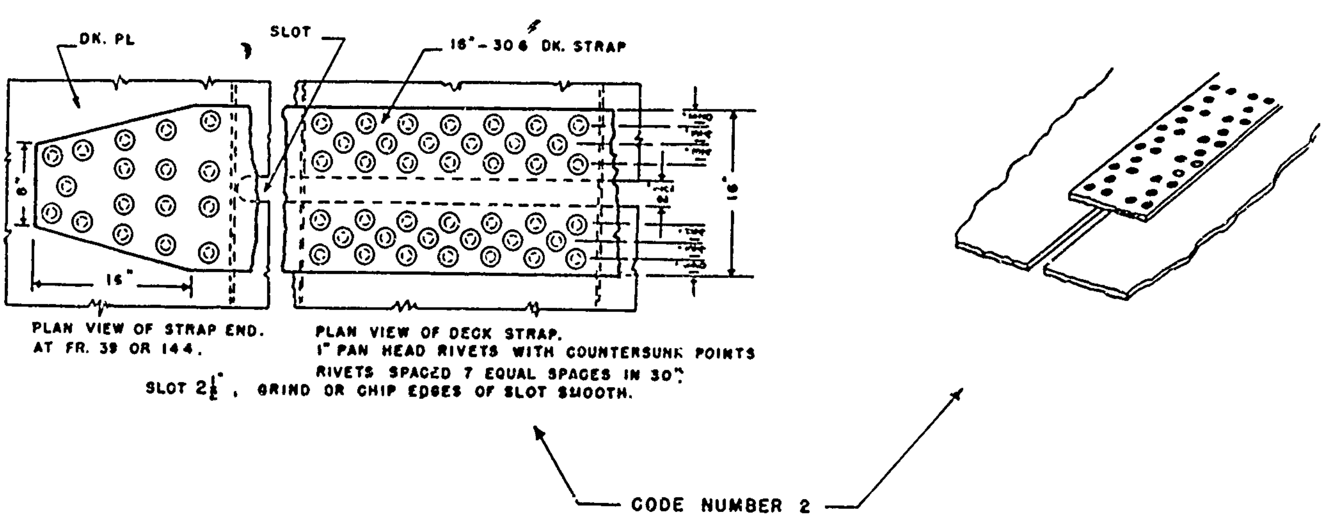

LIBERTY TYPE VESSELS
(EC2-S-C1 ONLY)
35 %
30 %
25 %
20 %
15 %
10 %
5 %
0 %
PERCENT OF FRACTURES ACCORDING TO LOCATION ON VESSEL.
A.P. TANK
No 5 HOLD
No 4 HOLD
MACH'Y
No 3 HOLD
No 2 HOLD
No 1 HOLD
F.P. TANK
FRACTURES WITHIN LENGTH OF DK. ARRESTOR = 95.1 %
FRACTURES WITHIN LENGTH OF GUN'L ARRESTOR = 96.5 %
FRACTURES WITHIN LENGTH OF SHORT GUN'L ARRESTOR = 94.4 %
NOTE:
THIS DRAWING IS BASED ON 1736 FRACTURES IN ALL PARTS OF LIBERTY SHIP STRUCTURE AND REPORTED BEFORE 17, OCT 1944

Figure 49.

CRACK ARRESTOR ON DECK





CODE NUMBER 1

U.S MARITIME COMMISSION M.C PLAN EC2-S-C1-S11-6-6 DETAIL B
U.S COAST GUARD PLAN M.I 14-S11-17-1 DETAIL B
ARTHUR G. BLAIR INC. PLAN DGA 95 DETAIL B
DELTA S.B. CO. M.C PLAN S11-6-6-A

CODE NUMBER 2

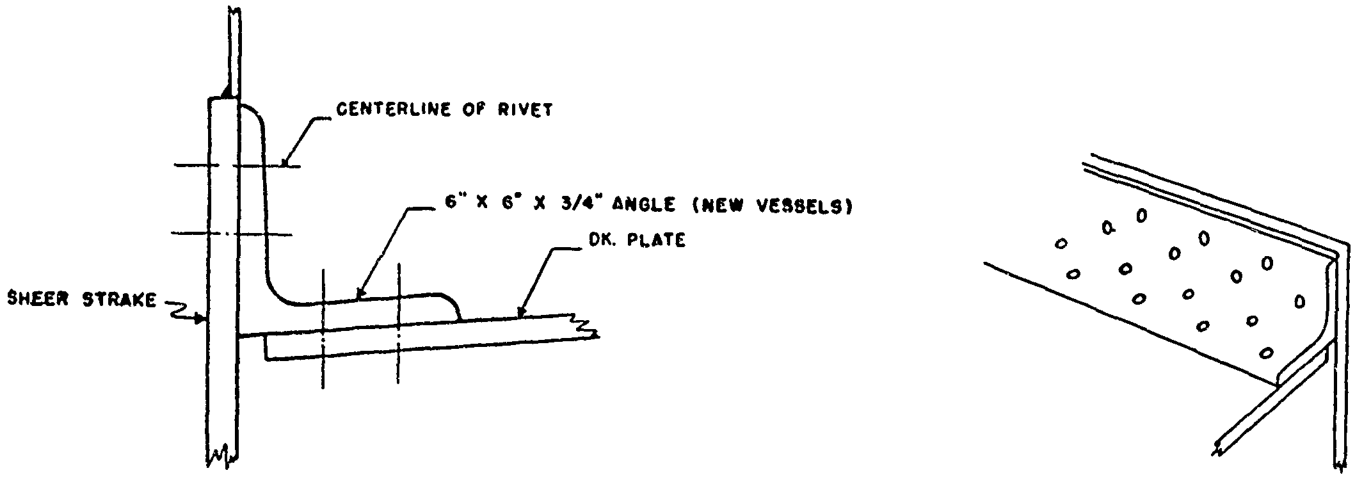
U.S COAST GUARD PLAN M.I 15 S11-17-1 DETAIL B

CODE NUMBER 3 - SIMILAR TO CODE NO. 2, BUT EXTENDING FROM FR. 17 TO 154

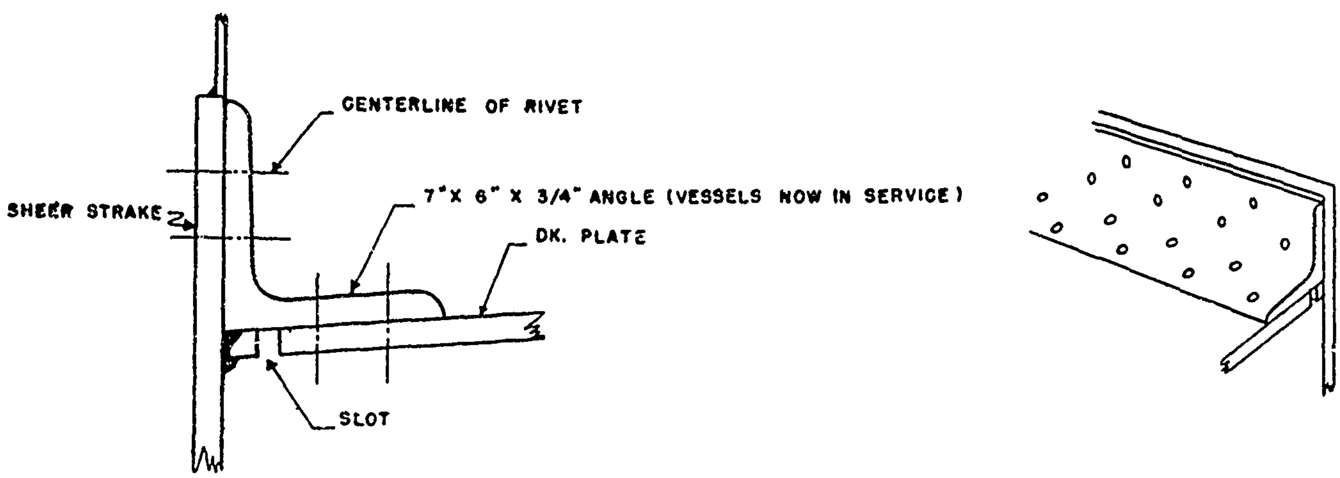
WAR DEPT. PLAN NO L1-66-A-R DETAIL B

Figure 50.

GUNWALE ARRESTOR



CODE NUMBER 1

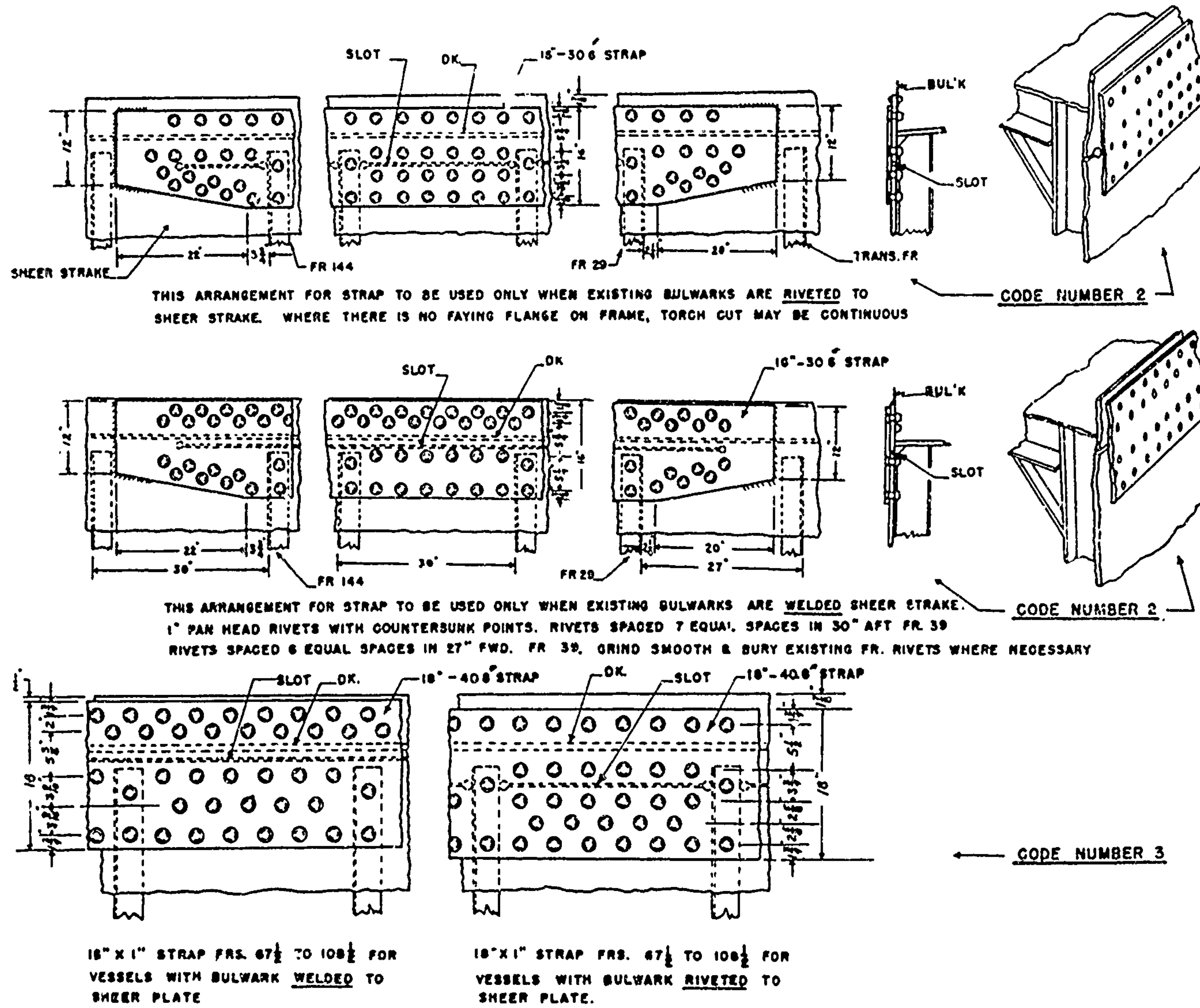


CODE NUMBER 4
&
CODE NUMBER 9

CODE NUMBER 1 -(EXTENDS FROM FR 28 TO 145)
U.S. MARITIME COMMISSION M.C. PLAN EC2-S-C1-S11-6-6
WITH MC PLAN NO. S11-6-4A
DELTA S.B. CO. MC PLAN S11-6-4A
DELTA S.B. CO. PLAN S11-6-3
J.A. JONES, PANAMA CITY PLAN AT11-6-4A
CODE NUMBER 4 - (EXTENDS FROM FR. 28 TO 145)
U. S. MARITIME COMMISSION MCE PLAN S11-6-4B
CODE NUMBER 9 --(EXTENDS FROM FR. 38 TO 135)
U.S. COAST GUARD PLAN EMM.17-S11-17-1 ALTERATION "B"

Figure 51.

GUNWALE CRACK ARRESTOR



CODE NUMBER 2
U.S. COAST GUARD PLAN M.I. 14-SH-17-1 DETAIL C
ARTHUR G. BLAIR INC. PLAN DBA-85 DETAIL C
DELTA S B CO. SKETCH H-223

CODE NUMBER 8---IDENTICAL TO CODE NUMBER 2, BUT EXTENDING FROM FR. 38 TO FR. 135
U.S. COAST GUARD PLAN EMM 17-SH-17-1 ALTERATION "C"

CODE NUMBER 3----SIMILAR TO CODE NUMBER 2, BUT MIDDLE PORTION 18" X 1" AS SHOWN.
U.S. COAST GUARD PLAN M.I. 15-SH-17-1 DETAIL "C"
WAR DEPT PLAN LI-68-A-R DETAIL "C"

Figure 52.

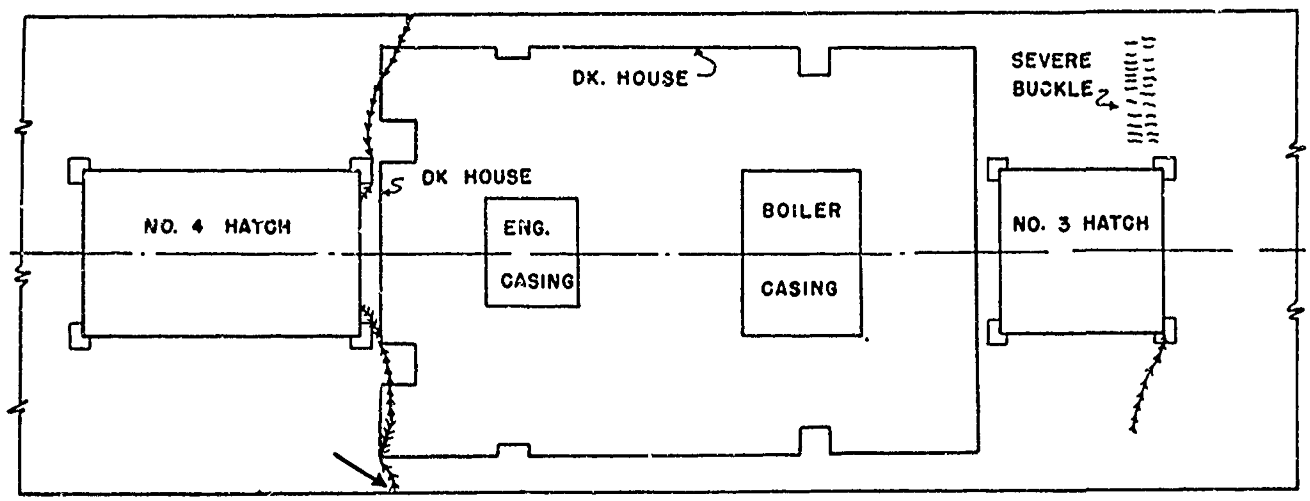
sufficient time to remove the personnel aboard. The details of each case are included in table X.

In no case is any crack known to have crossed an arrestor.

Figure 10 was originally prepared to weigh the effects of reducing the length of the gunwale crack arrestor and shows the percent of the fractures in way of arrestors of various lengths.

Figures 53, 54 and 55 describe a typical case of an effective crack arrestor. The photographs were taken

FWD. →



PLAN VIEW OF UPPER DECK.

S.S. COLIN P. KELLY JR.

Figure 53.

from the location indicated by an arrow on the sketch. The fractured specimen shown was removed from the ship by the British Admiralty and is available for examination at Coast Guard Headquarters.

Many cases have been reported where riveted seams and chain intermittent welding have been responsible for limiting the extent of fracture but such cases have not been tabulated.

D. *Gunwale Cuts on Liberty Ships*

Thirty-two fractures occurred at the gunwale cut. Of these, eighteen were Class 1 and fourteen Class 2. Three of the Class 1's had "alterations" No. 5, a rounded gunwale cut. The rest were unaltered.

E. *Serrated Bilge Keels*

There have been seventeen bilge keel fractures. Sixteen of these involved bilge keels which had not been altered. Fifteen of these failures were Class 2 and one was Class 1. Only one altered bilge keel failed. This was a Class 2 failure and the bilge keel was altered with Code 1 (serrated).

F. *Underdeck Girders on T2 Tankers*

Underdeck girders were fitted on the T2 Tankers. These girders were not welded to the deck and it was expected that they would remain intact in the event of a major deck fracture. So far all of the major structural failures occurring since these girders were fitted started in the bottom. For this reason, there has never been an opportunity to evaluate fully their effectiveness. In one case of a fire on board one of the vessels, the deck fractured and the girders held. Full details of this casualty are not yet available.

G. *Bulkhead Intersections on T2 Tankers*

Various alterations have been made at the bulkhead intersections of the T2 Tankers. Test data indicate that the changes made should relieve the trouble but actual casualty data are not yet available for this report.

FIGURE 51.—Termination of fracture at gunwale, starboard side, *S. S. Colin P. Kelly Jr.* (see arrow fig. 53.)

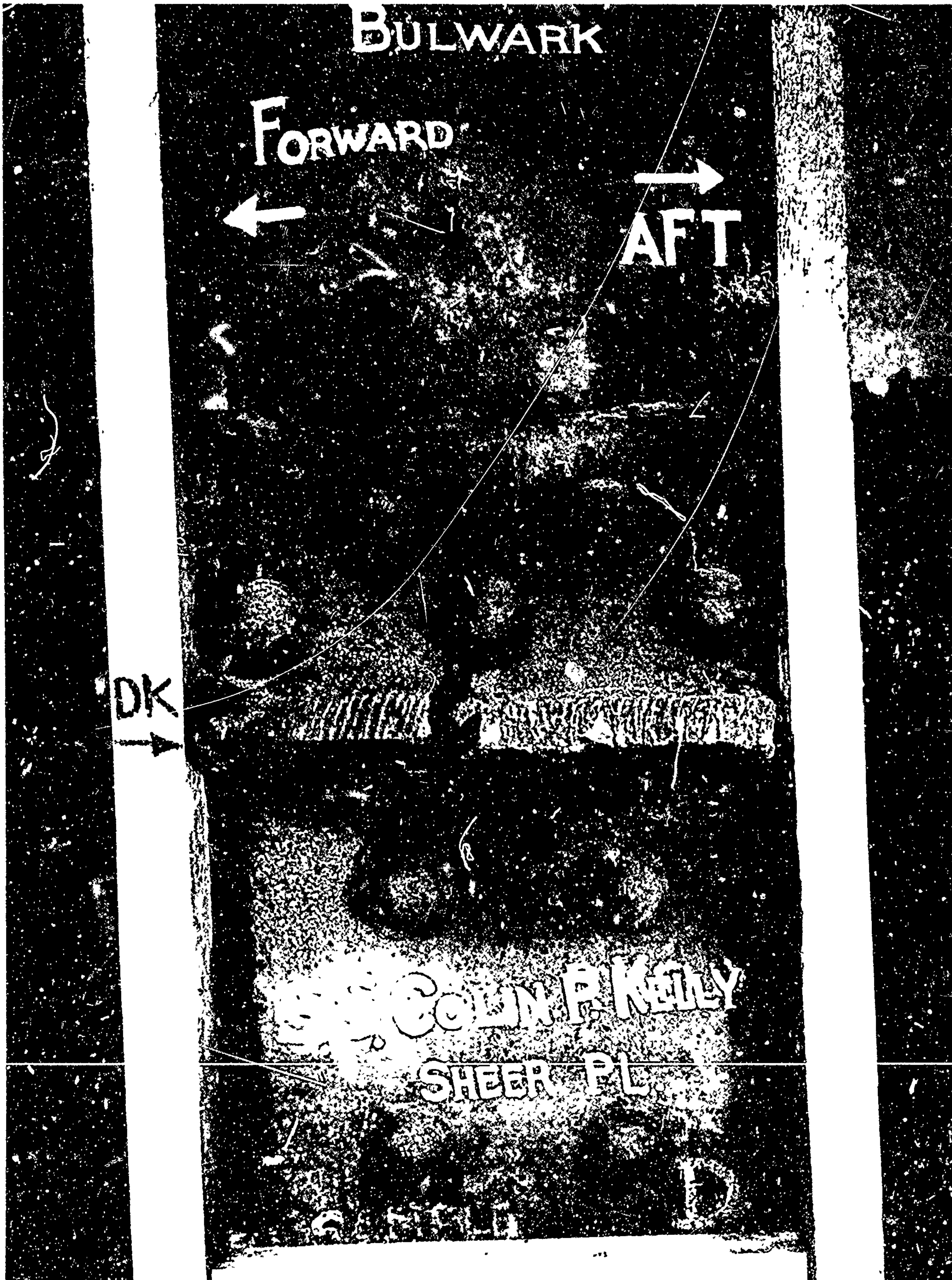


FIGURE 55. Termination of fracture at gunwale, starboard side, *S. S. Colin P. Kelly Jr.* (Note horizontal torch cut below deck, see fig. 52.)

701292—47—6

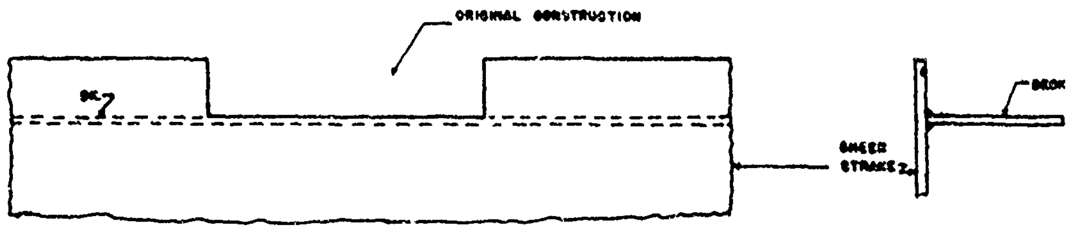
TABLE X

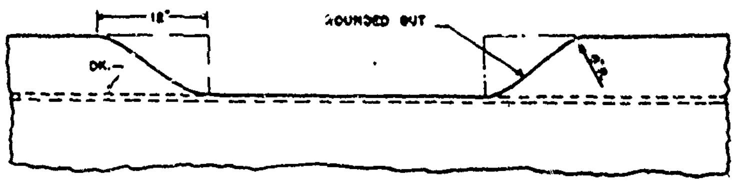
Casualties Which Tested the Effectiveness of the Crack Arrestor

Name of ship	Type	Date of casualty	Type of crack arrestor	EC2 code	Distance from starting point to arrestor	Length of longest leg of crack	Did crack stop at arrestor?
1. Angus McDonald	EC2-S-C1	8 Aug 1945	Gunwale angle	1	?	3′ 0″	Yes
2. Belgian Amity	EC2-S-C1	Dec 1945	Gunwale angle	1	1′ 6″	2 8	Yes
3. Costa Rica Victory	VC2	26 Dec 1945	Gunwale angle		?	0 3	Yes
4. George Gipp	EC2-S-C1	16 Dec 1945	Sheer strake strap	8	0[1]	2 10	Yes
5. Hall J. Kelley	EC2-S-C1	1 Jan 1946	Sheer strake strap	8	?	2 8	Yes
6. J. D. Yeager	EC2-S-C1	19 Feb 1945	Gunwale angle	1	?	16 6	Yes
			Gunwale angle	1	?	1 8	Yes
7. Jean Ribaut	EC2-S-C1	8 Nov 1945	Sheer strake strap	8	4 2	21 9	Yes
			Sheer strake strap	8	?	0 2	Yes
8. Laurance J. Gallagher	EC2-S-C1	Dec 1945	Gunwale angle	1	1 6	1 6	Yes
9. Lebanc	C1-M-AV1	9 Jan 1945	Gunwale angle		?	29 0	Yes
10. Petersburgh Victory	VC2	26 Dec 1945	Gunwale angle		1 6	2 0	Yes
11. Richard J. Reiss	L6-S-B1	17 Oct 1943	Gunwale angle and strap		11 0	11 0	Yes
12. Robert C. Stanley	L6-S-B1	10 Nov 1943	Gunwale angle and strap		11 0	12 0	Yes
13. Robert F. Stockton	EC2-S-C1	Feb 1946	Sheer strake strap	8	?	30 0	Yes
14. Stephen W. Kearney	EC2-S-C1	3 Feb 1946	Sheer strake strap	8	?	5 4	Yes
15. Walter Forward	EC2-S-C1	29 Jan 1945	Sheer strake strap	8	?	2 4	Yes
War and Marine Casualties:							
1. Colin P. Kelly, Jr.	EC2-S-C1	4 June 1945	Sheer strake strap	8	4 6	56 11	Yes
			Sheer strake strap	8	18 6	56 11	Yes
			Sheer strake strap	8	?	0 6	Yes
2. George Hawley	EC2-S-C1	21 Jan 1945	Gunwale angle	1	20 0	21 6	Yes
3. Henry Bergh	EC2-S-C1	31 May 1944	Gunwale angle	2	Port 4 0	4 0	Delayed failure and changed cleavage to shear.
			Deck strap	1	Port 2 4	2 4	
			Deck strap	1	Stbd 2 4	2 4	
4. James Egan Layne	EC2-S-C1	8 Dec 1944	Gunwale angle	1	?	56 11	Yes
			Gunwale angle	1	?	56 11	Yes
5. Lucien B. Maxwell	EC2-S-C1	6 Aug 1945	Sheer strake strap	8	?	17 +	Yes
			Sheer strake strap	8	?	17 +	Yes
			Sheer strake strap	8	?	?	?
			Sheer strake strap	8	?	?	?

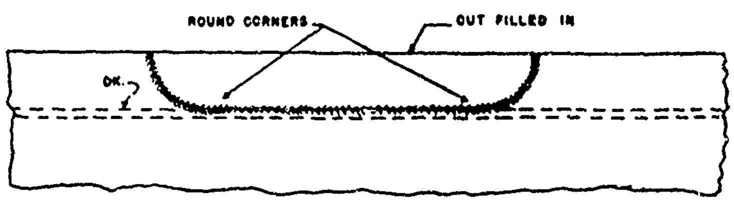
[1] Butt weld in sheer strake

GUNWALE ALTERATION





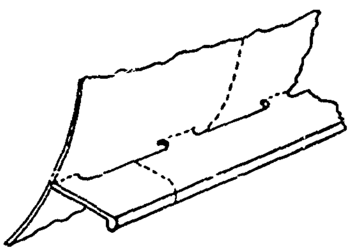
CODE NUMBER 5



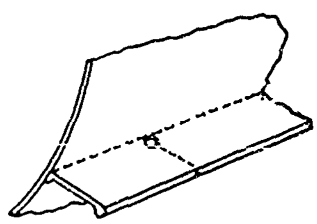
CODE NUMBER 6

CODE NUMBER 5
U S COAST GUARD PLAN EMM17-S11-17-1 ALTERATION "B
WAR SHIPPING ADMINISTRATION PLAN MR 18-S11-1-1
GIBBS & COX INC, CALSHIP MCE PLAN 1-S12-S11-6-4-4 ALT XX
CODE NUMBER 6
U.S. COAST GUARD PLAN EMM17-S11-17-1 ALTERATION "F"
U.S COAST GUARD PLAN M.L 18-S11-17-1 DETAIL 6
WAR DEPARTMENT PLAN L1-68-A-R DETAIL C
HURLEY MARINE WORKS PLAN EOE-37
CODE NUMBER 7 ---CUT OMITTED
GIBBS & COX INC. CALSHIP MCE PLAN 1-S12-S16-4-4A ALT. 1

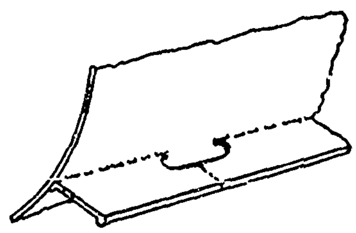
BILGE KEEL ALTERATION



CODE NUMBER 1



CODE NUMBER 2



CODE NUMBER 3

CODE NUMBER 1---AS SHOWN
CODE NUMBER 2
U.S. COAST GUARD PLAN EMM 17-S11-17-1 ALTERATION "D"
ARTHUR G. BLAIR INC. PLAN D8A-83 DETAIL D
CODE NUMBER 3
U S COAST GUARD PLAN ML-18-S11-17-1 DETAIL D

Figure 56.

PART V
Steel Quality

Defective material might offer an easy explanation of the fractures but such an explanation would be conditional and incomplete.

Samples of steel were removed from several of the ships which fractured, and forwarded to the Metallurgy Division of the National Bureau of Standards, where tests were made to determine their properties. It was usually impossible to test the steel removed from the starting point of the fracture because this usually occurred in a defective weld or a design detail and not in the plating itself. Most of the plates submitted and described in part V are the first plates through which the fractures progressed as they spread from the starting point.

A. *Routine Tests*

The material in which the fractures started was tested in the case of many ships, from which samples were taken near the point of origin. Thus 25 specimens from the ships showed agreement with applicable standards of yield strength, ultimate strength, and elongation. In addition, the material had passed the usual inspection tests with requirements for sampling and physical properties.

Complete certainty is not assured by these tests, with respect to every part of every piece of steel, but we can be sure that the fractures, which are numerous and widespread in occurrence, do not result from failure of steel to meet specifications.

B. *Notched Bar Tests*

There are indications that the steel is deficient in a property not covered by the specifications. In the report of the Research Advisory Committee, data are given on this property in relation to notch sensitivity, and the significance of this property for fractures like those seen in the ships has been studied in the laboratory.

Thirty one steel samples from the ships were given the standard V-notch Charpy test for evaluation of energy absorption in a notched bar. They are designated Group A.

In all cases, the bar was located with notch perpendicular to the surface of the plate, and in such a manner that the notch orientation corresponded to that of the crack as it progressed through the plate. This resulted in placing the bar parallel to the direction of rolling in all cases except on the *SS Sea Bass* where the deck plating is transverse. Four bars were tested at each of eight or nine temperatures or about 30 bars per plate.

Data for the 31 plates have been averaged with respect to temperature: the averages are shown in the lower portion of figure 57, along with the best and the worst curves. The energy absorption values at 70° F are also indicated for each of the plates tested (upper left) with dotted lines to indicate the spread of the energy absorption values covered by the four specimens tested at that temperature.

Since the specifications for hull steel do not include notch bar tests, there was no standard value for comparison. For this reason, the Coast Guard Merchant Marine inspectors obtained from the shipyards' stock and scrap piles numerous samples of ½ inch hull steel plate which were forwarded to the United States Naval Shipyard, New York. These are Group B samples. In addition, the Navy had requested the steel mills to submit samples of plate complying with both their own and the American Bureau of Shipping hull steel specifications. These are Group C samples. On Groups B and C a series of Charpy tests was also run, but only at 70°F. The results are indicated on the plots, figure 57 (upper center and right). The spread of values was similar to that in Group A and has not been indicated.

Data from Groups B and C have been entered in the temperature diagram on figure 57 and comparison suggests that specimens of steel in Group A (from fractured plates) were more notch sensitive than

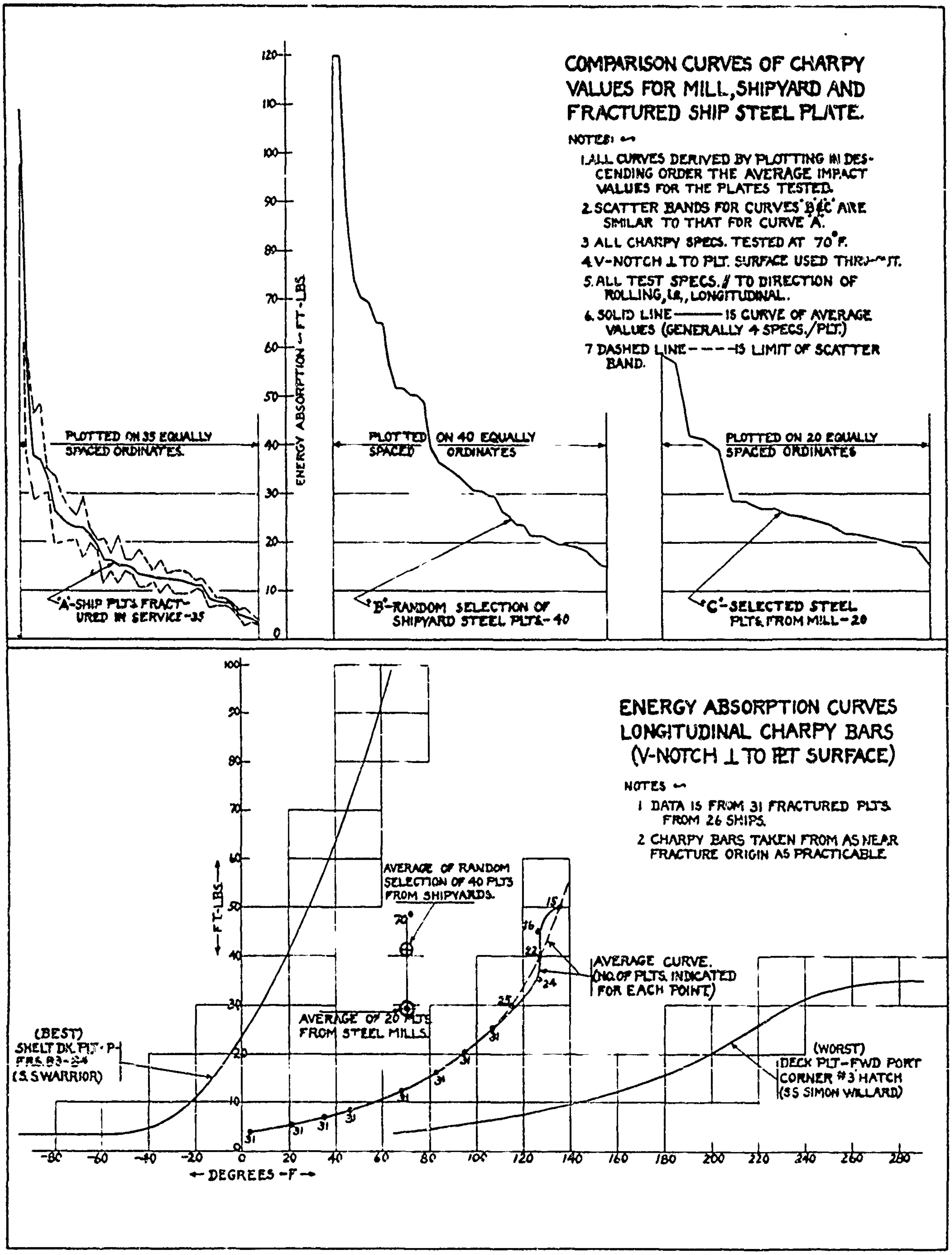

COMPARISON CURVES OF CHARPY VALUES FOR MILL, SHIPYARD AND FRACTURED SHIP STEEL PLATE.
NOTES: —
1. ALL CURVES DERIVED BY PLOTTING IN DESCENDING ORDER THE AVERAGE IMPACT VALUES FOR THE PLATES TESTED.
2. SCATTER BANDS FOR CURVES 'B' & 'C' ARE SIMILAR TO THAT FOR CURVE 'A'.
3 ALL CHARPY SPECS. TESTED AT 70°F.
4 V-NOTCH ⊥ TO PLT. SURFACE USED THRU-OUT.
5. ALL TEST SPECS. // TO DIRECTION OF ROLLING, I.E., LONGITUDINAL.
6. SOLID LINE ——— IS CURVE OF AVERAGE VALUES (GENERALLY 4 SPECS./PLT.)
7 DASHED LINE - - - - IS LIMIT OF SCATTER BAND.
ENERGY ABSORPTION — FT-LBS
PLOTTED ON 35 EQUALLY SPACED ORDINATES.
PLOTTED ON 40 EQUALLY SPACED ORDINATES
PLOTTED ON 20 EQUALLY SPACED ORDINATES
'A'-SHIP PLTS. FRACTURED IN SERVICE-35
'B'-RANDOM SELECTION OF SHIPYARD STEEL PLTS.-40
'C'-SELECTED STEEL PLTS. FROM MILL-20
ENERGY ABSORPTION CURVES LONGITUDINAL CHARPY BARS (V-NOTCH ⊥ TO PLT SURFACE)
NOTES —
1 DATA IS FROM 31 FRACTURED PLTS. FROM 26 SHIPS.
2 CHARPY BARS TAKEN FROM AS NEAR FRACTURE ORIGIN AS PRACTICABLE.
AVERAGE OF RANDOM SELECTION OF 40 PLTS FROM SHIPYARDS.
AVERAGE OF 20 PLTS FROM STEEL MILLS
AVERAGE CURVE. (NO. OF PLTS. INDICATED FOR EACH POINT)
(BEST) SHELT DK. PLT. P- FRS. 83-84 (S.S. WARRIOR)
(WORST) DECK PLT-FWD PORT CORNER #3 HATCH (SS SIMON WILLARD)
← FT-LBS →
← DEGREES - F →

Figure 57.

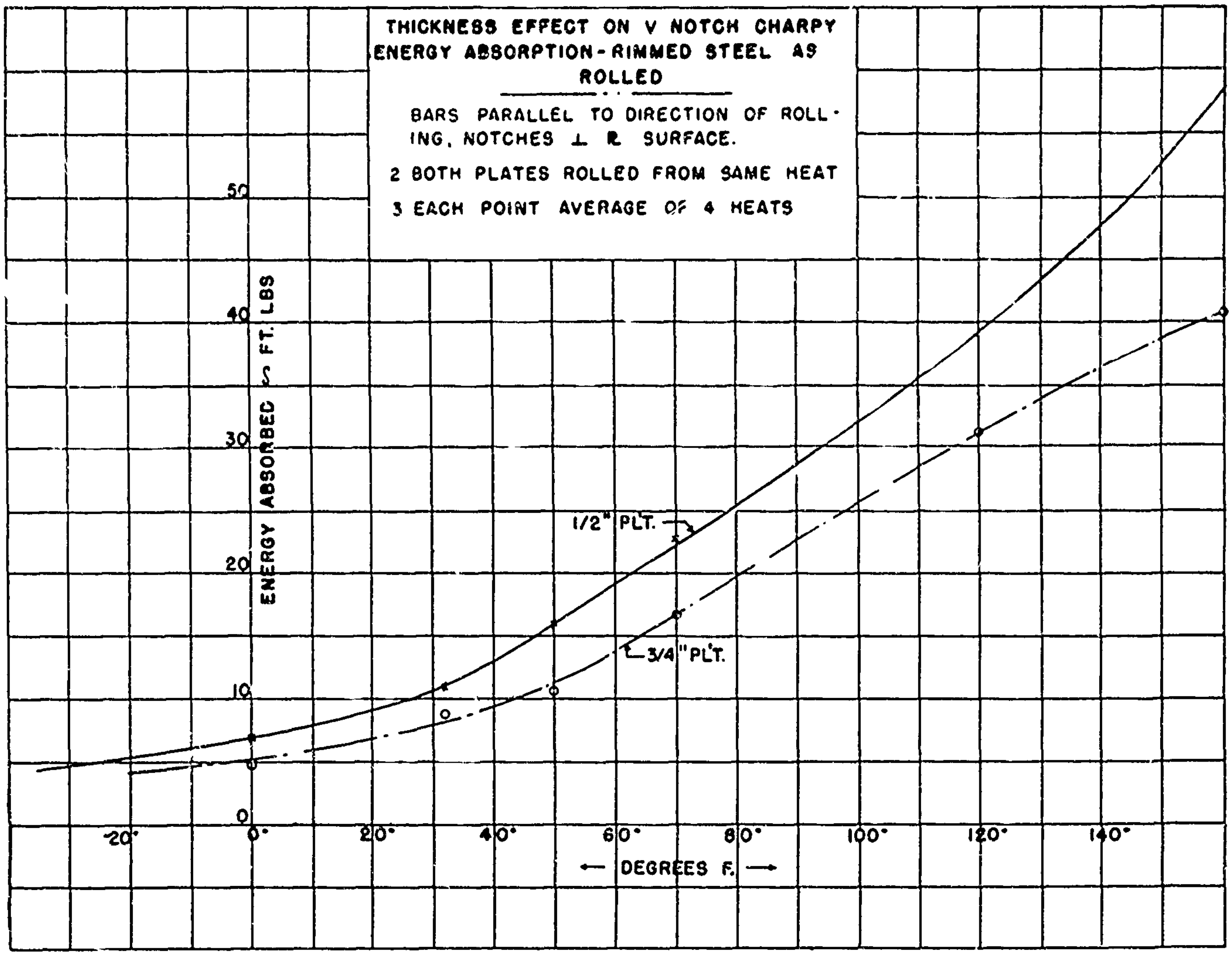


Figure 58.

the samples from the steel mills (Group C) and these in turn more so than samples from yards (Group B). These comparisons are based on averages, however, and in view of wide dispersions, stand in need of a quantitive estimate of their significance.

Even if a significant difference in notch sensitivity existed, it might be partially caused by a difference in thickness, since Groups B and C were ½ inch and Group A averaged ¾ inch thick. To test this, similar tests were made to compare two plates rolled to these two thicknesses from the same heat of steel. The results are shown in figure 58. They suggest that if Groups B and C had been ¾ inch thick, the values would have been about 5 foot pounds less, and the spread between Groups A, B and C reduced.

The fractured plates are thus not notably more notch sensitive than other plates which might have been used, though more precise work might establish a moderate difference.

C. *Chemical Analyses*

Chemical analyses were made on the fractured plates from the ships to determine if there was any specific trend which might be indicated on surveying the chemical constituents of the plates involved in the fractures. The detailed analysis of each plate so tested is included in Table XI.

These tests were conducted by the United States Naval Shipyard, Philadelphia, and the National Bureau of Standards.

D. *Temperature and Notch Sensitivity*

Figure 57 shows that the steel in fractured plates loses the ability to absorb energy in the notched condition as temperature goes down. Low temperature is said to increase the notch sensitivity of the steel. Experience also shows that fractures in service gain in frequency at lower temperatures. It would be

Table XI

Chemical Constituents—Ship Plates Fractured in Service

Vessel's name	Fracture temperature degrees F.	Charpy *Ft. Lbs.*	C	Mn.	P	S	Si	Cu	Ni	Cr	V	Mo	Al	Miscellaneous
Champlain (port plate)	11–29	3.5–4.5	0.23	0.32	0.013	0.035	0.04	0.03	0.02	0.03	0.003	0.002	0.017	Ti 0.002
Valeri Chkalov	29–36	10–12	.19	.39	.011	.035	.09	.04	.11	.03	.003	.025	.013	Ti .004
Esso Pittsburgh	42	8.5	.23	.42	.016	.025	.00	.17	.15	.06	.003	.030	.005	Ti .003
Harry L. Glucksman			.37	.39	.011	.035	.00	.05	.03	.03	.003	.007	.017	Ti .004
Harry L. Glucksman	40	7.2	.28	.40	.008	.030	.00	.05	.03	.03	.003	.006	.022	Ti .002
Ferdinando Gorges	39–47	8–9.5	.25	.42	.010	.030	.03	.02	.05	.03	.003	.019	.042	Ti .002
Roger Griswold			.20	.40	.010	.042	.02	.01	.02	.02	.003	.002	.022	Ti .003
Roger Griswold			.29	.32	.015	.035	.02	.03	.05	.03	.003	.006	.052	Ti .003
Meacham	53	10	.30	.46	.007	.035	.01	.03	.02	.02	.003	.008	.008	Ti .002
Jeeacham			.23	.40	.010	.035	.05	.01	.04	.02	.003	.004	.041	Ti .002
Man Ribaut	37	3.5	.30	.20	.010	.020	.00	.01	.02	.03	.003	.004	.053	Ti .002
Henry C. Wallace	50	4	.37	.38	.011	.042	.02	.04	.06	.03	.003	.030	.009	Ti .003
Warrior	32	7	.22	.39	.015	.030	.00	.05	.03	.04	.003	.023	.006	Ti .002
William Black Yates			.24	.51	.017	.035	.00	.01	.01	.02	.003	.002	.013	Ti .002
William Black Yates			.25	.37	.008	.030	.01	.05	.07	.03	.003	.030	.015	Ti .003
Stephen S. Austin			.22	.47	.016	.027	.03	.01	.01	.01	.001	.004		
Simon Willard	51	3.5	.30	.29	.014	.029	.02	.03	.02	.02	.001	.004		
Sea Bass	55	5.5	.26	.46	.041	.064	.01	.17	.06	.03	.001	.050		
U. S. C. G. C. Northland	32	4.5	.23	.50	.013	.041	.01		Trace					
U. S. C. G. C. Mohawk	32	5	.32	.40	.014	.045	< .03	.09	03	.03	< .01	< .010	.002	As. .023
Esso Wilmington (deck)	42	19	.20	.46	.005	.027	.06	.05	.05	.04	< .01	< .010		Al_2O_3 .003
Esso Wilmington (E strake bottom)	56	15.8	.27	.59	.025	.031	.01	.21	.07	.10	< .001	.006		
John P. Altgeld	45	11.4	.21	.46	.022	.019	.04	.01	.02	.01	.001	.004		
George Crocker			.25	.44	.031	.041	.04	.10	.04	.07	< .001	.010		
Enos A. Mills	[1]13	[1]10	.18	.34	.010	.025	.05	.11	.06	.05	< .001	.020		
Contreras	[1]45	[1]10	.23	.41	.007	.039	.02	.04	.04	.03	< .001	.006		
Schenectady (sheer strake)	23	6	.20	.39	.010	.032	.056	.02						Al_2O_3 .034
Schenectady (stringer plate)	23	10.5	.24	.47	.019	.029	.044	.07						Al_2O_3 .003
William Floyd	[1]68	[1]10	.23	.37	.014	.034	.03	.02	.04	.02	< .001	.004		
Warrior (deck K–9, starboard)			.25	.44	.013	.041	.02	.05	.05	.03			.007	Sn .011
Warrior			.26	.43	.019	.030	.02		Trace	.05		.019	.005	Sn .019
Warrior			.25	.38	.010	.032	.03							
Esso Manhattan			.24	.45	.007	.027	.02	.03	.10	.02	.05	.010		
Esso Manhattan			.21	.44	.012	.035	.04	.04	.10	.04	.05	.010		
Quebec	66	7.3	.21	.41	.006	.028	.05	.25	.02	.02	< .01	< .010		

Table XI

Chemical Constituents—Ship Plates Fractured in Service (Cont.)

Vessel's name	Fracture temperature degrees F.	Charpy *Ft. Lbs.*	C	Mn.	P	S	Si	Cu	Ni	Cr	V	Mo	Al	Miscellaneous
Quebec	......	......	0.22	0.42	0.034	0.038	0.04	0.03	0.03	0.06	< 0.001	0.002	......	......
Richard J. Cleveland	24	10.5	.20	.44	.019	.034	.03	.01	.02	.05	< .001	.006	......	......
Richard J. Cleveland	[1]24–34	7.5–10	.24	.48	.014	.035	.05	.02	.02	.03	< .001	.006	......	......
Christopher Greenup	30	8	.27	.42	.008	.031	.04	.03	.01	.03	< .001	.002	......	......
John W. Weeks	[1]30	[1]10	.26	.36	.007	.036	.02	.05	.03	.02	< .001	.006	......	......
Edward Rutledge	[1]60	[1]10	.27	.54	.053	.028	.01	.28	.12	.11	< .001	.012	......	......
Edward Rutledge	[1]54	[1]10	.29	.47	.014	.042	.01	.24	.10	.05	< .001	.008	......	......
Markay (D strake bottom)	[1]53	[1]10	.24	.43	.013	.035	.05	.02	.05	.03	< .001	.002	......	......
Markay (C strake bottom)	......	......	.24	.43	.011	.028	.05	.05	.02	.05	< .01	< .01	.015	......
Average of above plates	......	......	.27	.42	.015	.034	.027	.065	.047	.036	< .005	.011	.021	......
Range of chemical values														
Maximum values from above plates	......	......	.37	.59	.053	.064	.09	.28	.15	.11	.05	.050	.053	Ti .004
Minimum values from above plates	......	......	.18	.20	.005	.019	.00	.01	.01	.01	< .001	.002	.002	Ti .002

[1] The specific temperature of fracture was not known for these vessels. However, since Charpy values are available the temperature corresponding to 10 foot-pounds energy absorption has been set down. The value 10 foot-pounds was chosen as it represents a figure close to the average Charpy value obtained for the ship plates fracturing at known temperatures. Most of the ([1]) fractures were in spring and winter.

Note: (1) Charpy values in table are for longitudinal V notch specimens, with notch perpendicular to plate surface.

(2) The *SS Maria Sanford* not included in the above table sustained a fracture at 75°F and at this temperature the plate had a 5.5 foot-pounds Charpy value.

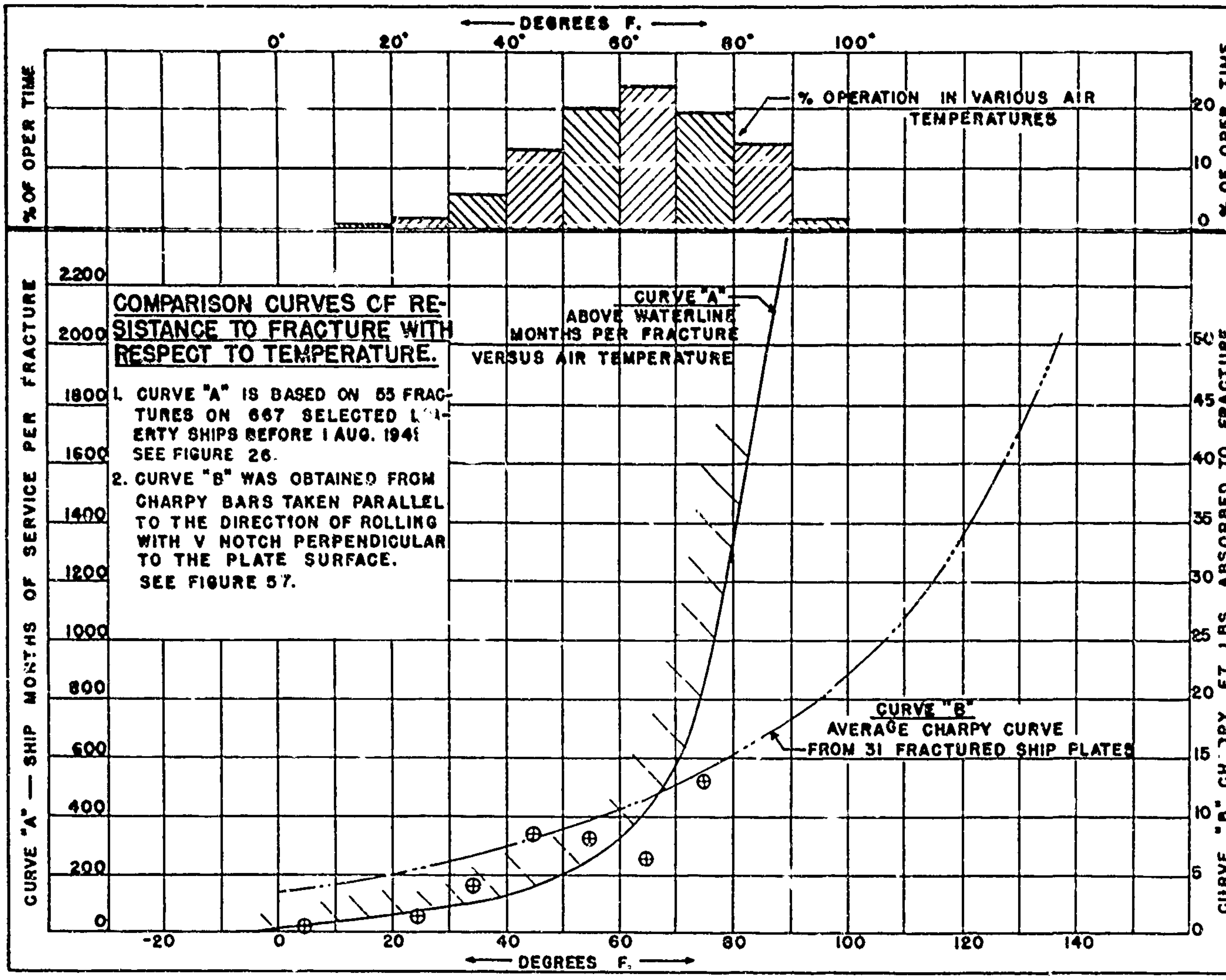


Figure 59.

natural to explain this as a result of increased notch sensitivity.

This similarity is shown in figure 59 where the average curve for Group A from figure 57 is superimposed on another curve drawn from the data on service fractures. This second curve was obtained by plotting ship months per fracture, the simple reciprocal of the quotient "fractures per ship month" in figure 26. When these two curves are brought together, it appears that the ships lose heavily their resistance to fracture and the notched bars become highly notch sensitive at a temperature which is the same for both, roughly from 40° to 80°F.

It has been found that many fractures emanate from minor discontinuities which cannot be economically eliminated from ships under construction and from pads and clips welded on for various purposes after the vessel is in service. Protection against trouble resulting from such minor transgressions can best be provided by improved steel characteristics.

Conclusions

1. The serious epidemic of fractures in the steel structure of welded merchant vessels has been curbed through the combined effect of the corrective measures taken on the structure of the ships both during construction and after completion, improvements in new designs and improved construction practices in the shipyards.

2. Fractures occur more frequently at lower temperatures.

3. By far the greatest frequency of fracture occurs under a combination of heavy seas and low temperatures.

4. Statistically the age of the vessel has no appreciable influence on the tendency to fracture.

5. The longitudinal distribution of cargo on the Liberty ships which fractured was not abnormal and little would be gained by establishing cargo loading prescriptions designed to reduce the number of casualties.

6. The longitudinal distribution of ballast on the Liberty ships including those which fractured was not abnormal but this was improved by changes in the ballasting prescriptions without interfering with operating conditions.

7. In the case of the tankers, poor distribution of cargo or ballast on the tankers can create high stresses more readily than in Liberty ships. General loading prescriptions for tankers appear feasible and desirable.

8. A tendency for certain ships to incur repeated casualties can be measured but the trend is not great.

9. No marked correlation between the incidence of fracture on the ships and the shipyard construction practices could be found. However, with due allowance for difference in design, the ships constructed in yards utilizing sub-average shipyard construction practices showed a higher than average incidence of fracture.

10. Steel removed from plates which had fractured complied with American Bureau of Shipping physical requirements for hull steel.

11. The hatch corner modifications on the Liberty ships have proved effective.

12. The riveted crack arrestor at the gunwale has been effective. Riveted shell seams have also been responsible for limiting the extent of fracture. No crack has been known to pass an arrestor.

13. More fractures started at notches occasioned by design than at notches resulting from defective workmanship. Although the relative contribution of poor workmanship was less, there were important cases where workmanship was the sole cause.

14. Every fracture investigated could be traced to a starting point at a definite geometrical discontinuity involving design or workmanship.

FIGURE 1

WEATHER DECK OF S.S. SEA BASS AS VIEWED FROM ABOVE SHOWING FRACTURE FROM THE AFTER PORT CORNER OF NO. 3 HATCH.

NOTE: LOCATIONS MAY BE MARKED EITHER BEFORE OR AFTER TAKING PHOTOGRAPHS.

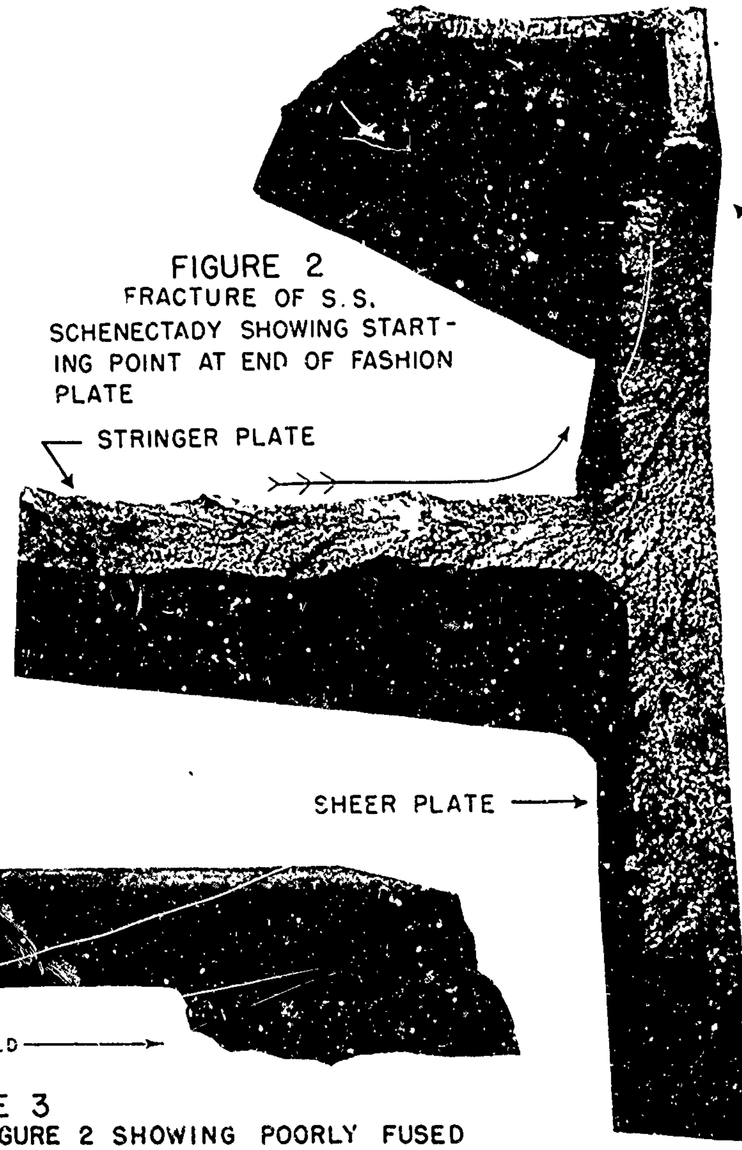


FIGURE 2

FRACTURE OF S.S. SCHENECTADY SHOWING STARTING POINT AT END OF FASHION PLATE

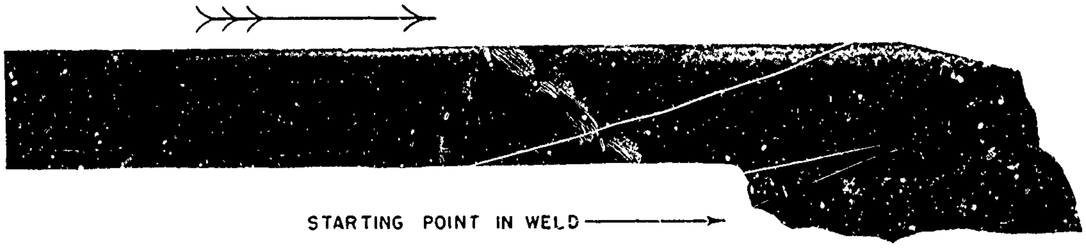


FIGURE 3

FRACTURED 51* DECK PLATE FROM FIGURE 2 SHOWING POORLY FUSED WELD IN UPPER FLANGE OF LONGITUDINAL HATCH SIDE GIRDER.

FIGURE 60.

Appendix

UNITED STATES COAST GUARD

Merchant Marine Inspection Instructions

Chapter 4, Part I

Material Inspection: Hulls—Construction

4-1-1 *Structural failures*

NAVCG 2752

A. Report structural failures on Form NAVCG-2752 unless the damage is so extensive that advantageous use can be made of the large forms for Liberty ships and Maritime Commission tankers. Supplement the report with photographs and large scale sketches emphasizing the point at which the fracture started. Mark the sketches and photos clearly with ship's name and with reference points such as frame numbers, strake of plate, deck or shell, port or starboard side, etc. See figure 1. Use arrows or lines to point out the fracture and particularly its starting point. No letter of transmittal will be required in submission of the above form. *The form shall be signed by the OCMI in the space provided, and shall be stamped on the back with the date of issue and the issuing office.* Any necessary remarks should be typed on the back of the form.

Details of Failures Required

(1) *Details regarding the starting point of the failure are the most important part of the report* because all contributing factors are assembled at that point. There is a herringbone pattern on the edge of a fractured plate. The apices of the angles of this herringbone point toward the starting point of the fracture. Figures 2 and 3 are typical fractures. They show how it is possible to trace a fracture back to its source, and how it should be marked. Where it is impracticable to obtain a square view as shown in figures 2 and 3, take photographs properly angled to show clearly the herringbone pattern on both sides of the starting point. Each such photograph shall include the starting point. Where accurate data regarding "Circumstances Surrounding Failure" required by NAVCG-2752 are not available, *do not leave the spaces blank. Give best available information* such as date damage was found or examined, ports of departure and arrival, a statement as to loading, i.e., either "Ballasted" or "Loaded" and weather, temperature, sea condition, and other pertinent data as it is recorded in the ship's log for the voyage. Where it is not obvious that certain of the information is approximate, label it as such.

Samples of Steel Repaired

(2) If steel is removed in repairing the fracture, two pieces about two feet square taken from opposite sides of the fracture and each including one side of the starting point, should be obtained. If sufficient scrap is not available for these sizes or close approximations thereto, obtain such smaller samples including the starting point, as are available. Mark the steel samples with reference points. Indicate these reference points and the sample location on sketches marked in similar fashion to those on figure 1, and then forward both samples and sketches to the Metallurgy Division, National Bureau of Standards, Washington, D. C.

HQ Advised of Failures of Major Importance

B. If a structural failure of major importance occurs on a vessel, HQ should be advised by dispatch immediately in order that a representative can examine the fracture before critical features have been destroyed in commencing repairs.

Table XII

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date	Months Afloat	Casualty date	Loading and drafts
1	ENDERS M. VOORHEES	Bulk freighter not MC	Great Lakes Engineering Works, River Rouge	Del. July 1942	4 approx.	10 Nov. 1942	Ballasted 12′-3″/21′-8½″
2	JEREMIAH WADSWORTH	EC2-S-C1	Houston Shipbuilding Corp.	7 Sept. 1942	2	11 Nov. 1942	Loaded
3	THOMAS MACDONOUGH	EC2-S-C1	Oregon Shipbuilding Corp.	28 Jan. 1942	9	14 Nov. 1942	Loaded 27′-8″/29′-0″
4	JAMES MCNEILL WHISTLER	EC2-S-C1	Oregon Shipbuilding Corp.	30 Sept. 1942	1	28 Nov. 1942	Ballasted 7′-1″/18′-0″
5	ALDEN GIFFORD	N3-S-A1	Leathem D. Smith	2 Aug. 1942	2	x Nov. 1942	Ballasted
6	GEORGE CHAMBERLIN	EC2-S-C1	Oregon Shipbuilding Corp.	14 Aug. 1942	3	1 Dec. 1942	Unknown
7	HARVEY W. SCOTT	EC2-S-C1	Oregon Shipbuilding Corp.	19 July 1942	4	5 Dec. 1942	Loaded
8	JOHN C. AINSWORTH	EC2-S-C1	Oregon Shipbuilding Corp.	24 July 1942	5	25 Dec. 1942	Ballasted 6′-6″/15′-8″
9	HENRY BALDWIN	EC2-S-C1	California Shipbuilding Corp.	18 Oct. 1942	2	27 Dec. 1942	Loaded
10	WILLIAM T. SHERMAN	EC2-S-C1	Oregon Shipbuilding Corp.	25 Nov. 1942	1	27 Dec. 1942	Loaded
11	DANIEL HEISTER	EC2-S-C1	Houston Shipbuilding Corp.	22 Aug. 1942	4	1-12 Jan. 1943	Unknown
12	NICHOLAS GILMAN	EC2-S-C1	Houston Shipbuilding Corp.	25 July 1942	5	3-4 Jan. 1943	Unknown
13	SCHENECTADY	T2-SE-A1	Kaiser Co., Inc., Swan Island	24 Oct. 1942	2	16 Jan. 1943	Ballasted 6′-4″/17′-0″
14	ABRAHAM BALDWIN	EC2-S-C1	Delta Shipbuilding Co., Inc.	16 May 1942	8	x Feb. 1943	Ballasted
15	CHAMPLAIN ex BELLE ISLE	L6-S-B1	American Shipbuilding Co., Cleveland	15 Nov. 1942	2	12 Feb. 1943	Incomplete
16	JOHN FITCH	EC2-S-C1	Permanente Metals No. 2	28 Aug. 1942	5	15 Feb. 1943	Loaded 22′-10″/26′-5″
17	HENRY WYNKOOP	EC2-S-C1	Delta Shipbuilding Co., Inc.	26 Nov. 1942	2	16 Feb. 1943	Loaded 24′-0″/27′-6″
18	JAMES BOWIE	EC2-S-C1	Houston Shipbuilding Corp.	27 Oct. 1942	3	19 Feb. 1943	Loaded 25′-10″/27′-9″
19	THOMAS SUMTER	EC2-S-C1	North Carolina Shipbuilding Co.	31 May 1942	9	2-4 Mar. 1943	Loaded 27′-0″/27′-3″
20	THOMAS HOOKER	EC2-S-C1	New England Shipbuilding Corp.	13 July 1942	7	5 Mar. 1943	Ballasted 14′-0″/22′-0″

[1] Speed indicated in revolutions per minute.

Table XII

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
Heavy	36 mph	80	25°/42°	Sheer and stringer plates, frame 134 starboard and frame 130 port.	Probably at gunwale.	Complete fracture of strength deck.	1
Normal Port Qrtr.			Spring	Sheer strake frames 90–91.	Cut in sheer strake for accommodation ladder.		2
Heavy			Autumn	Bulwark, sheer strake and deck to within 6" of No. 4 hatch at forward starboard corner.	Probably at butt weld of bulwark insert plate.		3
Heavy	9	1–2	32°/42°	Deck at aft port end No. 3 hatch; bulwark, sheer and strake below, frames 81–82; bilge strake frames 74–75.	Probably at deck butt weld 15" from hatch corner; unknown; unknown.		4
Normal			Autumn	Stringer and sheer strake for 2'–0" opposite aft end No. 3 hatch, port.	Unknown		5
Heavy	9–10		Autumn	Stringer and adjacent strake at after end of No. 3 hatch, starboard.	Unknown		6
Normal			Spring	Stringer, sheer and strake below, frames 90–91 starboard.	Cut in sheer strake for accommodation ladder.		7
Heavy cross.	5	3–4	40°/40°–46°.	Sheer and stringer plates frames 90–91.	Cut in sheer strake for accommodation ladder.		8
Heavy	10	2	70°/	Deck at forward port corner of No. 3 hatch and sheer strake.	Probably at hatch corner.		9
Heavy	8 ?		Winter	Sheer strake and stringer plates about frame 128.	Unknown.		10
Unknown			Winter	Sheer and stringer plates frames 90–91.	Cut in sheer strake for accommodation ladder.		11
Heavy			40°/	Stringer and adjacent strake, about frame 113, starboard.			12
Calm			23°–38°/	Deck, side shell and longitudinal bulkheads in way of No. 5 tank.	Defective weld connecting starboard fashion plate and sheer strake.	Broke in two in port-repaired.	13
Unknown			26°–50°/ 31°–50°	Sheer and stringer plates frames 90–91.	Cut in sheer strake for accommodation ladder.		14
Calm			11°–29°/	Sheer, stringer plates and hopper sides, port and starboard frame 100 (No. 9 hatch).	Defective butt welds of hatch facing channels.	Complete fracture of strength deck.	15
Normal	4		–10°/33°	Stringer and two inboard strakes, bulwark, sheer and strake below, frames 83–85 port.	Probably at butt weld of bulwark rail.		16
Calm			7°–17°/31°	Upper deck from centerline, port, frames 62–64, sheer and strake below.	Unknown.		17
Heavy port Qrtr.	9–10		44°/38°	Stringer, sheer and strake below, frames 91–92.	Cut in sheer strake for accommodation ladder.		18
Heavy	8		24°/34°	Sheer and stringer plates frames 90–91, 91–92, and 102–103.	At frames 90–92 cut in sheer strake for accommodation ladder.		19
Heavy	7	9	22°/38°	Deck and shell in way of No. 3 hatch.	Probably at hatch corner.	Complete fracture of strength deck —abandoned.	20

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date	Months Afloat	Casualty date	Loading and drafts
21	J. L. M. CURRY	EC2-S-C1	Alabama Drydock and Shipbuilding Co.	31 Jan. 1942	13	7 Mar. 1943	Ballasted 12′-0″/19′-0″
22	STEPHEN C. FOSTER	EC2-S-C1	Houston Shipbuilding Corp.	12 Jan. 1943	2	14 Mar. 1943	Loaded 23′-3″/28′-6″
23	JOAQUIN MILLER	EC2-S-C1	Permanente Metals No. 1	22 July 1942	7	15 Mar. 1943	Loaded 25′-11″/26′-1″
24	LEW WALLACE	EC2-S-C1	Permanente Metals No. 1	21 July 1942	8	26 Mar. 1943	Ballasted
25	ESSO MANHATTAN	T2-SE-A1	Sun Shipbuilding and Drydock Co.	31 July 1942	7	29 Mar. 1943	Ballasted 17′-6″/23′-0″
26	CHRISTOPHER GREENUP	EC2-S-C1	Oregon Shipbuilding Corp.	5 Mar. 1943	1	29 Mar.-6 Apr. 1943	Loaded
27	WILLIAM L. SMITH	EC2-S-C1	Houston Shipbuilding Corp.	6 Jan. 1943	2	5 Apr. 1943	Ballasted
28	THOMAS JOHNSON	EC2-S-C1	California Shipbuilding Corp.	24 Oct. 1942	5	14 Apr. 1943	Loaded 25′-6″/27′-6″
29	BROCKHOLST LIVINGSTON	EC2-S-C1	California Shipbuilding Corp.	21 Oct. 1942	6	2 May 1943	Ballasted 14′-0″/20′-0″
30	ANDREW MOORE	EC2-S-C1	Delta Shipbuilding Co., Inc.	7 Sept. 1942	7	5 May 1943	Ballasted
31	WILLIAM H. CRAWFORD	EC2-S-C1	Houston Shipbuilding Corp.	5 Feb. 1943	3	5 May 1943	Loaded 26′-3″/28′-10″
32	FREDERIC REMINGTON	EC2-S-C1	Permanente Metals No. 1	6 Dec. 1942	4	5 May 1943	Loaded 24′-11″/27′-0″
33	MARKAY	Tanker not MC	Sun Shipbuilding and Drydock Co.	Sept. 1942	9	18 June 1943	Loaded
34	JOHN GORRIE	EC2-S-C1	St. John's River Shipbuilding Co.	27 Mar. 1943	6	13 Oct. 1943	Ballasted
35	ABRAHAM BALDWIN	EC2-S-C1	Delta Shipbuilding Co., Inc.	16 May 1942	19	13 Oct. 1943	Ballasted 13′-6″/19′-6″
36	S. M. BABCOCK	EC2-S-C1	Oregon Shipbuilding Corp.	1 Nov. 1942	11	14 Oct. 1943	Ballasted, 16 mean
37	RICHARD J. REISS	L6-S-B1	Great Lakes Engineering Works, River Rouge	19 Sept. 1942	12	17 Oct. 1943	Loaded
38	ROBERT C. STANLEY	L6-S-B1	Great Lakes Engineering Works, River Rouge	19 June 1943	4	10 Nov. 1943	Light
39	JOHN P. GAINES	EC2-S-C1	Oregon Shipbuilding Corp.	11 July 1943	4	24 Nov. 1943	Ballasted 13′-0″/19′-0″
40	THEODORE SEDGWICK	EC2-S-C1	Houston Shipbuilding Corp.	19 Aug. 1942	15	28 Nov. 1943	Ballasted 13′-9″/21′-0″

[1] Speed indicated in revolutions per minute.

Table XII—*Continued*

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
Heavy	10	5	31°–40°/	Deck and shell at forward corners No. 3 and No. 4 hatch starboard, after corners No. 3 and No. 4 hatch port.	Probably at hatch corner.	Complete fracture of strength deck —abandoned.	21
Calm			32°/30°	Deck at forward port corner No. 3 hatch and sheer strake; aft starboard corners No. 3 hatch for two strakes.	Exactly at hatch corners.		22
Heavy	9		30°/34°	Deck at forward port corner No. 3 hatch, sheer and two strakes below.	Exactly at hatch corner.		23
Heavy	9		17°–20°/37°	Stringer, sheer and strake below, frames 91–92 port.	Probably at cut in sheer strake for accommodation ladder.		24
Normal	2	14	30°–42°/	Complete section of hull frames 55–56 (No. 6 tank).	Defective butt weld of centerline strake main deck.	Broke in two at sea —salvaged.	25
Normal			16°/	Sheer and stringer plates in way of half round moulding.	Butt weld of half round moulding.		26
Heavy			33°/48°	Deck and sheer strake at forward starboard corner of No. 3 hatch.	Exactly at hatch corner.		27
Heavy		6–11	Unknown	Stringer and sheer strake, frames 112–113 starboard.			28
Heavy	8	[1] 65	32°–41°/ 42°–44°	Deck except centerline strake, bulwark, sheer and strake below, frames 112–113.	Unknown.	Complete fracture of strength deck.	29
Heavy	8–10		Spring	Bilge keel and bilge strakes, frames 64–65.	Defective butt weld of bilge keel.		30
Heavy	8	[1] 66	Autumn Australian area	Deck and sheer strake at forward starboard corner and after port corner No. 3 hatch.	Probably at hatch corner.	Complete fracture of strength deck.	31
Heavy	9		Autumn	Sheer and stringer plates frames 90–91.	Cut in sheer strake for accommodation ladder.		32
Heavy		16	Unknown	Bilge strakes in way of No. 5 port tank.	Defective butt weld of shell plating.		33
Heavy	8		43°/	Deck, sheer and strake below forward port and after starboard corner No. 3 hatch; sheer and strake below, frames 134–135 starboard.	Forward starboard corner No. 3 hatch probably at butt weld of bulwark.	Complete fracture of strength deck.	34
Heavy head.	7		36°–42°/ 45°–47°	Sheer, stringer and adjacent strake about frame 90 port.	Probably at cut in sheer strake for accommodation ladder.		35
Heavy	10		38°/46°	Deck from ventilator to gunwale, sheer and strake below, frames 113–115 starboard.			36
Heavy			Autumn	Stringer and hopper side at frame 100, port.	Probably at corner of access opening.		37
Heavy			Autumn	Stringer and hopper side between No. 9 and No. 10 hatches, starboard.	Probably in welding of insert plate of access opening.		38
Normal head	5–6	9	40°–45°/	Complete cross section in way of forward end No. 3 hatch.	Near forward corners of hatch.	Broke in two at sea —abandoned.	39
Heavy head	6	4.7	55°/	Deck, sheer and strake below at forward starboard corner No. 3 hatch; deck from ventilator to gunwale and sheer strake frames 82–83 port.	Exactly at hatch corner; probably ventilation opening in deck.		40

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date		Months Afloat	Casualty date		Loading and drafts
41	GEORGE B. SELDEN	EC2-S-C1	Permanente Metals No. 2	4 Nov	1942	12	29 Nov	1943	Ballasted 11′-0″/20′-0″
42	LAMBERT CADWALADER	EC2-S-C1	Houston Shipbuilding Corp.	16 Nov	1942	12	x Dec	1943	Loaded
43	LAURA KEENE	EC2-S-C1	Kaiser Co., Inc. Vancouver	1 Feb	1943	10	11 Dec	1943	Ballasted 11′-0″-20′-0″
44	PHINEAS BANNING	EC2-S-C1	California Shipbuilding Corp.	9 Feb	1943	10	11 Dec	1943	Ballasted 11′-4″/21′-7″
45	CHIEF WASHAKIE	EC2-S-C1	Oregon Shipbuilding Corp.	24 Dec	1942	11	11 Dec	1943	Ballasted 11′-6″/19′-6″
46	VALERI CHKALOV	EC2-S-C1	Permanente Metals No. 2	4 Apr	1943	7	11 Dec	1943	Ballasted
47	HAT CREEK	T2-SE-A1	Alabama Drydock and Shipbuilding Co.	30 Apr	1943	7	11 Dec	1943	Loaded 29′-6″/32′-6″
48	HAT CREEK	T2-SE-A1	Alabama Drydock and Shipbuilding Co.	30 Apr	1943	7	13 Dec	1943	Light
49	JOAQUIN MILLER	EC2-S-C1	Permanente Metals No. 1	22 July	1942	16	15 Dec	1943	Loaded 25′-3″, 28′-6″
50	ASKOLD	EC2-S-C1	Oregon Shipbuilding Corp.	24 June	1943	5	15 Dec	1943	Unknown
51	JAMES GORDON BENNETT	EC2-S-C1	California Shipbuilding Corp.	13 Sept	1942	15	18 Dec	1943	Unknown
52	CHARLES CROCKER	EC2-S-C1	California Shipbuilding Corp.	11 May	1943	7	21 Dec	1943	Loaded 23′-10″/26′-6″
53	WALTER HINES PAGE	EC2-S-C1	North Carolina Shipbuilding Co.	27 Apr	1943	7	23 Dec	1943	Ballasted
54	ALEXANDER NEVSKY	EC2-S-C1	Oregon Shipbuilding Corp.	29 Mar	1943	8	24 Dec	1943	Ballasted
55	WILLIAM BLACK YATES	EC2-S-C1	Southeastern Shipbuilding Corp.	27 Sept	1943	3	28 Dec	1943	Ballasted
56	ABIEL FOSTER	EC2-S-C1	California Shipbuilding Corp.	22 Mar	1942	21	29 Dec	1943	Ballasted 11′-8″/21′-0″
57	GEORGE CHAMBERLIN	EC2-S-C1	Oregon Shipbuilding Corp.	14 Aug	1942	16	29 Dec	1943	Ballasted 11′-6″/21′-0″
58	JOHN VINING	EC2-S-C1	Delta Shipbuilding Co., Inc.	23 Nov	1942	13	2 Jan	1944	Loaded 24′-0″/25′-2″
59	SEA BASS	C3-S-A2	Western Pipe & Steel Co.	2 Aug	1942	17	5 Jan	1944	Loaded 24′-10″/29′-8″
60	EMILIAN PUGACHEV	EC2-S-C1	Oregon Shipbuilding Corp.	13 Apr	1943	8	5 Jan	1944	Ballasted
61	ROBERT NEWELL	EC2-S-C1	Oregon Shipbuilding Corp.	2 May	1943	8	6 Jan	1944	Loaded 21′-4″/25′-2″

[1] Speed indicated in revolutions per minute.

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
Heavy	9–10		45°/45°	Stringer, sheer and strake below, frames 102–103, port.			41
Unknown			42°/	Stringer and sheer strakes frames 91–92 port.	Cut in sheer strake for accommodation ladder.		42
Normal	5	9½	Autumn	Deck, bulwark, sheer and strake below at forward starboard corner No. 3 hatch.	Probably at hatch corner.		43
Heavy	8-10	2.5–4.0	60°/64°	Deck, bulwark and sheer strake at two starboard corners and aft port corner No. 3 hatch.	Exactly at hatch corners.	Complete fracture of strength deck.	44
Heavy Bow	10	[1] 45	29°/42°	Deck and sheer strake at forward starboard and aft port corners No. 3 hatch; stringer and 2 inboard strakes, sheer and strake below, frames 85–86 port.	Exactly at hatch corners; unknown.	Complete fracture of strength deck.	45
Heavy	11		29°–36°/	Complete cross section in way of forward end No. 3 hatch.	Exactly at hatch corners.	Broke in two at sea —salvaged.	46
Heavy	6	8	32°/45°	Bilge strakes in way of No. 3 port tank for 20′-0″.			47
Unknown			Autumn	Sheer stringer and strake inboard in way of No. 4 tank; B and D strakes in bottom shell of No. 6 tank and C strake butt weld.	Unknown; probably in butt weld of shell plates.		48
Calm			Autumn	Stringer, sheer and strake below, frames 90–91 port.	Cut in sheer strake for accommodation ladder.		49
Unknown			Autumn	Deck, stringer and strake below, from No. 2 hatch.	Probably at hatch corner.		50
Unknown			26°–42°/	Stringer, sheer and strake below, frames 43–44.			51
Normal	4	9½	76°/75°	Stringer and sheer strakes frames 110–112, port.			52
Heavy			33°/54°	Deck and sheer strake at forward starboard corner No. 3 hatch.	Probably at hatch corner.		52
Heavy	9	5–6	Winter	In vicinity of No. 2 hatch in deck and shell.			54
Heavy	7–8		34°/35°	Stringer, sheer and bulwark frames 101–102, port.	Probably at forward corner of freeing port.		55
Heavy	7–8	5	42°/50°	Deck and sheer strake at forward starboard corner; deck at forward port corner No. 3 hatch.	Exactly at hatch corners.	Complete fracture of strength deck.	56
Heavy	11–12		40°/	Deck, bulwark, sheer and strake below at forward starboard corner No. 4 hatch.	Probably at hatch corner.		57
Calm	1		13°/38°	Stringer, bulwark, sheer and strake below, frames 109–110 port.			58
Heavy	6		55°/52°	Deck and sheer strake port, deck starboard, at after corners No. 3 hatch.	Hatch corners.	Complete fracture of strength deck.	59
Unknown			Winter North Pacific	Deck, sheer strake and strake below at forward port corner and aft starboard corner No. 4 hatch.		Complete fracture of strength deck.	60
Heavy, 2 points on port quarter	7	10	Winter	Deck from gunwale to within 2 feet of No. 3 hatch frames 75–76, starboard.	Probably in butt weld of deck.		61

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TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date	Months Afloat	Casualty date	Loading and drafts
62	JOSEPH R. LAMAR	EC2-S-C1	J. A. Jones Construction, Brunswick	29 Apr 1943	8	9 Jan 1944	Ballasted 13'-0"/21'-0"
63	JOSEPH SMITH	EC2-S-C1	Permanente Metals No. 2	22 May 1943	7	9 Jan 1944	Ballasted 7'-0"/21'-0"
64	THEODORE PARKER	EC2-S-C1	California Shipbuilding Corp.	24 Feb 1943	10	9 Jan 1944	Ballasted 11'-0"/20'-0"
65	WILLIAM L. MARCY	EC2-S-C1	California Shipbuilding Corp.	28 Dec 1942	12	12 Jan 1944	Ballasted 12'-5"/20'-3"
66	ROGER GRISWOLD	EC2-S-C1	Delta Shipbuilding Co., Inc.	1 Mar 1943	10	12 Jan 1944	Ballasted 12'-0"/21'-6"
67	JOSEPH N. NICOLLET	EC2-S-C1	Delta Shipbuilding Co., Inc.	24 May 1943	7	14–16 and 27 Jan 1944	Loaded 25'-2"/28'-1"
68	ESSO WASHINGTON	T2-SE-A1	Sun Shipbuilding and Drydock Co.	10 Nov 1942	12	16 Jan 1944	Loaded
69	JEFFERSON DAVIS	EC2-S-C1	Alabama Shipbuild- and Drydock Co.	12 July 1942	18	16 Jan 1944	Loaded 24'-10"/25'-9"
70	LORENZO DE ZAVALA	EC2-S-C1	Houston Shipbuilding Corp.	29 May 1943	7	20 Jan 1944	Ballasted 13'-6"/20'-6"
71	GEORGE GALE	EC2-S-C1	Delta Shipbuilding Co., Inc.	15 July 1942	18	21 Jan 1944	Ballasted
72	SAMUEL DEXTER	EC2-S-C1	Delta Shipbuilding Co., Inc.	29 Mar 1943	9	21 Jan 1944	Ballasted 9'-6"/21'-0"
73	JANE LONG	EC2-S-C1	Houston Shipbuilding Corp.	14 May 1943	8	22 Jan 1944	Ballasted 13'-6"/21'-0"
74	JAMES GORDON BENNETT	EC2-S-C1	California Shipbuilding Corp.	13 Sept 1942	16	22 Jan 1944	Ballasted 11'-1"/18'-3"
75	JULIEN POYDRAS	EC2-S-C1	Delta Shipbuilding Co., Inc.	17 May 1943	8	24 Jan 1944	Loaded 23'-4"/26'-10"
76	GEORGE A. CUSTER	EC2-S-C1	California Shipbuilding Corp.	23 Sept 1942	16	25 Jan 1944	Ballasted 14'-1"/20'-1"
77	RICHARD J. CLEVELAND	Z-ET1-S-C3	California Shipbuilding Corp.	15 Sept 1943	4	28 Jan 1944	Loaded 25'-0"/28'-4"
78	DEKABRIST	EC2-S-C1	Oregon Shipbuilding Corp.	27 Feb 1943	11	29 Jan 1944	Loaded
79	ABRAHAM BALDWIN	EC2-S-C1	Delta Shipbuilding Co., Inc.	16 May 1942	20	29 Jan 1944	Ballasted
80	WILLIAM H. PRESCOTT	EC2-S-C1	California Shipbuilding Corp.	21 July 1942	18	1 Feb 1944	Ballasted 12'-10"/21'-6"
81	AMELIA EARHART	EC2-S-C1	Houston Shipbuilding Corp.	18 Dec 1942	13	2 Feb 1944	Ballasted 11'-10"/21'-2"
82	JOHN L. SULLIVAN	EC2-S-C1	Permanente Metals No. 2	26 May 1943	8	2 Feb 1944	Ballasted 13'-3"/19'-8"
83	SAMUEL ADAMS	EC2-S-C1	California Shipbuilding Corp.	31 Jan 1942	24	3 Feb 1944	Ballasted 8'-5"/15'-0"

[1] Speed indicated in revolutions per minute.

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
.... Heavy.....	8–10	7	50°/68°....	Deck from centerline to gunwale, forward No. 4 hatch.			 62
.... Heavy cross.	6–9	7	34°/50°....	Deck and shell near forward end No. 4 hatch; two corners No. 3 hatch.		Complete fracture of strength deck —abandoned.	 63
.... Heavy.....	6	6	44°/54°....	Deck at forward port corner and one strake at after starboard corner No. 3 hatch.	Exactly at hatch corner.		 64
Heavy..... head.	8–9	5	38°/51°....	Deck, sheer and strake below at after port corner; deck at forward starboard corner No. 3 hatch.	Exactly at hatch corners.	Complete fracture of strength deck.	... 65
.... Heavy..... head	8	9	38°/58°....	Deck, bulwark, sheer and strake below at forward starboard corner No. 3 hatch.	Exactly at hatch corner.		 66
.... Heavy.....	10	½ speed	32°/.......	Deck from ventilator to gunwale, sheer to second deck frames 112–113.			 67
.... Heavy.....	5–8	13	Winter.....	Three bilge strakes at forward end No. 6 tank, starboard.	Probably butt weld of shell.		 68
.... Heavy.....	8–9	....	41°/42°....	Stringer and two inboard strakes, frames 83–84, starboard.			 69
.... Heavy........	....	....	56°/47°....	Deck, sheer, and strake below at forward starboard corner No. 4 hatch.	Probably at hatch corner.		 70
.... Heavy.....	8	....	42°/50°....	Stringer, sheer and strake below, port side, near amidships.			 71
.. . Heavy..... 3 points on starboard bow	8	[1] 47	40°/48°....	Deck and sheer strake at forward corners No. 3 hatch and forward starboard corner No. 4 hatch.	Probably at hatch corner.	Complete fracture of strength deck —abandoned.	 72
.... Heavy...........		6	37°–49°/....	Deck, sheer and strake below from port side No. 4 hatch.			 73
.... Heavy.....	7	10	Winter.....	Deck to ventilator, bulwark and sheer strake, frames 83–84 starboard.			 74
.... Heavy.....	5–7	....	47°/54°....	Deck at forward port corner No. 3 hatch.	Exactly at hatch corner.		 75
... Heavy..... head	8–6	8	46°/47°....	Deck at forward port corners No. 3 hatch.	Probably at hatch corner.	Complete fracture of strength deck.	 76
.... Heavy..... 2 points on starboard bow	8	....	24°/34°....	Deck from ventilator to gunwale, sheer and strake below, frames 112 starboard.	Probably at vent opening in deck.		 77
.... Heavy........	....	....	Winter.....	Deck and shell to tween deck at forward port corner No. 3 hatch.	Probably at hatch corner.		 78
.... Heavy........	....	....	Winter.....	Deck inboard 16′, shell 14′ about 5′ aft of No. 3 hatch.			 79
. Heavy..... head	8–10	4–5	52°/50°....	Deck and shell in tween deck at forward port and after starboard corners No. 3 hatch.	Probably at hatch corner.	Complete fracture of strength deck.	 80
.... Heavy.....	9	5.2	50°/49°....	Deck at forward starboard corner No. 3 hatch; deck from vent. to gunwale frame 83 port.	Probably at hatch corner		 81
.... Heavy.....	9–11	3	50°/54°....	Deck and shell to tween deck at forward starboard corner No. 3 hatch.	Probably at hatch corner.		 82
.... Calm......	2	....	32°/34°....	Stringer, bulwark and sheer, frames 111–112, starboard.			 83

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date	Mos. afloat	Casualty date	Loading and drafts
84	SAM HOUSTON II	EC2–S–C1	Houston Shipbuilding Corp.	30 June 1943	7	4 Feb 1944	Loaded 26′–7″/25′–11″
85	VERNON L. KELLOGG	EC2–S–C1	California Shipbuilding Corp.	15 July 1943	6	5 Feb 1944	Loaded 24′–0″/29′–0″
86	CYRUS H. MCCORMACK	EC2–S–C1	Permanente Metals No. 2	2 Oct 1942	16	12 Feb 1944	Ballasted 8′–4″/18′–4″
87	CHAMP CLARK	EC2–S–C1	Houston Shipbuilding Corp.	30 Dec 1942	13	20 Feb 1944	Ballasted
88	CHARLES TREADWELL	N3–S–A1	Pacific-Bridge Co.	7 Nov. 1942	15	x Mar 1944	Ballasted
89	GEORGE P. GARRISON	EC2–S–C1	Houston Shipbuilding Corp.	12 July 1943	7	2 Mar 1944	Loaded 20′–0″/25′–3″
90	MCCLELLAN CREEK	T2–SE–A1	Alabama Drydock & Shipbuilding Co.	4 Apr 1943	10	2 Mar 1944	Ballasted 4′–7″/15′–11″
91	ELISHA GRAVES OTIS	EC2–S–C1	Permanente Metal No. 2	5 May 1943	9	3 Mar 1944	Ballasted
92	JANE A. DELANO	EC2–S–C1	Permanente Metals No. 2	9 Mar 1943	11	4 Mar 1944	Loaded 20′–5″/27′–5″
93	JOEL R. POINSETT	EC2–S–C1	Houston Shipbuilding Corp.	19 Feb 1943	12	4 Mar 1944	Ballasted 13′–0″/21′–5″
94	JAMES IREDELL	EC2–S–C1	North Carolina Shipbuilding Co.	29 Nov 1942	15	4 Mar 1944	Loaded
95	WILLIAM M. MEREDITH	EC2–S–C1	Oregon Shipbuilding Corp.	5 Feb 1943	13	5 Mar 1944	Loaded 19′–4″/24′–6″
96	CHARLES CROCKER	EC2–S–C1	California Shipbuilding Corp.	11 May 1943	10	15 Mar 1944	Loaded 28′–7″/28′–7″
97	WHITE OAK	T2–SE–A1	Kaiser Co., Inc. Swan Island	25 Sept 1943	5	13–20 Mar 1944	Unknown
98	SUCHAN	EC2–S–C1	California Shipbuilding Corp.	2 May 1943	12	16 May 1944	Unknown
99	JOHN P. ALTGELD	Z–ETI–S–C3	California Shipbuilding Corp.	18 Oct 1943	11	9 Oct 1944	Loaded 26′–0″/28′–0″
100	FERDINANDO GORGES	EC2–S–C1	New England Shipbuilding Corp.	12 Aug 1943	16	16 Dec 1944	Loaded 27′–1″/30′–5″
101	LEBANON	C1–M–AV1	Walter Butler Shipbuilders, Inc.	14 Oct 1944	2	9 Jan 1945	Light 1′–11″/14′–0″
102	JOHN SERGEANT	EC2–S–C1	Bethlehem-Fairfield Shipyard, Inc.	21 Aug 1942	29	25 Jan–11 Feb 1945	Loaded 19′–4″/25′–0″
103	WARRIOR	C2–S–E1	Gulf Shipbuilding Corp.	14 Mar 1943	22	27 Jan 1945	Loaded 26′–8″/27′–8″
104	WALTER FORWARD	EC2–S–C1	Oregon Shipbuilding Corp.	22 Jan 1943	24	29 Jan 1945	Loaded

[1] Speed indicated in revolutions per minute.

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
Heavy Port Beam	6	163	38°/42°	Deck and shell to tween deck at forward starboard end No. 3 hatch and at gangway.	Exactly at hatch corner; unknown.		84
Heavy	7–8	8.5	52°/63°	Deck inboard from gunwale for 8′–0″ and sheer strake for 3′–0″.			85
Heavy 3 Pts. on starboard bow	8	5.5	50°/54°	Stringer and sheer, strake frames 90–91 starboard.	Cut in sheer strake for accommodation ladder.		86
Heavy	6	9	20°/.	Deck and shell to tween deck at forward port corner No. 4 hatch.	Exactly at hatch corner.		87
Heavy			Winter	Stringer and sheer strake starboard.			88
Heavy	11–12	4.4	36°/45°	Stringer and two inboard strakes and sheer frames 134 port.			89
Normal	4		16°/35°	Deck from cargo hatch to gunwale, sheer and two strakes below, frames 53–54 starboard.			90
Heavy			Winter	Deck and shell to tween deck after port and deck for 10′–0″ at forward starboard corner No. 3 hatch.	Probably at hatch corner.		91
Heavy Forward port beam	6–8	6	20°/40°	Deck from center line to gunwale, sheer and strake below. Frames 83–84 starboard.			92
Heavy 3 pts. on starboard bow	8–12	5	20°/40°	Complete cross section between No. 3 hatch and deckhouse.		Broke in two-stern part salvaged.	93
Heavy quarter			Winter	Deck at after port corner No. 2 hatch for 12′; deck from center line and bulwark, frames 60–62 port.	Exactly at hatch corner; unknown.		94
Calm			34°/35°	Stringer, sheer and strake below, frames 137–138 port.	Butt weld of half round gunwale moulding.		95
Normal	4	7.5	50°/70°	Deck and sheer strake at forward starboard corner No. 3 hatch.	Exactly at hatch corner.		96
Unknown			Spring	Bilge and bottom shell for about 14′ frame 61 starboard.	Defective welding in adjacent shell butts.		97
Unknown			Spring	Sheer and stringer plates frame 111 starboard.			98
Heavy	9		45°/50°	Sheer, stringer and strake inboard, frames 113–114 starboard.	End of slotted freeing port in bulwark.		99
Normal beam	5	7	39°–47°/48°–52°	Deck, sheer, and strake below, frames 81-82 port.	Defective butt weld of stringer plates.		100
Calm			-16°/32°	Deck from coaming No. 3 hatch to rivet in gunwale, frames 81–82 starboard.	Probably in hatch coaming.	Crack stopped at riveted gunwale angle.	101
Heavy	6–7		22°–32°/42°	Frame 96–97 accommodation ladder upper deck continued down through sheer strake.		Crack on port side stopped at riveted seam and deck house.	102
Normal port qtr.	4	14	32°/47°	Deck and side shell in middle of No. 3 hatch P. & S.; deck and coaming port side No. 3 hatch. deck forward of house for 7′–0″ starboard.	Butt welds of bulwark rail; vicinity of stringer; deck doubler.	Complete fracture of strength deck.	103
Normal			51°–60°/66°–69°	Upper deck stringer plate frames 104–105.		Crack ran inboard for 20″ and down sheer strake, stopping at crack arrestor.	104

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date	Months afloat	Casualty date	Loading and drafts
105....	McCLELLAN CREEK	T2-SE-A1	Alabama Drydock and Shipbuilding Co.	4 Apr 1943	21	30 Jan 1945	Loaded 29'-10"/31'-0"
106....	ESSO PATERSON	T2-SE-A1	Sun Shipbuilding and Drydock Co.	11 Nov 1942	26	x Jan 1945	Loaded 28'-10"/30'-4"
107....	J. D. YEAGER	EC2-S-C1	Houston Shipbuilding Corp.	6 Oct 1944	4	19 Feb 1945	Ballasted 11'-3"/21'-0"
108....	ESSO LITTLE ROCK	Tanker Not. M. C.	Sun Shipbuilding and Drydock Co.	Del. Jan 41	50 approx.	8 Mar 1945	Loaded 29'-3"/30'-5"
109....	LELAND STANFORD	EC2-S-C1	California Shipbuilding Corp.	4 Aug 1942	18	x Mar 1945	Unknown
110....	ATLANTIC STATES	Tanker Not M.C.	Sun Shipbuilding and Drydock Co.	Del. Mar 43	24 approx.	17 Mar 1945	Loaded 29'-7"/30'-1"
111....	HILARY A. HERBERT	EC2-S-C1	North Carolina Shipbuilding Co.	27 June 1943	21	x Mar 1945	Unknown
112 ...	ESSO PITTSBURGH	Tanker Not M.C.	Sun Shipbuilding and Drydock Co.	Del. Feb 1943	27 approx.	11 May 1945	Loaded 30'-11"/31'-6"
113....	SAMUEL CHASE	EC2-S-C1	Bethlehem - Fairfield Shipyard, Inc.	22 Feb 1942	40	4 June 1945	Unknown
114....	CAPE ISABEL	C-1B	Consolidated Steel Corp. Ltd.	28 May 1943	25	27 June 1945	Loaded 26'-3"/27'-0"
115....	HENRY C. WALLACE	Z-ET1-S-C3	California Shipbuilding Corp.	15 Aug 1943	25	18 Sept 1945	Loaded 28'-9"/28'-10"
116....	WILLIAM W. MAYO	EC2-S-C1	Permanente Metals No. 2	10 June 1943	28	24 Oct 1945	Loaded 24'-7", 27'-11"
117....	JEAN RIBAUT	EC2-S-C1	J. A. Jones Construction, Panama	5 May 1944	18	8 Nov 1945	Loaded 26'-10"/27'-5"
118....	MEACHAM	T2-SE-A1	Kaiser Co., Inc., Swan Island	30 Dec 1943	23	12 Nov 1945	Loaded 29'-2"/32'-5"
119....	CAMP NAMANU	T2-SE-A1	Kaiser Co., Inc., Swan Island	25 Apr 1944	19	18 Nov 1945	Light 1'-0"/19'-10"
120....	JOSEPH HOOKER	EC2-S-C1	Permanente Metals No. 1	20 June 1942	41	12 Dec 1945	Ballast 12'-6"/20'-0"
121. ..	JOHN C. SPENCER	EC2-S-C1	Houston Shipbuilding Corp.	5 Mar 1943	21	21 Dec 1945	Ballasted

[1] Speed indicated in revolutions per minute.

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
.... Heavy.....	8	179	32°/38°....	Shell plate at bulkhead 53–47 port side vertical crack from G12 to B13.			105
.... Unknown................			37°/38°....	No. 4 tank starboard vertical from "F" strake to "B" strake.	28″ above seam connecting "E" and "F" strakes.		106
.. Heavy.....	9–10	....	40°........	Upper deck cracked from starboard gunwale to ventilator opening at frame 113	Possibly deck house corner at upper deck.	Crack stopped at vent. and riveted gunwale angle.	107
.... Normal....	5	14.5	30°/47°....	Shell plate at No. 3 starboard wing tank. Crack 21′ vertical from seam at top E5 to within 18″ bottom of C4.	Bilge keel weld.		108
.... Unknown................			49°–58°/ 62°–64°	Stringer plate between frames 113–114 starboard.			109
.... Normal....	3	14	40°/37°....	Shell plate, port side in way of No. 7 tank. Across bottom strakes A and B.			110
.... Unknown................			Unknown...	Shell butt in starboard "D" strake in No. 4 hold extending 6″ in "E" strake.			111
.. Heavy	5–6	8	43°/42°....	No. 4 and No. 5 cargo tanks, frames 28–32. Shell cracked from 2′ below upper deck to 4′ below upper deck around bottom.	Defective butt weld in port bilge strake. 2nd crack appears to start at fatigue crack in shell at end of longitudinal.	Bottom completely fractured.	112
.... Unknown...........................				Shell plate cracked at butt weld frame 96 between D-9 and D-10 starboard for 14″.			113
.... Normal.... N.W.	5	13	57°/53°....	Cut for accommodation ladder starboard crack went down and stopped at riveted seam.	Probably at corner of cut in sheer plate.		114
.... Heavy......	9	158	50°/52°....	Deck plate at frame 113 starboard proceed down shell plate 1″ into plate H-11, deck plate E-11 deck.	After starboard corner of deck house at frame 113 on upper deck.		115
.... Heavy..... Aft	7–10	9.6	58°/61°....	Sheer strake plate between frames 89–90 port side fractured down to seam, stringer plate fractured inboard 1′.	Top of sheer strake plate.		116
.... Heavy.....	7–8	9	37°/42°....	Upper deck frame 83 starboard stringer plate E8 to B7.	Probably at dbl. at point where deck house meets deck plate.	Stopped outboard at crack arrestor.	117
.... Heavy..... Swell	4–5	13.3	50°/53°....	Frame 56-57 port shell plate strake "A" to "H" rupturing 20 long'ls also frame 60.	Plates E-13 and E-14 occurred near end of long'ls weld. S.H.		118
.... Calm.......	1	0	55°/60°....	30″ forward frame 54, No. 7 wing. deck plate from sheer strake inboard for 16′.	At sheer strake.		119
.... Heavy...........		9	48°/62°....	Shell plate between frames 74 and 75 from "D" strake to 24″ inboard B-C seam	Faulty weld at butt in bilge keel. Serrated holes not tangent to shell.		120
.... Heavy.....	6–7	4.08	54°/63°....	Frame 112 starboard sheer strake, to forward corner No. 4 hatch. Also aft deck cracked for 3′ outboard from winch.			121

TABLE XII—*Continued*

CLASS I CASUALTIES

Chronological Order

	Name of vessel	Type	Yard	Launching date	Months afloat	Casualty date	Loading and drafts
122	WILLIAM A. HENRY	EC2-S-C1	Oregon Shipbuilding Corp.	14 Dec 1943	25	3–4 Jan 1946	Vessel Loading
123	QUAKER HILL	T2-SE-A1	Alabama Drydock and Shipbuilding Co.	7 Oct 1944	15	8 Jan 1946	Loaded (at dock) 25′-0″/27′-0″
124	CANYON CREEK	T2-SE-A1	Alabama Drydock and Shipbuilding Co.	28 Feb 1943	35	14 Jan 1946	Loaded 22′-4″/25′-6″
125	HENRY BALDWIN	EC2-S-C1	California Shipbuilding Corp.	18 Oct 1942	39	15 Jan 1946	Ballasted 13′-8″/19′-6″
126	ROBERT LOWERY	EC2-S-C1	Delta Shipbuilding Co., Inc.	10 May 1943	32	19 Jan 1946	Loaded 22′-7″/24′-6″
127	FREDERICK C. HICKS	EC2-S-C1	California Shipbuilding Corp.	4 Mar 1944	22	21 Jan 1946	Unknown
128	AMIENS	T2-SE-A1	Sun Shipbuilding and Drydock Co.	17 Mar 1945	10	22 Jan 1946	Loaded 28′-8″/30′-8″
129	DONBASS III (Lend leased to Russia.)	T2-SE-A1	Kaiser Co., Inc., Swan Island	8 Aug 1944	18	17 Feb 1946	Loaded
130	CHRISTOPHER GALE	EC2-S-C1	North Carolina Shipbuilding Co.	21 Mar 1943	35	26 Feb 1946	Ballast cargo
131	SACKETT'S HARBOR	T2-SE-A1	Kaiser Co., Inc., Swan Island	5 July 1943	33	1 Mar 1946	Ballast
132	MIKHAIL KUTUZOV (Lend leased to Russia.)	EC2-S-C1	Oregon Shipbuilding Corp.	21 Mar 1943	36	17 Mar 1946	Unknown

[1] Speed indicated in revolutions per minute.

Table XII—*Continued*

CLASS I CASUALTIES

Chronological Order

Sea condition and direction	Wind force Beaufort Scale	Ship's speed in knots	Temperature air/water Degrees Fahrenheit	Location of fracture	Origin of fracture	Remarks	
Calm		0	50°/42°	Frame 60–61 starboard shell plates cracked vertically 11′ from E6 to C11. Seam at frame 62 slugged.	Faulty weld in butt between D6–D7.		122
Calm			25°/45°	Shell plate at No. 7 starboard wing and center tanks from plate F12-B-13.	At butt weld in bilge keel.		123
Calm	3–4		8°/36°	Shell plate No. 5 starboard wing tank. 18″ inboard of seam D–E starboard to 1/2 of F–9.	Probably at bilge keel butt.		...124
Heavy	10	3	30°/42°	Frame 138–139 forward starboard corner No. 5 hatch to rivet hole of frame 135 at J–13.	Probably in "D" strake on deck in way of padeyes.		125
Calm			30°/43°	Upper deck cracked. Starboard side of No. 5 hatch to gunwale frame 141–2.			126
Heavy			Unknown	Frame 83–84 upper deck cracked from ventilator to gunwale, and into sheer strake and strake below.			127
Calm	3–4	13.3	36°/36°	Frame 59, No. 5 and No. 6 tank shell plate C–10, E–13, bulkhead at frame 59 cracked 8″.			128
Heavy			37°/41°–43°	No. 5 tank at frame 6[illegible] Vessel had additional stre[illegible] installed.	Crack indicates it probably originated below water line, presumably at bulkhead.	Vessel broke in two. 15 lives lost on bow section.	129
Heavy	6-7	3.8	48°/68°	Frame 90 crack in upper deck extended into deck house and 61″ down sheer stake to stop at rivet.	Sheer strake plate where bul. is recessed for accommodation ladder.		130
Heavy				Vessel cracked at No. 5 tank, aft of deck house.	Unknown	Vessel broke in two.	131
Unknown			Unknown	Unknown.			132

Alphabetical List of Serious Structural Failures

Name of Ship	Casualty date	Name of Ship	Casualty date	Name of Ship	Casualty date
Abiel Foster (1)	29 Dec 1943	Harvey W. Scott	5 Dec 1942	McClellan Creek (1)	2 Mar 1944
Abraham Baldwin (2)	X Feb 1943	Hat Creek (1)	11 Dec 1943	McClellan Creek (2)	28 Jan 1945
Abraham Baldwin (3)	13 Oct 1943	Hat Creek (2)	13 Dec 1943	Meacham	12 Nov 1945
Abraham Baldwin (4)	29 Jan 1944	Henry Baldwin (1)	27 Dec 1942	Mikhail Kutuzov	17 Mar 1946
Alden Gifford (1)	X Nov 1942	Henry Baldwin (3)	15 Jan 1946	Nicholas Gilman (1)	3 Jan 1943
Alexander Nevsky	24 Dec 1943	Henry C. Wallace	18 Sept 1945	Phineas Banning (2)	11 Dec 1943
Amelia Earhart	2 Feb 1944	Henry Wynkoop (1)	16 Feb 1943	Quaker Hill	8 Jan 1946
Amiens	22 Jan 1946	Hilary A. Herbert	X Mar 1945	Richard J. Cleveland (1)	28 Jan 1944
Andrew Moore	5 May 1943	J. D. Yeager	19 Jan 1945	Richard J. Riess	17 Oct 1943
Askold	15 Dec 1943	J. L. M. Curry	7 Mar 1943	Robert C. Stanley	10 Nov 1943
Atlantic States	17 Mar 1945	James Bowie (1)	19 Feb 1943	Robert Lowry (2)	19 Jan 1945
Brockholst Livingston (1)	2 May 1943	James Gordon Bennett (1)	18 Dec 1943	Robert Newell (3)	6 Jan 1944
Camp Namanu (2)	18 Nov 1945	James Gordon Bennett (2)	22 Jan 1944	Roger Griswold (1)	12 Jan 1944
Canyon Creek (2)	14 Jan 1946	James Iredell	4 Mar 1944	S. M. Babcock (1)	14 Oct 1943
Cape Isabel	27 Jan 1945	James McNeill Whistler	28 Nov 1942	Sackett's Harbor	1 Mar 1946
Champ Clark	20 Feb 1944	Jane A. Delano (3)	4 Mar 1944	Sam Houston II (1)	4 Feb 1944
Champlain	12 Feb 1943	Jane Long	22 Jan 1944	Samuel Adams	3 Feb 1944
Charles Crocker (1)	21 Dec 1943	Jean Ribaut	8 Nov 1945	Samuel Chase (3)	X June 1945
Charles Crocker (2)	15 Mar 1944	Jefferson Davis	16 Jan 1944	Samuel Dexter (2)	21 Jan 1944
Charles Treadwell (2)	X Mar 1944	Jeremiah Wadsworth	11 Nov 1942	Schenectady (1)	16 Jan 1943
Chief Washakie (2)	11 Dec 1943	Joaquin Miller (1)	15 Mar 1943	Sea Bass	5 Jan 1944
Christopher Gale	26 Feb 1946	Joaquin Miller (3)	15 Dec 1943	Stephen C. Foster (1)	14 Mar 1943
Christopher Greenup (1)	29 Mar 1943	Joel R. Poinsett	4 Mar 1944	Suchan	16 May 1944
Cyrus H. McCormack (2)	12 Feb 1944	John C. Ainsworth (1)	25 Dec 1942	Theodore Parker (1)	9 Jan 1944
Daniel Hiester	1 Jan 1943	John C. Spencer (3)	21 Dec 1945	Theodore Sedgwick	28 Nov 1943
Dekabrist	29 Jan 1944	John Fitch (2)	15 Feb 1943	Thomas Hooker	5 Mar 1943
Donbass III	17 Feb 1946	John Gorrie (1)	13 Oct 1943	Thomas Johnson (2)	14 Apr 1943
Elisha Graves Otis (3)	3 Mar 1944	John L. Sullivan (2)	2 Feb 1944	Thomas McDonough	14 Nov 1942
Emilian Pugachev (2)	5 Jan 1944	John P. Altgeld (2)	9 Oct 1944	Thomas Sumter (1)	2 Mar 1943
Enders M. Voorhees	10 Nov 1942	John P. Gaines	27 Nov 1943	Valeri Chkalov	11 Dec 1943
Esso Little Rock	8 Mar 1945	John Sergeant	25 Jan 1945	Vernon L. Kellogg	5 Feb 1944
Esso Manhattan (1)	29 Mar 1943	John Vining (2)	2 Jan 1944	Walter Forward	X Jan 1945
Esso Paterson (4)	X Jan 1945	Joseph Hooker	12 Dec 1945	Walter Hines Page (1)	23 Dec 1943
Esso Pittsburgh	11 May 1945	Joseph N. Nicollet	14 Jan 1944	Warrior (2)	27 Jan 1945
Esso Washington (2)	16 Jan 1944	Joseph R. Lamar (1)	9 Jan 1944	White Oak	22 Mar 1944
Ferdinando Gorges	16 Dec 1944	Joseph Smith	9 Jan 1944	William A. Henry (3)	3 Jan 1946
Frederic Remington (1)	5 May 1943	Julien Poydras	24 Jan 1944	William Black Yates (1)	28 Dec 1943
Frederick C. Hicks	21 Jan 1946	Lambert Cadwalader	X Dec 1943	William H. Crawford	5 May 1943
George A. Custer	25 Jan 1944	Laura Keene	11 Dec 1943	William H. Prescott	1 Feb 1944
George B. Selden	29 Nov 1943	Lebanon	9 Jan 1945	William L. Marcy (3)	12 Jan 1944
George Chamberlain (1)	1 Dec 1942	Leland Stanford (2)	X Mar 1945	William L. Smith (2)	5 Apr 1943
George Chamberlain (2)	29 Dec 1943	Lew Wallace	26 Mar 1942	William M. Meredith	5 Mar 1944
George Gale (2)	21 Jan 1944	Lorenzo De Zavala	20 Jan 1944	William T. Sherman	27 Dec 1942
George P. Garrison	2 Mar 1944	Markay	18 June 1943	William W. Mayo (1)	24 Oct 1945

Abbreviations used in Tables XIII and XIV

Abbreviated name used in index	*Full name and location*
Alabama	Alabama Dry Dock and Shipbuilding Co., Mobile, Ala.
American-Cleveland	American Shipbuilding Co., Cleveland, Ohio
American-Lorain	American Shipbuilding Co., Lorain, Ohio
Barnes-Duluth	Barnes-Duluth Shipbuilding Co., (Later Walter Butler), Duluth, Minn.
Bethlehem-Fairfield	Bethlehem-Fairfield Shipyard, Inc., Fairfield, Baltimore, Md.
Bethlehem-Fore River	Bethlehem Steel Co., Shipbuilding Division, Fore River Yard, Quincy, Mass.
Bethlehem-San Francisco	Bethlehem Steel Co., Shipbuilding Division, San Francisco, Calif.
Bethlehem-Sparrows	Bethlehem-Sparrows Point Shipyard, Inc., Sparrows Point, Md.
Calship	California Shipbuilding Corp., Wilmington, Calif.
Chicago	Chicago Shipbuilding Co., Chicago, Ill.
Consolidated-Long Beach	Consolidated Steel Corp., Ltd., Long Beach, Calif.
Consolidated-Wilmington	Consolidated Steel Corp., Ltd., Wilmington, Calif.
Delta	Delta Shipbuilding Co., Inc., New Orleans, La.
Detroit	Detroit Shipbuilding Co., Wyandotte, Mich.
Federal	Federal Shipbuilding & Dry Dock Co., Kearny, N. J.
Globe	Globe Shipbuilding Co., Superior, Wis.
Great Lakes-Ashtabula	Great Lakes Engineering Works, Ashtabula, Ohio
Great Lakes-River Rouge	Great Lakes Engineering Works, River Rouge, Mich.
Gulf	Gulf Shipbuilding Corp., Chickasaw, Ala.
Houston	Houston Shipbuilding Corp., (Later Todd-Houston), Houston, Tex.
Ingalls	Ingalls Shipbuilding Corp., Pascagoula, Miss.
Jones-Brunswick	J. A. Jones Construction Co., Inc., Brunswick Yard, Brunswick, Ga.
Jones-Panama	J. A. Jones Construction Co., Inc., Wainright Yard, Panama City, Fla.
Kaiser-Swan	Kaiser Co., Inc., Swan Island, Portland, Ore.
Kaiser-Vancouver	Kaiser Co., Inc., Vancouver, Wash.
Leathem D. Smith	Leathem D. Smith Shipbuilding Co., Sturgeon Bay, Wis.
Marinship	Marinship Corp., Sausalito, Calif.
Moore	Moore Dry Dock Co., Oakland, Calif.
New England	New England Shipbuilding Corp., South Portland, Me.
Newport News	Newport News Shipbuilding & Dry Dock Co., Newport News, Va.
North Carolina	North Carolina Shipbuilding Co., Sunset Park, Wilmington, N. C.
Odenbach	Odenbach Shipbuilding Corp., Rochester, N. Y.
Oregon	Oregon Shipbuilding Corp., St. John Station, Portland, Ore.
Pacific Bridge	Pacific Bridge Co., Alameda, Calif.
Pennsylvania	Pennsylvania Shipyards, Inc., Beaumont, Tex.
Permanente	Permanente Metals Corp., Richmond, Calif.
Pusey and Jones	Pusey and Jones Corp., Wilmington, Del.
Rheem	Rheem Manufacturing Co., (Later Walsh-Kaiser), Providence, R. I.
St. Johns	St. Johns River Shipbuilding Co., Jacksonville, Fla.
Seattle-Tacoma	Seattle-Tacoma Shipbuilding Corp., Tacoma, Wash.
South Portland	South Portland Shipbuilding Corp., (Later New England), South Portland, Me.
Southeastern	Southeastern Shipbuilding Corp., Savannah, Ga.
Sun	Sun Shipbuilding and Dry Dock Co., Chester, Pa.
Todd-Houston	Todd-Houston Shipbuilding Co., Houston, Tex.
U. S. Shipbuilding	U. S. Shipbuilding Corp., Yonkers, N. Y.
Walsh-Kaiser	Walsh-Kaiser Co., Inc., Providence, R. I.
Walter Butler	Walter Butler Shipbuilders, Inc., Riverside Yard, Duluth, Minn.
Welding Shipyard	Welding Shipyards Inc., Norfolk, Va.
Western Pipe	Western Pipe & Steel Co., San Francisco, Calif.

Sea conditions:

C Calm
N Normal
H High

TABLE XIII

Casualties Reported from 1 August 1945 to 1 April 1946

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
ABIEL FOSTER (3)	11-27-45	Calship, 15	?	?	?
AFRICAN DAWN	8-23-45	Federal, 237	H	56	61
AMIENS	1-22-46	Sun, 464	C	36	36
ANGUS MCDONALD (2)	8-45	Todd-Houston, 49	?	?	?
ANTIOCH VICTORY	12-22-45	Bethlehem-Fairfield, 2469	H	?	?
ARTHUR RIGGS (3)	12-10-45	Oregon, 634	N	54	49
BENJAMIN GOODHUE	11-20-45	Calship, 16	?	?	?
BOWDOIN VICTORY	12-11-45	Permanente, 588	?	?	?
BROWN VICTORY	2-21-46	Oregon, 1225	C	20	?
CAMP NAMANU (2)	11-18-45	Kaiser-Swan, 64	?	55	60
CANYON CREEK (2)	1-14-46	Alabama, 249	C	8	36
CAPE CONSTANTINE (1)	8-45	Pennsylvania, 271	H	?	?
CAPE CONSTANTINE (2)	12-2-45	Pennsylvania, 271	?	?	?
CAPE ELIZABETH	9-45	Consolidated-Wilmington, 248	?	?	?
CHARLES CROCKER (3)	1-45	Calship, 186	?	?	?
CHARLESTOWN (2)	8-45	Sun, 317	?	?	?
CHRISTOPHER GALE	2-26-46	North Carolina, 78	H	48	68
COLINA (2)	11-45	Sun, 251	?	?	?
COSTA RICA VICTORY	12-26-45	Permanente, 529	H	39	42
CROSBY S. NOYES	11-27-45	Bethlehem-Fairfield, 2168	?	?	?
DANIEL WILLARD (2)	11-45	Bethlehem-Fairfield, 2075	?	?	?
DONBASS III	2-17-46	Kaiser-Swan, 84	H	37	41-43
EDGAR E. CLARK (2)	8-45	Jones-Panama, 23	?	?	?
ELIAS REISBERG (3)	8-45	New England, 3110	?	?	?
ELIHU THOMSON	12-45	Permanente, 427	?	?	?
FORT GEORGE	12-21-45	Kaiser-Swan, 19	?	?	?
FRANCIS DRAKE (2)	11-45	Calship, 54	?	?	?
FRANCIS VIGO	8-45	Bethlehem-Fairfield, 2237	?	?	?
FRANKLIN K. LANE (2)	1-46	Calship, 196	?	?	?
FREDERICK C. HICKS	1-21-46	Calship, 302	H	?	?
GEORGE GIPP	12-16-45	Permanente, 1116	H	47	53
GEORGE ROSS	1-25-46	Permanente, 52	H	45	45
GEORGE W. BROWN	1-25-46	Walter Butler, 25	H	56	70
GRINNELL VICTORY	8-45	Permanente, 729	?	?	?
HALL J. KELLEY (3)	1-1-46	Oregon, 637	H	56	60
HANNIS TAYLOR (2)	12-24-45	North Carolina, 162	H	60	61
HARRY PERCY	2-20-46	Todd-Houston, 105	?	?	?
HENRY BALDWIN (3)	1-15-46	Calship, 82	H	30	42
HENRY C. WALLACE	9-18-45	Calship, T-2	H	50	52
HENRY FAILING (2)	1-8-46	Oregon, 662	N	41	39
HENRY W. LONGFELLOW (2)	1-18-46	Oregon, 188	C	32	34
HORACE H. HARVEY (1)	1-16-46	Delta, 85	C	37	46
HORACE H. HARVEY (2)	3-2-46	Delta, 85	N	69	72
JACOB THOMPSON (4)	1-3-46	Delta, 68	?	?	?
JAMES B. RICHARDSON (3)	12-16-45	North Carolina, 35	H	50	60
JEAN BAPTISTE LE MOYNE	11-45	Delta, 81	?	?	?
JEAN RIBAUT	11-8-45	Jones-Panama, 41	H	37	42
JOHN C. SPENCER (3)	12-21-45	Todd-Houston, 45	H	54	63
JOHN P. ALTGELD (5)	8-9-45	Calship, T-17	?	?	?
JOHN STAGG	11-13-45	Delta, 67	?	?	?
JOSEPH HOOKER	12-12-45	Permanente, 67	H	48	62
JOSEPH M. TERRELL	12-21-45	Jones-Brunswick, 131	H	50	58
JOSHUA SENEY	11-27-45	Delta, 15	C	49	53
LEHIGH VICTORY	8-18-45	Calship, V-59	C	84	63

TABLE XIII—Continued

Casualties Reported from 1 August 1945 to 1 April 1946

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
LEWISTON VICTORY (1)	12-17-45	Oregon, 1202	H	?	?
LEWISTON VICTORY (2)	1-23-46	Oregon, 1202	?	?	?
LIMON	10-28-45	Gulf, 20	?	?	?
LOST HILLS	12-20-45	Marinship, 58	?	?	?
LOUIS KOSSUTH (2)	2-1-46	Bethlehem-Fairfield, 2286	H	54-62	56-59
MAHANOY CITY VICTORY	1-24-46	Bethlehem-Fairfield, 2451	H	52	58
MANDON VICTORY	12-6-45	Oregon, 1025	H	60	63
MARIE M. MELONEY(2)	11-17-45	Bethlehem-Fairfield, 2226	H	59	57
MARINE LYNX	12-30-45	Kaiser-Vancouver, 510	H	52	58
MARY ASHLEY TOWNSEND	9-12-45	Delta, 65	?	?	?
MARY M. DODGE	9-22-45	Permanente, 2138	H	60	60
MEACHAM	11-12-45	Kaiser-Swan, 46	H	50	53
MEREDITH VICTORY	10-45	Calship, V-83	?	?	?
MERIDIAN VICTORY	1-21-24-46	Calship, V-24	H	46	45
MICHAEL J. STONE	11-45	Todd-Houston, 5	H	?	?
MIDLAND VICTORY	12-26-45	Oregon, 1252	?	?	?
MIKHAIL KUTUZOV	3-17-46	Oregon, 652	?	?	?
MOLINO DEL REY (3)	9-21-45	Sun, 283	?	?	?
MORTON PRINCE	11-6-45	Calship, T-14	?	?	?
NORWAY VICTORY	2-6-46	Oregon, 1005	H	?	?
PETERSBURG VICTORY	12-25-45	Calship, V-96	N	83	82
PLYMOUTH VICTORY	1-12-46	Oregon, 1015	H	52	64
QUAKER HILL	1-8-46	Alabama, 310	C	25	45
QUEMADO LAKE	8-45	Alabama, 257	?	?	?
R. C. STONER (2)	12-14-45	Sun, 239	?	?	?
ROBERT LOWRY (2)	1-19-46	Delta, 55	C	30	43
RUFUS W. PECKHAM	12-13-45	Bethlehem-Fairfield, 2090	H	36	60
RUSSELL R. JONES	12-16-45	Todd-Houston, 195	H	58	61
SACKETTS HARBOR	3-1-46	Kaiser-Swan, 20	H	?	?
ST. JOHNS VICTORY	1-18-46	Permanente, 596	N	29	46
SANTA MARIA (2)	11-1-45	Federal, 235	H	65	66
SEA PARTRIDGE (1)	10-28-45	Western Pipe, 127	H	44	51
SEA PARTRIDGE (2)	11-23-45	Western Pipe, 127	H	55	57
SEA SHARK	2-7-46	Western Pipe, 133	?	?	?
STEPHEN W. KEARNEY	2-3-46	Permanente, 1729	H	56	50
STONY POINT	8-45	Kaiser-Swan, 6	?	?	?
THOMAS J. LYONS	12-13-45	St. Johns, 42	C	22	40
TICONDEROGA (4)	10-18-45	Sun, 268	N	76	70
WACO VICTORY	1-24-46	Calship, V-30	H	?	?
WAYCROSS VICTORY	12-17-45	Bethlehem-Fairfield, 2493	N	42	56
WILLIAM A. HENRY (3)	1-3-4-46	Oregon, 817	C	50	42
WILLIAM BRADFORD (2)	12-7-45	South Portland, 208	H	70	74
WILLIAM FEW (2)	12-10-45	Bethlehem-Fairfield, 2059	H	?	?
WILLIAM W. MAYO (1)	10-24-45	Permanente, 1572	H	58	61
WILLIAM W. MAYO (2)	12-19-45	Permanente, 1572	H	31	51
WOOD ISLAND	8-45	Globe, 106	?	?	?

Table XIV

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
A. J. Cermak	12–21–43/2–24–44	Bethlehem-Fairfield, 2284	?	21–62	30–60
Abel Stearns	10–9-14–43	Calship, 99	H	36–47	53
Abiel Foster (1)	12–29–43	Calship, 15	H	42	50
Abiel Foster (2)	3–3–44	Calship, 15	?	25–37	36
Abigail Gibbons	11–20–44	Jones-Brunswick, 164	H	?	?
Abner Doubleday	1–31–44/2–2–44	Oregon, 598	H	?	?
Abraham Baldwin (1)	1–31–43	Delta, 4	H	?	?
Abraham Baldwin (2)	2–43	Delta, 4	?	26–50	31–50
Abraham Baldwin (3)	10–13–43	Delta, 4	H	36–42	45–47
Abraham Baldwin (4)	1–29–44	Delta, 4	H	?	?
Abraham Clark	1–44	Calship, 18	?	?	?
Adolph Sutro	2–44	Permanente, 1560	?	?	?
Aedanus Burke (1)	4–21–44/5–8–44	Delta, 46	H	76	61
Aedanus Burke (2)	5–27–44/6–15–44	Delta, 46	N	65	59
African Sun	2–5-8–44	Federal, 238	H	?	?
Agwimonte	5–1–43	Consolidated-Long Beach, 156	H	?	?
Agwiprince	7–44	Consolidated-Long Beach, 157	H	?	?
Albert Gallatin	8–43	Calship, 8	?	?	?
Albert J. Berres	3–14-17–45	Calship, T–3	H	?	?
Alcoa Pilgrim	12–43	Consolidated-Long Beach, 234	H	?	?
Alcoa Pointer	3–45	Consolidated-Long Beach, 236	N	?	?
Alden Gifford (1)	11–42	Leathem D. Smith, 269	N	?	?
Alden Gifford (2)	1–44	Leathem D. Smith, 269	H	?	?
Alden Gifford (3)	3–27–44	Leathem D. Smith, 269	?	?	?
Alexander Graham Bell (1)	1–27–44	Oregon, 583	?	40	55
Alexander Graham Bell (2)	2–10–44	Oregon, 583	?	?	?
Alexander Hamilton	2–18–44	Oregon, 180	N	38	46
Alexander J. Dallas	3–27–44	Oregon, 620	?	48–50	56
Alexander Lillington	2–43	North Carolina, 47	H	?	?
Alexander Nevsky	12–24–43	Oregon, 657	H	?	?
Alexander White (1)	1–12–44	Delta, 20	C	45	49
Alexander White (2)	4–12–45	Delta, 20	N	56–73	49
Alexander Wilson	4–22–44	Permanente, 2706	?	?	?
Alexandr Suvorov	3–44	Oregon, 651	?	?	?
Amelia Earhart	2–2–44	Todd-Houston, 23	H	50	49
American Builder	2–12–44	Western Pipe, 59	?	?	?
American Manufacturer (1)	9–16–43	Western Pipe, 57	?	?	?
American Manufacturer (2)	3–23–44	Western Pipe, 57	H	?	?
American Packer	3–10–42	Western Pipe, 61	?	?	?
American Sun	4–13–44	Sun, 196	?	?	?
Am-mer-mar (1)	11–44	Delta, 134	?	?	?
Am-mer-mar (2)	1–18–45	Delta, 134	N	21	43
Amos G. Throop (1)	2–29–44	Calship, 101	?	?	?
Amos G. Throop (2)	3–6–44	Calship, 101	?	20–38	35
Ancil F. Haines	5–45	Delta, 132	H	?	?
Andrew A. Humphreys (1)	2–45	Delta, 77	?	?	?
Andrew A. Humphreys (2)	5–45	Delta, 77	?	?	?
Andrew Briscoe	3–44	Todd-Houston, 108	H	?	?
Andrew Carnegie (1)	7–43	Oregon, 566	?	?	?
Andrew Carnegie (2)	2–21–44	Oregon, 566	?	52-76	36
Andrew Moore	5–5–43	Delta, 12	H	?	?
Andrew Pickens	4–45	Southeastern, 17	?	?	?
Andrew Turnbull (1)	3–44	St. Johns, 30	H	?	?
Andrew Turnbull (2)	2–45	St. Johns, 30	?	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
ANDREW TURNBULL (3)	4-6-45	St. Johns, 30	H	?	?
ANGUS MCDONALD (1)	4-21-45/8-13-45	Todd-Houston, 149	N	38-70	42-75
ANNA H. BRANCH	3-44	Todd-Houston, 118	H	?	?
ANNA HOWARD SHAW (1)	10-18-23-43	New England, 240	H	?	?
ANNA HOWARD SHAW (2)	1-44	New England, 240	H	?	?
ANSON P. K. SAFFORD	1-24-44	Calship, 216	H	44	53
ANTHONY WAYNE (1)	1-3-44	Permanente, 45	N	65	?
ANTHONY WAYNE (2)	2-45	Permanente, 45	H	?	?
ANTINOUS (1)	3-1-28-45	Gulf, 26	N	59	66
ANTINOUS (2)	5-7-45	Gulf, 26	?	?	?
APPOMATTOX	6-45	Sun, 289	?	?	?
ARCHBISHOP LAMY	2-18-43	Calship, 107	H	85	80
ARLIE CLARK	4-45	Southeastern, 87	?	?	?
ARTHUR L. PERRY (1)	3-44	New England, 233	?	?	?
ARTHUR L. PERRY (2)	1-4-45	New England, 233	?	?	?
ARTHUR P. DAVIS	10-15-43	Calship, 229	?	?	?
ARTHUR RIGGS (1)	4-44	Oregon, 634	H	?	?
ARTHUR RIGGS (2)	4-10-45	Oregon, 634	N	63	67
ARTHUR SEWALL (1)	3-7-44	New England, 3006	C	29	?
ARTHUR SEWALL (2)	4-44	New England, 3006	H	?	?
ASKOLD	12-15-43	Oregon. 714	?	?	?
ATCHISON VICTORY	6-17-44	Calship, V-11	?	?	?
ATLANTIC STATES	3-17-45	Sun, 230	N	40	37
ATLANTIC SUN	8-11-43	Sun, 212	?	?	?
B. F. SHAW	4-4-17-45	Oregon, 663	H	?	?
BALD EAGLE (1)	5-28-43	Moore, 217	?	?	?
BALD EAGLE (2)	9-27-43	Moore, 217	C	76	82
BALD EAGLE (3)	1-7-44	Moore, 217	H	?	?
BARTHOLOMEW GOSNOLD	2-14-44	New England, 237	?	?	?
BELVA LOCKWOOD (1)	1-29-44/2-16-44	Oregon, 646	H	?	?
BELVA LOCKWOOD (2)	4-44	Oregon, 646	H	?	?
BELVA LOCKWOOD (3)	9-6-44	Oregon, 646	?	?	?
BELVA LOCKWOOD (4)	1-45	Oregon, 646	?	?	?
BEMIS HEIGHTS	3-28-45	Alabama, 303	?	?	?
BENJAMIN BOURN	6-9-44	Todd-Houston, 7	?	?	64
BENJAMIN CHEW	2-28-43/3-13-43	Bethlehem-Fairfield, 2045	H	?	?
BENJAMIN D. WILSON	5-16-44	Calship, 179	?	?	?
BENJAMIN FRANKLIN (1)	3-18-43/4-3-43	Calship, 3	H	40	50
BENJAMIN FRANKLIN (2)	4-17-43/5-5-43	Calship, 3	H	42	40
BENJAMIN H. BRISTOW	9-44	Permanente, 515	?	?	70
BENJAMIN H. GRIERSON	1-6-44	Oregon, 650	H	56	52
BENJAMIN H. HILL	12-44	Jones-Brunswick, 130	H	?	?
BENJAMIN H. LATROBE (1)	2-43	Alabama, 283	H	?	?
BENJAMIN H. LATROBE (2)	1-9-12-44	Alabama, 283	H	56	?
BENJAMIN H. LATROBE (3)	3-6-44	Alabama, 283	H	50	50
BENJAMIN HOLT	3-44	Permanente, 1108	?	?	?
BENJAMIN LUNDY	10-43	Calship, 141	H	36-39	46
BENJAMIN R. MILAM	6-45	Todd-Houston, 65	?	?	?
BENJAMIN SCHLESINGER	5-45	Bethlehem-Fairfield, 2315	?	?	?
BENJAMIN WILLIAMS (1)	2-15-43	North Carolina, 21	N	70	?
BENJAMIN WILLIAMS (2)	1-1-45	North Carolina, 21	?	68-69	68
BEN ROBERTSON	2-14-44/4-1-44	Southeastern, 37	H	?	?
BENNINGTON (1)	10-43	Sun, 269	?	?	?
BENNINGTON (2)	1-10-11-44	Sun, 269	H	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
BENNINGTON (3)	2–23–44	Sun, 269	H	66	65
BENNINGTON (4)	4–8–44	Sun, 269	C	45	?
BENNINGTON (5)	7–20–44	Sun, 269	H	?	?
BERNARD CARTER	9–28–44	Bethlehem-Fairfield, 2042	?	?	?
BETTY ZANE (1)	2–26–43	North Carolina, 51	?	66–76	71
BETTY ZANE (2)	5–26–44	North Carolina, 51	?	66	72
BIENVILLE	2–9–45	Gulf, 9	?	?	?
BIGFOOT WALLACE	4–44	Todd-Houston, 22	H	?	?
BILLY MITCHELL	6–29–44	Calship, 200	?	?	?
BINGER HERMAN	3–44	Oregon, 717	H	60	58
BLUE JACKET	7–17-19–44	Moore, 214	N	73–80	75–78
BOUNDBROOK	6–44	Sun, 335	H	?	?
BRANDYWINE	9–1-15–44	Sun, 323	?	?	?
BROAD RIVER	12–2–44	Kaiser-Swan, 25	?	?	?
BROCKHOLST LIVINGSTON (1)	5–2–43	Calship, 83	H	32–41	42–44
BROCKHOLST LIVINGSTON (2)	3–11–44	Calship, 83	?	27–47	39
BROOKFIELD	2–44	Kaiser-Swan	?	?	?
BUENA VISTA (1)	2 23–44	Sun, 280	H	?	?
BUENA VISTA (2)	3–12–44	Sun, 280	N	32	39
BUFFALO WALLOW	10–44	Alabama, 247	?	?	?
BULKCRUDE	7–22–44	Welding Shipyard, 10	?	?	?
BULKFUEL (1)	2–10–45	Welding Shipyard, 15	H	?	?
BULKFUEL (2)	5–11–45	Welding Shipyard, 15	H	51	56
BULKLUBE	9–15–44	Welding Shipyard, 4	H	?	?
BULL RUN	11–1-7–44	Sun, 287	?	?	?
BUNKER HILL (1)	9–22–43	Sun, 242	?	?	?
BUNKER HILL (2)	4–4-16–44	Sun, 242	H	55–90	51–79
BUNKER HILL (3)	10–1-27–44	Sun, 242	?	?	?
CADILLAC	3–14–43	Great Lakes-River Rouge, 291	C	?	?
CAMP NAMANU (1)	1–1-11–45	Kaiser-Swan, 6	?	?	?
CANYON CREEK (1)	3–45	Alabama, 249	?	?	?
CAPE BLANCO (1)	1–20–43	Pennsylvania, 270	C	28	32
CAPE BLANCO (2)	5–20–44	Pennsylvania, 270	?	?	?
CAPE BORDA	3–45	Pusey and Jones, 1100	?	?	?
CAPE CATOCHE	3–13–45	Consolidated-Wilmington, 537	H	?	?
CAPE CHALMERS	2–21–45	Consolidated-Wilmington, 344	N	54	52
CAPE CORWIN (1)	1–1-2–45	Pusey and Jones, 1087	?	?	?
CAPE CORWIN (2)	11–17–43	Pusey and Jones, 1087	?	?	?
CAPE CORWIN (3)	3–2–44	Pusey and Jones, 1087	?	?	?
CAPE FAIRWEATHER	8–25–44	Seattle-Tacoma, 4	N	80	83
CAPE HENLOPEN (1)	10–43	Pusey and Jones, 1084	H	?	?
CAPE HENLOPEN (2)	7–18–44	Pusey and Jones, 1084	?	?	?
CAPE ISABEL	6–27–45	Consolidated-Wilmington, 342	N	57	53
CAPE LOOKOUT	4–10–45	Pennsylvania, 366	N	?	?
CAPE MEARES	5–13–44	Consolidated-Wilmington, 250	?	?	?
CAPE MEREDITH (1)	2–5–44	Consolidated-Wilmington, 279	?	?	?
CAPE MEREDITH (2)	5–21–44	Consolidated-Wilmington, 279	H	?	?
CAPE POSSESSION	8–16–44	CONSOLIDATED-Wilmington, 754	?	?	?
CAPE RACE	4–45	Pusey and Jones, 1098	?	?	?
CAPE ROMAIN	4–25-28–44	Consolidated-Wilmington, 240	H	?	?
CAPE ST. GEORGE	12–1-19–44	Pennsylvania, 257	?	?	?
CARIBBEAN	3–11-17–43	Sun, 273	?	?	?
CARL SCHURZ (1)	2–3–43	Oregon, 602	?	39–45	49
CARL SCHURZ (2)	9–4–43	Oregon, 602	?	55–59	52

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Carl Schurz (3)	10-1-19-43	Oregon, 602	?	?	?
Carl Schurz (4)	1-24-44	Oregon, 602	?	45	47
Carl Schurz (5)	5-30-44	Oregon, 602	C	70	58
Carl Schurz (6)	8-3-44	Oregon, 602	?	54	56
Carl Zachary Webb	2-10-45	Delta, 159	H	?	?
Carleton Ellis	6-45	Calship, T-12	?	?	?
Carlos Carrillo	1-17-44	Calship, 123	C	47	50
Casimir Pulaski (1)	8-43	Southeastern, 15	?	?	?
Casimir Pulaski (2)	3-17-44	Southeastern, 15	?	?	?
Casimir Pulaski (3)	4-44	Southeastern, 15	H	?	?
Cecil N. Bean	6-45	Delta, 106	?	?	?
Champ Clark	2-20-44	Todd-Houston, 24	H	20	?
Champion's Hill	1-7-18-45	Sun, 451	?	?	?
Champlain	2-12-43	American-Cleveland, 1009	C	11-29	?
Champoeg (1)	11-3-43	Kaiser-Swan, 33	C	38	45
Champoeg (2)	5-1-12-45	Kaiser-Swan, 33	?	?	?
Chancellorsville	2-45	Sun, 295	?	?	?
Charles A. McAllister	6-45	Bethlehem-Fairfield, 2135	?	?	?
Charles Brantley Aycock	2-29-44	Delta, 26	?	?	?
Charles Bulfinch (1)	1-44	Bethlehem-Fairfield, 2149	H	?	?
Charles Bulfinch (2)	12-16-44	Bethlehem-Fairfield, 2149	?	?	?
Charles Crocker (1)	12-21-43	Calship, 186	N	76	75
Charles Crocker (2)	3-15-44	Calship, 186	N	50	70
Charles D. Poston	3-44	Calship, 194	H	?	?
Charles Dauray	7-17-45	New England, 3013	C	32	63
Charles H. Herty	1-31-44	Southeastern, 31	H	55	45
Charles L. McNary	5-45	Todd-Houston, 179	H	?	?
Charles M. Schwab (1)	5-10-44	Bethlehem-Fairfield, 2114	?	?	?
Charles M. Schwab (2)	11-44	Bethlehem-Fairfield, 2114	H	?	?
Charles M. Schwab (3)	3-20-45	Bethlehem-Fairfield, 2114	?	?	?
Charles M. Schwab (4)	7-2-45	Bethlehem-Fairfield, 2114	N	68	59
Charles Robinson	4-10-44	Permanente, 1583	?	?	?
Charles Scribner (1)	1-44	Bethlehem-Fairfield, 2266	H	?	?
Charles Scribner (2)	5-19-45	Bethlehem-Fairfield, 2266	H	?	?
Charles Treadwell (1)	6-10-11-43	Pacific Bridge, 8	N	?	?
Charles Treadwell (2)	3-44	Pacific Bridge, 8	H	?	?
Charles Willson Peale	[illegible]-4-45	Oregon, 605	N	31-45	56
Charlestown (1)	1-45	Sun, 317	?	?	?
Charlotte P. Gilman (1)	5-1-44	Calship, T-13	?	?	?
Charlotte P. Gilman (2)	5-29-44	Calship, T-13	?	?	?
Cherry Valley	8-1-24-44	Sun, 249	?	?	?
Chickamauga	9-44	Sun, 260	?	?	?
Chief Washakie (1)	6-10-43/7-15-43	Oregon, 613	?	?	?
Chief Washakie (2)	12-11-43	Oregon, 613	H	29	42
Chief Washakie (3)	7-24-44	Oregon, 613	?	55-57	54
Chief Washakie (4)	5-45	Oregon, 613	?	?	?
China Mail (1)	6-26-43	Sun, 201	?	?	?
China Mail (2)	2-5-44	Sun, 201	?	?	?
China Mail (3)	2-44	Sun, 201	H	?	?
China Mail (4)	9-1-18-44	Sun, 201	H	?	?
Christopher Gadsden (1)	2-43	North Carolina, 50	H	47-60	66-72
Christopher Gadsden (2)	11-9-18-44	North Carolina, 50	H	56	56
Christopher Greenup (1)	3-29-43/4-6-43	Oregon, 644	N	16	?
Christopher Greenup (2)	1-24-44	Oregon, 644	?	?	?

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Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit Air	Water
Christopher Greenup (3)	4–26–45	Oregon, 644	?	?	?
Christopher L. Sholes (1)	4–44	Calship, T–8	?	?	?
Christopher L. Sholes (2)	11–44	Calship, T–8	?	?	?
Churubusco (1)	6–5–44	Sun, 254	?	?	?
Churubusco (2)	6–45	Sun, 254	?	?	?
Cimarron	12–17–42	Sun, 172	?	?	?
Clara Barton (1)	12–11–28–43	Calship, 61	H	28–34	36–40
Clara Barton (2)	1–45	Calship, 61	H	?	?
Clara Barton (3)	3–30–44	Calship, 61	?	?	33
Clarence B. Randall	4–2–43	Great Lakes-Ashtabula, 523	C	?	?
Cleveland Abbe	3–43	Oregon, 565	?	?	?
Colin P. Kelly, Jr.	1–14–45	Alabama, 285	N	54	58
Colina (1)	12–5–44	Sun, 251	H	?	?
Collis P. Huntingdon	1–5–43	North Carolina, 38	C	28	?
Colombia Victory	9–18–44	Calship, V–10	N	53–75	53–65
Conastoga (1)	3–2–43	Sun, 277	C	?	?
Conastoga (2)	9–43	Sun, 277	?	?	?
Conastoga (3)	2–28–44	Sun, 277	H	44	47
Conastoga (4)	3–18–44	Sun, 277	C	52	37
Conastoga (5)	4–13–44	Sun, 277	H	56	57
Conastoga (6)	9–1–22–44	Sun, 277	?	?	?
Conastoga (7)	4–5–45	Sun, 277	?	?	?
Conastoga (8)	6–45	Sun, 277	?	?	?
Contreras	4–3–44	Sun, 282	?	?	?
Coquille (1)	10–1–18–44	Kaiser-Swan, 44	?	?	?
Coquille (2)	3–45	Kaiser-Swan, 44	?	?	?
Corinth	12–1–18–44	Sun, 305	?	?	?
Corvallis (1)	2–1–9–45	Kaiser-Swan, 35	?	?	?
Corvallis (2)	2–26–45/3–13–45	Kaiser-Swan, 35	H	49–98	54–80
Crater Lake	7–9–44	Kaiser-Swan, 51	?	?	?
Crown Point (1)	8–15–44	Sun, 321	?	?	?
Crown Point (2)	1–1–29–45	Sun, 321	?	?	?
Cushman K. Davis	1–10–44	Oregon, 681	?	?	?
Cyrus H. McCormick (1)	7–19–43	Permanente, 76	?	72–84	85
Cyrus H. McCormick (2)	2–12–44	Permanente, 76	H	50	54
Cyrus W. Field	8–8–45	Permanente, 1105	?	?	?
Dan Beard (1)	12–11–12–43	Permanente, 464	H	56	64
Dan Beard (2)	3–44	Permanente, 464	?	?	?
Daniel Carroll	11–3–43	Todd-Houston, 6	H	?	?
Daniel Drake (1)	7–43	Calship, 140	?	?	?
Daniel Drake (2)	1–44	Calship, 140	H	33–50	40
Daniel Hiester	1–1–12–43	Todd-Houston, 12	?	?	?
Daniel H. Lownsdale	9–22–43	Oregon, 557	?	?	?
Daniel S. Lamont (1)	11–25–43	Oregon, 619	H	31–44	48
Daniel S. Lamont (2)	4–44	Oregon, 619	?	?	?
Daniel S. Lamont (3)	9–5–44	Oregon, 619	?	?	52
Daniel Willard (1)	7–31–44	Bethlehem-Fairfield, 2075	?	84	89
David C. Shanks	12–20–22–44	Ingalls, 298	?	?	?
David Gaillard	12–26–43	Permanente, 441	H	55	53
David J. Brewer	3–30–44	Permanente, 506	?	42–47	46
David R. Francis	2–3–44	Calship, 238	?	?	?
David R. LeCraw	1–10–44	Walter Butler, 20	C	17–20	32
David Starr Jordan	1–13–44	Permanente, 472	?	?	?
David Wilmot (1)	10–15–43	Todd-Houston, 82	?	?	?

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
David Wilmot (2)	12–43	Todd-Houston, 82	?	?	?
Dekabrist	1–29–44	Oregon, 641	H	?	?
Delaware	8–44	Sun, 325	?	?	?
Delazon Smith	1–9–44	Oregon, 721	?	?	?
Dolly Madison	12–43	Jones-Panama, 12	?	?	?
Donald Macleay	7–15–43	Oregon, 718	C	?	?
Duncan U. Fletcher	4–17–44	Jones-Panama, 11	?	?	?
Durham Victory	7–17–44	Calship, V–19	C	?	?
Dwight L. Moody	6–5–44	Jones-Panama, 8	?	?	?
E. H. Blum	6–5–44	Sun, 211	?	?	?
Edgar E. Clark (1)	1–24–45	Jones-Panama, 23	H	47–54	62
Edmund Fanning	10–24–43/1–26–44	Calship, 135	H	35–40	50
Edmund G. Ross	11–44	Oregon, 787	?	?	?
Edward D. Baker	7–18–44	Oregon, 735	?	?	?
Edward H. Crockett	5–2–44	New England, 2211	?	?	?
Edward Kavanagh	12–30–43	New England, 2207	N	10	?
Edward N. Hurley	5–17-27–43	Bethlehem-Fairfield, 2113	?	?	?
Edward N. Westcott	9–19–43	Oregon, 750	?	?	?
Edward Rutledge (1)	6–23–43	North Carolina, 29	?	70–89	75
Edward Rutledge (2)	4–11–44	North Carolina, 29	?	?	?
Edward Sparrow	10–18-20–43	Delta, 62	H	?	?
Edward W. Scripps	1–2–44	Calship, 178	H	52	?
Edwin Booth	9–5–44	Oregon, 606	N	90	69
Edwin M. Stanton	5–31–44	Oregon, 564	?	68–81	77
Edwin Markham	5–43	Calship, 25	?	45–50	50
Edwin W. Moore	2–15–44	Todd-Houston, 80	H	?	?
Egg Harbor	4–5–43	Kaiser-Swan, 5	C	53	50
Elbert H. Gary	11–17–43	Chicago, 66	?	?	?
Elbridge Gerry	3–8–44	Calship, 12	C	?	56
Elias Howe (1)	2–10–43	Kaiser-Vancouver, 2	C	37–44	45
Elias Howe (2)	3–8–43	Kaiser-Vancouver, 2	H	75	?
Elias Reisberg (1)	5–45	New England, 3110	H	?	?
Elias Reisberg (2)	7–45	New England, 3110	?	?	?
Elihu Root	2–44	Jones-Panama, 6	H	?	?
Eliphalet Nott	5–8–44	South Portland, 261	?	?	?
Elisha Graves Otis (1)	12–11–43	Permanente, 1110	H	?	?
Elisha Graves Otis (2)	1–25–44	Permanente, 1110	H	?	?
Elisha Graves Otis (3)	3–3–44	Permanente, 1110	H	?	?
Eliza Jane Nicholson	12–22–44	Delta, 83	H	45	53
Elk Hills	1–1-26–45	Marinship, 57	?	?	?
Elmer A. Sperry (1)	12–17–43/1–1–44	Oregon, 588	H	?	?
Elmer A. Sperry (2)	3–29–44	Oregon, 588	?	34–74	39
Elmira Victory	7–6–44	Oregon, 1021	C	82	75
Eloy Alfaro (1)	3–44	Bethlehem-Fairfield, 2311	H	?	?
Eloy Alfaro (2)	1–45	Bethlehem-Fairfield, 2311	H	?	?
Emilian Pugachev (1)	10–19–43	Oregon, 665	?	?	?
Emilian Pugachev (2)	1–5–44	Oregon, 665	?	?	?
Emma Willard	4–15–43	New England, 267	C	34	39
Enders M. Voorhees	11–10–42	Great Lakes-River Rouge, 288	H	25	42
Enos A. Mills (1)	2–5–44	Oregon, 812	C	?	?
Enos A. Mills (2)	7–18–45	Oregon, 812	?	?	?
Ephraim W. Baughman	3–44	Oregon, 706	N	?	?
Erivan (1)	11–43	Oregon, 720	?	?	?
Erivan (2)	2–21–44	Oregon, 720	?	?	?

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Esso Bayway	11–43	Federal, 144	?	?	?
Esso Buffalo	3–44	Sun, 214	H	?	?
Esso Hartford (1)	1-1-4–45	Bethlehem-Sparrows, 4367	?	?	?
Esso Hartford (2)	2-1-22–45	Bethlehem-Sparrows, 4367	?	?	?
Esso Little Rock	3-8–45	Sun, 197	N	30	47
Esso Manhattan (1)	3–29–43	Sun, 267	N	30-42	?
Esso Manhattan (2)	9–44	Sun, 267	H	?	?
Esso New Orleans	2–45	Sun, 235	?	?	?
Esso Norfolk	4-1-24–45	Sun, 274	?	?	?
Esso Paterson (1)	12–43	Sun, 272	?	?	?
Esso Paterson (2)	2–15–44	Sun, 272	H	?	?
Esso Paterson (3)	3–12–44	Sun, 272	?	?	?
Esso Paterson (4)	1–45	Sun, 272	?	37	38
Esso Philadelphia	3–14–44	Sun, 219	?	?	?
Esso Pittsburgh	5–11–45	Sun, 220	H	43	42
Esso Raleigh (1)	2–43	Sun, 237	?	?	?
Esso Raleigh (2)	9–43	Sun, 237	?	?	?
Esso Raleigh (3)	3–21–44	Sun, 237	?	?	?
Esso Raleigh (4)	6–3–44	Sun, 237	?	?	?
Esso Raleigh (5)	7–3–45	Sun, 237	?	?	?
Esso Richmond (1)	10–43	Sun, 215	?	?	?
Esso Richmond (2)	7–8–44	Sun, 215	?	?	?
Esso Rochester (1)	3–9–43	Sun, 213	?	?	?
Esso Rochester (2)	2–26–44	Sun, 213	N	56	70
Esso Rochester (3)	3–22–44	Sun, 213	?	?	?
Esso Scranton	4-1-11–45	Sun, 414	?	?	?
Esso Washington (1)	1–43	Sun, 271	H	?	?
Esso Washington (2)	1–16–44	Sun, 271	H	?	?
Esso Washington (3)	3–44	Sun, 271	H	?	?
Esso Wilmington (1)	2–43	Sun, 270	?	?	?
Esso Wilmington (2)	2–14–44	Sun, 270	N	43	56
Esso Wilmington (3)	4–30–44	Sun, 270	H	37	32
Esso Wilmington (4)	10–16–19–44	Sun, 270	H	?	?
Esso Wilmington (5)	12–29–44	Sun, 270	C	24	?
Esso Wilmington (6)	1–7-9–45	Sun, 270	H	?	?
Esso Wilmington (7)	1–30–45/2–5–45	Sun, 270	H	?	?
Eugene E. O'Donnell (1)	2–9–44	New England, 2209	C	?	?
Eugene E. O'Donnell (2)	8–44	New England, 2209	?	?	?
Eugene Skinner	1–4–43	Oregon, 556	C	?	?
Evans Creek (1)	3-1-8–45	Alabama, 266	?	?	?
Evans Creek (2)	3–11–45	Alabama, 266	?	?	?
Exchequer	3–1–44	Bethlehem-Sparrows, 4394	?	?	?
Ezra Cornell	3–21-25–43	South Portland, 264	C	42	38
Ezra Meeker (1)	1–22–43	Oregon, 611	C	?	?
Ezra Meeker (2)	3–43	Oregon, 611	?	?	?
F. Marion Crawford	4–17–44	Permanente, 487	?	41–51	42
F. Scott Fitzgerald	2–17-18–45	New England, 3086	H	33–38	52–56
F. T. Frelinghuysen	3–30–45	Delta, 50	N	42	45
Fairfax (1)	4–7–44	Sun, 308	?	?	?
Fairfax (2)	11-1-14–44	Sun, 308	?	?	?
Fairland (1)	7–12–43/8–4–43	Gulf, 3	H	?	?
Fairland (2)	9–43	Gulf, 3	H	?	?
Fallen Timbers	10–15–43	Kaiser-Swan, 11	?	?	?
Felipe De Neve	2–10–44	Calship, 64	?	33–39	41

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Felix Reisenberg	1-30-45	Jones-Brunswick, 176	H	?	?
Ferdinando Gorges	12-16-44	New England, 238	N	39-47	48-52
Fisher Ames (1)	11-11-43/12-27-43	Oregon, 190	H	52	50
Fisher Ames (2)	12-14-44	Oregon, 190	?	?	?
Fort Erie	5-26-44	Kaiser-Swan, 23	?	?	?
Fort Henry	3-18-44	Kaiser-Swan, 23	?	?	?
Fort McHenry	4-13-44	Kaiser-Swan, 27	?	?	?
Fort Moultrie	2-1-26-45	Kaiser-Swan, 3	?	?	?
Fort Niagara (1)	4-16-21-44	Sun, 316	H	?	?
Fort Niagara (2)	11-1-20-44	Sun, 316	?	?	?
Fort Orange	3-44	New England, 241	H	?	?
Fort Schuyler	3-14-45	Sun, 336	?	?	?
Fort Stephenson	10-1-27-44	Kaiser-Swan, 17	?	?	?
Fort Sumter	9-26-44	Kaiser-Swan, 28	N	80	?
Fort Washington	7-21-43	Kaiser-Swan, 4	H	57	61
Fort Winnebago	4-1-8-45	Kaiser-Swan, 74	?	?	?
Francis Asbury	9-20-44	St. Johns, 3	N	56-73	62-76
Francis Drake (1)	2-8-24-44	Calship, 54	H	60-65	60
Francis L. Lee	5-16-18-43	Bethlehem-Fairfield, 2013	H	76	79
Francis Marion (1)	3-1-43	North Carolina, 6	H	37	45-50
Francis Marion (2)	2-14-44	North Carolina, 6	?	22-34	35
Francis Scott Key	11-43	Bethlehem-Fairfield, 2003	?	?	?
Francis W. Parker	4-20-44	Oregon, 793	?	?	?
Frank Armstrong (1)	3-30-43	Great Lakes-Ashtabula, 522	C	?	?
Frank Armstrong (2)	3-44	Great Lakes-Ashtabula, 522	?	?	?
Frank Gilbreth	2-12-45	Walsh Kaiser, 3120	?	?	?
Franklin K. Lane (1)	12-22-43	Calship, 196	C	72	32
Franklin B. Mall	9-44	Bethlehem-Fairfield, 2107	?	?	?
Frederick Remington (1)	5-5-43	Permanente, 508	H	?	?
Frederick Remington (2)	5-3-44	Permanente, 508	?	54-73	52-55
Frederick W. Taylor	7-25-44	New England, 2220	?	?	?
Fredericksburg	10-1-18-44	Sun, 294	?	?	?
Fremont Older	5-24-44	Permanente, 1576	C	52	49
Frenchtown	3-45	Sun, 391	?	?	?
G. W. Goethals (1)	11-7-43	Oregon, 599	?	?	?
G. W. Goethals (2)	3-30-44	Oregon, 599	C	40	38
G. W. Goethals (3)	2-27-45	Oregon, 599	H	58	60
Gabriel Duval	1-22-43	Calship, 81	?	?	?
Gaines Mile	1-45	Sun, 262	?	?	?
Gauntlet	11-9-44	Moore, 252	H	?	?
General Fleischer	1-8-10-44	Permanente, 269	H	?	?
General George W. Goethals (1)	2-20-43	Ingalls, 268	C	?	?
General George W Goethals (2)	1-6-44	Ingalls, 268	?	?	?
George A. Custer	1-25-44	Calship, 71	H	46	47
George A. Sloan (1)	3-19-43	Great Lakes-River Rouge, 292	C	?	?
George A. Sloan (2)	11-14-43	Great Lakes-River Rouge, 292	H	?	?
George B. Selden	11-29-43	Permanente, 428	H	45	45
George Berkeley (1)	5-9-44	Permanente, 1568	?	?	?
George Berkeley (2)	10-44	Permanente, 1568	H	?	?
George Chamberlain (1)	12-1-42	Oregon, 560	H	?	?
George Chamberlain (2)	12-29-43	Oregon, 560	H	40	?
George Chamberlain (3)	3-4-44	Oregon, 560	H	?	?
George Crocker (1)	12-23-43	Walter Butler, 26	C	?	33
George Crocker (2)	12-30-43	Walter Butler, 26	C	36	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
GEORGE D. PRENTICE	11-43	Permanente, 536	H	?	?
GEORGE DAVIDSON	11-25-43	Oregon, 697	?	?	?
GEORGE DAVIS	5-11-45	North Carolina, 54	N	58	50
GEORGE DEWEY	4-44	St. Johns, 10	H	?	?
GEORGE DURANT (1)	2-16-44	North Carolina, 182	H	40	42
GEORGE DURANT (2)	2-16-44/3-23-44	North Carolina, 182	H	46	48
GEORGE E. HALE (1)	12-12-43	Calship, 125	H	?	?
GEORGE E. HALE (2)	3-44	Calship, 125	?	61-64	63-65
GEORGE E. MERRICK	11-44	St. Johns, 40	?	?	?
GEORGE F. PATTEN	12-23-43	New England, 226	?	?	?
GEORGE FLAVEL (1)	3-29-44	Oregon, 658	N	51	51
GEORGE FLAVEL (2)	4-19-45	Oregon, 658	H	46	44
GEORGE GALE (1)	12-19-42/1-10-43	Delta, 7	H	?	?
GEORGE GALE (2)	1-21-44	Delta, 7	H	42	50
GEORGE H. PENDLETON	4-24-45	Bethlehem-Fairfield, 2163	N	52	52
GEORGE H. POPHAM	12-5-13-43	New England, 2194	?	?	?
GEORGE H. THOMAS	5-10-45	Oregon, 569	H	55	51
GEORGE H. WILLIAMS (1)	12-31-43	Oregon, 544	?	?	58
GEORGE H. WILLIAMS (2)	2-44	Oregon, 544	?	68	67
GEORGE KENNY	4-45	Calship, 237	H	?	?
GEORGE L. BAKER	6-45	Oregon, 655	?	?	?
GEORGE M. BIBB	6-20-43	Oregon, 628	N	80	84
GEORGE P. GARRISON	3-2-44	Houston, 73	H	36	45
GEORGE POINDEXTER	2-44	Delta, 56	H	62	72
GEORGE ROGERS CLARK (1)	11-25-43	Permanente, 448	N	?	?
GEORGE ROGERS CLARK (2)	3-13-44	Permanente, 448	H	38-43	46
GEORGE ROGERS CLARK (3)	4-3-44	Permanente, 448	?	33-46	40
GEORGE ROGERS CLARK (4)	4-24-44	Permanente, 448	N	60	43
GEORGE S. WASSON (1)	12-20-43	New England, 2206	C	38	38
GEORGE S. WASSON (2)	12-28-43	New England, 2206	C	7	?
GEORGE STEERS	12-23-44	Houston, 119	N	50	52
GEORGE W. CAMPBELL	4-24-25-43	Oregon, 623	H	42	49
GEORGE W. KENDALL (1)	5-44	Delta, 64	?	?	?
GEORGE W. KENDALL (2)	9-4-44	Delta, 64	?	?	?
GEORGE W. KENDALL (3)	10-12-44	Delta, 64	?	?	?
GEORGE W. KENDALL (4)	1-45	Delta, 64	?	?	?
GEORGE WALTON	11-43	Southeastern, 4	H	?	?
GEORGE WHITEFIELD (1)	12-16-43/1-3-44	Southeastern, 19	H	47-56	54
GEORGE WHITEFIELD (2)	3-2-3-44	Southeastern, 19	H	18-20	40-42
GEORGE WYTHE (1)	8-43	Bethlehem-Fairfield, 2011	H	?	?
GEORGE WYTHE (2)	12-5-43	Bethlehem-Fairfield, 2011	?	?	?
GEORGE WYTHE (3)	2-29-44/3-2-44	Bethlehem-Fairfield, 2011	H	?	?
GEORGE WYTHE (4)	1-45	Bethlehem-Fairfield, 2011	?	?	?
GERONIMO	1-44	Permanente, 1122	?	?	?
GERVAIS	5-44	Kaiser-Swan, 36	H	?	?
GIDEON WELLES	2-45	Oregon, 563	N	47-52	64-70
GRACE ABBOTT	1-1-5-43	Bethlehem-Fairfield, 2069	H	58	57
GRACE R. HEBARD	12-44	Oregon, 813	H	35	39
GRANDE RONDE	6-16-44	Kaiser-Swan, 43	?	?	?
GREAT MEADOWS (1)	10-28-43	Sun, 319	?	?	?
GREAT MEADOWS (2)	6-12-44	Sun, 319	?	?	?
GREEN BAY VICTORY	2-3-6-45	Oregon, 1213	H	52	54
GROVER C. HUTCHERSON	2-3-7-45	St. Johns, 76	H	?	?
GUADALOUPE	5-5-43	Newport News, 371	?	?	?

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Gulf Caribbean	11–44	Sun, 240	?	?	?
Gutzon Borglum (1)	11–28–43/1–17–44	Calship, 240	N	65	53
Gutzon Borglum (2)	2–7–44	Calship, 240	?	?	?
Hadley F. Brown	6–45	New England, 3023	?	?	?
Hall J. Kelley (1)	3–44	Oregon, 637	N	?	?
Hall J. Kelley (2)	4–25–44	Oregon, 637	?	?	?
Hamlin Garland (1)	12–10-13–43	Southeastern, 16	H	59	66
Hamlin Garland (2)	12–10-19–44	Southeastern, 16	H	60	56
Hanging Rock (1)	6–2–44	Sun, 390	?	?	?
Hanging Rock (2)	4–45	Sun, 390	?	?	?
Hannibal Hamlin	3–28–4[illegible]	South Portland, 213	?	?	?
Hannis Taylor	12–19–44	North Carolina, 162	N	17	52
Harald Torsvik (1)	11–44	St. Johns, 66	H	?	?
Harald Torsvik (2)	2–5–45	St. Johns, 66	?	18–52	40
Harpers Ferry (1)	9–1-8–44	Sun, 300	?	?	?
Harpers Ferry (2)	11–44	Sun, 300	?	?	?
Harriet Tubman	8–44	New England, 3032	H	86	79
Harrington Emerson	4–4–44	Oregon, 823	?	?	?
Harry L. Glucksman	3–16–45	Southeastern, 50	N	76	40
Harry Lane (1)	8–43	Oregon, 559	?	?	?
Harry Lane (2)	3–16–44	Oregon, 559	?	51–77	49
Harry Lane (3)	6–21–44	Oregon, 559	?	?	?
Hart Crane	10–5–44	Calship, 276	?	?	?
Harvey W. Scott	12–5–42	Oregon, 552	N	?	?
Hastings	1–45	Gulf, 28	H	?	?
Hat Creek (1)	12–11–43	Alabama, 251	H	32	45
Hat Creek (2)	12–13–43	Alabama, 251	?	?	?
Hat Creek (3)	2–8-14–44	Alabama, 251	H	?	?
Helen Hunt Jackson (1)	4–6–44	Calship, 98	?	28–34	48
Helen Hunt Jackson (2)	6–28–44	Calship, 98	N	74–85	71
Henderson Luelling (1)	12–27–43	Oregon, 640	?	?	?
Henderson Luelling (2)	1–27-28–44	Oregon, 640	H	30	40
Henry Austin	2–7–44	Houston, 100	?	?	?
Henry Bacon	12–27–42	North Carolina, 40	C	?	?
Henry Baldwin (1)	12–27–42	Calship, 82	H	70	?
Henry Baldwin (2)	3–44	Calship, 82	H	56	70
Henry Barnard	2–8–43	Oregon, 603	?	42–47	51
Henry Clay	2–44	Alabama, 233	C	?	?
Henry D. Thoreau	4–18–44	Oregon, 197	?	47–54	51
Henry George	4–19–43	Oregon, 574	?	66–68	69–81
Henry Gibbins	4–44	Ingalls, 297	H	?	?
Henry Failing (1)	4–3–44	Oregon, 662	?	?	?
Henry H. Richardson	3–44	Permanente, 528	H	?	?
Henry H. Sibley	1–30–45	Calship, 153	?	?	?
Henry J. Raymond	6–11–44	Permanente, 442	?	?	?
Henry L. Ellsworth	3–44	Delta, 74	?	?	?
Henry M. Rice (1)	8–3–43	Calship, 154	H	45	45
Henry M. Rice (2)	11–28-29–43	Calship, 154	H	46	52
Henry S. Lane (1)	7–26-31–43	Oregon, 692	H	?	?
Henry S. Lane (2)	4–8–44	Oregon, 692	?	?	?
Henry S. Lane (3)	1–3–45	Oregon, 692	?	?	?
Henry Lomb	5–16–44	Bethlehem-Fairfield, 2232	?	?	?
Henry W. Grady	12–18–44	Jones-Brunswick, 117	C	38	51
Henry W. Longfellow (1)	8–25–42	Oregon, 188	H	?	?

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit Air	Temperature Degrees Fahrenheit Water
Henry Ward Beecher	2–44	Calship, 67	H	62–68	66–67
Henry Wilson (1)	5–1–8–43	New England, 272	C	40	40
Henry Wilson (2)	1–31–44	New England, 272	?	?	?
Henry Wynkoop (1)	2–16–43	Delta, 21	C	7–17	?
Henry Wynkoop (2)	3–2–11–44	Delta, 21	H	?	?
Henry Wynkoop (3)	3–6–45	Delta, 21	?	?	?
Herman Melville (1)	12–22–42	South Portland, 218	?	?	?
Herman Melville (2)	3–44	South Portland, 218	H	19	27
Herman Melville (3)	4–44	South Portland, 218	H	?	?
Hidalgo (1)	12–26–44	Walter Butler, 38	C	–12	?
Hidalgo (2)	1–5–45	Walter Butler, 38	C	–1	25
Hilary A. Herbert	3–45	North Carolina, 170	?	?	?
Hinton R. Helper	12–27–43/1–2–44	Calship, 49	H	?	?
Hiram S. Maxim	5–43	Permanente, 468	H	?	?
Hobkirk's Hill	12–1–14–44	Sun, 418	?	?	?
Horace Bushnell	3–4–44	Bethlehem-Fairfield, 2243	H	?	?
Horace See (1)	11–19–43	Calship, T–11	H	?	?
Horace See (2)	4–25–44	Calship, T–11	?	?	?
Horace See (3)	7–22–44	Calship, T–11	H	?	?
Horace See (4)	1–45	Calship, T–11	?	?	?
Horace See (5)	2–22–45	Calship, T–11	H	35	30
Horace See (6)	3–8–45	Calship, T–11	H	?	?
Horace See (7)	4–18–45	Calship, T–11	C	34	38
Horatio Allen	3–45	Calship, 296	?	?	?
Howard E. Coffin (1)	3–16–44	Jones-Brunswick, 128	H	?	?
Howard E. Coffin (2)	2–27–45	Jones-Brunswick, 128	H	?	?
Howard T. Ricketts (1)	1–12–44	Calship, 225	?	?	?
Howard T. Ricketts (2)	9–6–44	Calship, 225	H	52	58
Hubert Howe Bancroft (1)	1–25–45	Calship, 94	H	20–28	40
Hubert Howe Bancroft (2)	5–45	Calship, 94	H	69–75	68–75
Hugh Williamson	3–19–43	North Carolina, 13	H	41	53
Ina Coolbrith	6–23–44	Calship, 227	?	?	?
Iran Victory	6–22–44	Oregon, 1010	?	?	?
Irvin S. Cobb	11–29–44	St. Johns, 55	H	?	?
Irwin Russell	3–29–44/4–4–44	Delta, 73	H	46	48
Isaac I. Stevens	1–22–30–44	Oregon, 820	H	?	?
Isaac Coles	2–22–44	Calship, 33	H	36–47	42
Island Mail	5–30–45	Sun, 200	H	43	33
Israel Putnam (1)	12–21–42	Alabama, 242	C	21	?
Israel Putnam (2)	1–22–44	Alabama, 242	H	28–48	37
Israel Putnam (3)	1–17–45/2–1–45	Alabama, 242	H	54	66
J. D. Ross (1)	3–2–44	Oregon, 727	?	?	?
J. D. Ross (2)	6–5–44	Oregon, 727	?	?	?
J. D. Yeager	2–19–45	Todd-Houston, 169	H	40	?
J. E. B. Stuart (1)	12–43	Houston, 20	?	70	7?
J. E. B. Stuart (2)	7–31–45	Houston, 169	?	?	83
J. H. Hillman, Jr.	3–44	Great Lakes-Ashtabula, 524	?	?	?
J. H. Kinkaid	8–14–44	Permanente, 480	N	?	?
J. H. Tuttle	6–43	Sun, 238	?	?	?
J. L. M. Curry	3–7–43	Alabama, 231	H	14–30	?
J. Rufino Barrios	7–45	Delta, 140	?	?	?
J. Warren Keifer	4–9–10–44	Oregon, 789	H	?	?
Jacob S. Hausfeld	1–12–45	Calship, 198	?	?	?
Jacob Thompson (1)	2–1–2–44	Delta, 68	H	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
JACOB THOMPSON (2)	5-29-44	Delta, 68	?	?	?
JACOB THOMPSON (3)	3-10-45	Delta, 68	H	62	54
JACQUES CARTIER (1)	6-43	Calship, 162	H	?	?
JACQUES CARTIER (2)	8-17-43	Calship, 162	?	?	?
JACQUES CARTIER (3)	10-19-43	Calship, 162	H	?	?
JAMES A. WETMORE (1)	12-7-43	Jones-Brunswick, 118	H	40	?
JAMES A. WETMORE (2)	1-17-44	Jones-Brunswick, 118	H	39	?
JAMES A. WETMORE (3)	2-16-44	Jones-Brunswick, 118	?	?	?
JAMES A. WETMORE (4)	3-44	Jones-Brunswick, 118	?	?	?
JAMES B. RICHARDSON (1)	2-18-44	North Carolina, 35	N	47	56
JAMES B. RICHARDSON (2)	4-28-44	North Carolina, 35	?	45-52	48
JAMES B. WEAVER (1)	12-12-23-43	Calship, 157	H	37-61	54
JAMES B. WEAVER (2)	3-16-44	Calship, 157	?	?	?
JAMES BARBOUR	3-23-43	Houston, 41	H	?	?
JAMES BOWIE (1)	2-19-43	Houston, 32	H	44	38
JAMES BOWIE (2)	8-43	Houston, 32	?	75-88	84
JAMES CALDWELL	3-45	Bethlehem-Fairfield, 2065	?	?	?
JAMES COOK	3-12-44/4-3-44	Calship, T-7	?	?	?
JAMES DEVEREUX (1)	5-4-44	Permanente, 2745	?	?	?
JAMES DEVEREUX (2)	7-10-44	Permanente, 2745	?	?	?
JAMES FENIMORE COOPER (1)	1-21-44	Oregon, 235	H	?	?
JAMES FENIMORE COOPER (2)	3-44	Oregon, 235	H	?	?
JAMES G. MAGUIRE	12-28-44	Permanente, 2183	C	?	?
JAMES GORDON BENNETT (1)	12-18-43	Calship, 68	?	26-42	?
JAMES GORDON BENNETT (2)	1-22-44	Calship, 68	H	?	?
JAMES HARROD	6-43	Oregon, 643	?	?	?
JAMES HOBAN	1-43	Alabama, 281	?	?	?
JAMES I. MCKAY	4-44	North Carolina, 180	H	?	?
JAMES IREDELL	3-4-44	North Carolina, 45	H	?	?
JAMES IVES (1)	1-21-44	Permanente, 530	H	?	?
JAMES IVES (2)	4-29-44	Permanente, 530	?	41-48	47
JAMES LONGSTREET	8-43	Houston, 18	?	?	?
JAMES LYKES (1)	6-1-21-44	Bethlehem-Sparrows, 4344	H	?	?
JAMES LYKES (2)	7-26-44	Bethlehem-Sparrows, 4344	?	?	?
JAMES M. WAYNE (1)	6-43	Jones-Brunswick, 105	H	?	?
JAMES M. WAYNE (2)	1-5-44	Jones-Brunswick, 105	H	?	?
JAMES MANNING (1)	1-44	New England, 2198	N	?	?
JAMES MANNING (2)	4-3-44	New England, 2198	?	?	?
JAMES MCNEILL WHISTLER	11-28-42	Oregon, 576	H	32	42
JAMES SCHUREMAN	11-42	Calship, 30	H	?	?
JAMES SHIELDS	12-43	Calship, 201	?	?	?
JAMES SMITH (1)	12-17-43	Permanente, 53	H	37	?
JAMES SMITH (2)	12-26-43	Permanente, 53	H	37	45
JAMES SMITH (3)	2-44	Permanente, 53	H	?	?
JAMES W. FANNIN	6-21-44	Houston, 59	?	?	?
JAMES W. NESMITH	2-45	Oregon, 553	N	44-62	62-65
JAMES WHITCOMB RILEY (1)	2-28-43	Oregon, 199	H	40	44
JAMES WHITCOMB RILEY (2)	1-30-44	Oregon, 199	H	34	?
JAMES WOODROW	2-8-43/3-31-43	Bethlehem-Fairfield, 2079	H	47-60	66-72
JAN JORES (1)	10-23-43	Calship, 126	?	?	?
JAN JORES (2)	1-1-14-44	Calship, 126	H	?	?
JAN PIETERSZOON COEN	2-15-44	Permanente, 2263	C	48	53
JANE A. DELANO (1)	12-14-43	Permanente, 465	?	?	?
JANE A. DELANO (2)	1-20-44/2-4-44	Permanente, 465	H	42	50

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
JANE A. DELANO (3)	3-4-44	Permanente, 465	H	20	40
JANE LONG	1-22-44	Houston, 57	H	37	49
JANET LORD ROPER	11-44	Bethlehem-Fairfield, 2157	H	?	?
JARED INGERSOLL	4-45	Bethlehem-Fairfield, 2047	?	?	?
JASMINE	10-44	Bethlehem-Fairfield, 2020	H	?	?
JEAN LYKES	7-4-45	Consolidated-Wilmington, 229	H	80	77
JEFFERSON DAVIS	1-16-44	Alabama, 238	H	41	42
JEREMIAH O'BRIEN	3-28-44	New England, 230	?	?	?
JEREMIAH WADSWORTH	11-11-42	Houston, 31	N	?	?
JESSE APPLEGATE	8-44	Oregon, 549	?	?	?
JESSE BILLINGSLEY	3-44	Houston, 79	H	?	?
JESSE G. COTTING	6-17-44	Walter Butler, 8	?	?	?
JOAQUIN MILLER (1)	3-15-43	Permanente, 484	H	30	34
JOAQUIN MILLER (2)	9-43	Permanente, 484	?	?	?
JOAQUIN MILLER (3)	12-15-43	Permanente, 484	C	?	?
JOEL CHANDLER HARRIS	5-18-45	Alabama, 240	C	?	?
JOEL R. POINSETT	3-4-44	Houston, 43	H	20	40
JOHN A. CAMPBELL	1-45	Jones-Brunswick, 112	?	0	?
JOHN A. QUITMAN	1-16-44	Delta, 57	H	40	40
JOHN ARMSTRONG	6-45	Houston, 39	?	?	?
JOHN B. GORDON	12-24-43	Jones-Brunswick, 120	H	?	?
JOHN BARRY (1)	7-25-43	Oregon, 174	H	55	53
JOHN BARRY (2)	6-44	Oregon, 174	H	74-80	77-81
JOHN BURKE (1)	1-4-43/5-14-43	Oregon, 609	?	?	?
JOHN BURKE (2)	3-3-44	Oregon, 609	N	42	38
JOHN BURKE (3)	4-21-44	Oregon, 609	H	38	39
JOHN C. AINSWORTH (1)	12-25-42	Oregon, 554	H	40	40-46
JOHN C. AINSWORTH (2)	9-9-43	Oregon, 554	H	47	46
JOHN C. AINSWORTH (3)	1-8-44	Oregon, 554	C	45	39
JOHN C. SPENCER (1)	12-25-43	Houston, 45	H	?	?
JOHN C. SPENCER (2)	3-5-44	Houston, 45	H	54	57
JOHN CARVER (1)	6-1-15-43	South Portland, 207	?	68	70
JOHN CARVER (2)	9-44	South Portland, 207	?	?	?
JOHN CLARKE (1)	2-44	Walsh Kaiser, 2	?	?	?
JOHN CLARKE (2)	3-12-44	Walsh-Kaiser, 2	N	64	66
JOHN CROPPER (1)	3-44	North Carolina, 8	H	63-65	68-70
JOHN CROPPER (2)	10-20-44	North Carolina, 8	?	70	70
JOHN CROPPER (3)	1-45	North Carolina, 8	?	?	?
JOHN D. WHIDDEN	1-12-44	Walter Butler, 24	C	12	32
JOHN DAVENPORT	6-26-43	South Portland, 207	H	?	?
JOHN DRAKE SLOAT (1)	6-43	Calship, 122	?	48	60
JOHN DRAKE SLOAT (2)	10-43	Calship, 122	?	58-69	70-77
JOHN DREW	5-44	Calship, 274	H	?	?
JOHN E. SWEET	3-45	Southeastern, 43	?	?	?
JOHN EVANS	5-45	Permanente, 1712	H	64	?
JOHN F. APPLEBY (1)	5-43	Permanente, 421	H	50-51	47
JOHN F. APPLEBY (2)	10-11-43	Permanente, 421	H	40-44	46
JOHN F. APPLEBY (3)	3-16-44	Permanente, 421	?	11-15	38
JOHN F. APPLEBY (4)	4-44	Permanente, 421	H	?	?
JOHN F. STEFFEN	12-18-43	Oregon, 709	?	?	?
JOHN FITCH (1)	1-6-43/2-13-43	Permanente, 72	?	?	?
JOHN FITCH (2)	2-15-43	Permanente, 72	N	-10	33
JOHN G. CARLISLE	5-44	Permanente, 519	?	?	?
JOHN G. WHITTIER (1)	4-10-44	Oregon, 194	?	42-52	44

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
JOHN G. WHITTIER (2)	1–45	Oregon, 194	?	40–65	57–74
JOHN G. WHITTIER (3)	4–45	Oregon, 194	?	?	?
JOHN GOODE	3–20–44	Calship, T–1	H	43	53
JOHN GORRIE (1)	10–13–43	St. Johns, 2	H	43	?
JOHN GORRIE (2)	11–9–43/12–5–43	St. Johns, 2	?	?	?
JOHN GORRIE (3)	2–44	St. Johns, 2	H	?	?
JOHN GORRIE (4)	3–44	St. Johns, 2	H	?	?
JOHN H. HAMMOND (1)	2–45	Jones-Brunswick, 170	?	?	?
JOHN H. HAMMOND (2)	3–45	Jones-Brunswick, 170	?	?	?
JOHN H. MARION (1)	4–14–44	Calship, T–16	?	?	?
JOHN H. MARION (2)	10–44	Calship, T–16	?	?	?
JOHN H. MARION (3)	3–17–45	Calship, T–16	C	31	54
JOHN H. MARION (4)	6–45	Calship, T–16	?	?	?
JOHN H. MURPHY	2–21–45	Bethlehem-Fairfield, 2346	H	?	?
JOHN HARVEY	3–16–43	North Carolina, 56	?	50–63	60
JOHN HATHORN (1)	2–15–44	Calship, 24	H	?	?
JOHN HATHORN (2)	4–45	Calship, 24	?	?	50
JOHN HAY	3–30–44	Jones-Panama, 7	H	?	?
JOHN HENRY (1)	9–42	Bethlehem-Fairfield, 2032	H	?	?
JOHN HENRY (2)	1–25–44/2–4–44	Bethlehem-Fairfield, 2032	H	37	56
JOHN HOLMES	4–18–44	New England, 216	?	?	?
JOHN IRELAND	3–45	Houston, 125	?	?	?
JOHN J. CRITTENDEN	6–5–44	St. Johns, 4	?	?	?
JOHN L. MCCARLEY	3–45	Jones-Panama, 83	?	?	?
JOHN L. SULLIVAN (1)	12–26–43	Permanente, 1121	H	?	?
JOHN L. SULLIVAN (2)	2–2–44	Permanente, 1121	H	50	54
JOHN L. SULLIVAN (3)	6–11–28–44	Permanente, 1121	H	?	?
JOHN M. SCHOFIELD	2–15–45	Permanente, 433	C	30–33	35
JOHN MARY ODIN (1)	9–43	Houston, 67	H	?	?
JOHN MARY ODIN (2)	2–9–44	Houston, 67	?	?	?
JOHN MASON	3–16–44	New England, 239	?	?	?
JOHN MERRICK (1)	11–44	North Carolina, 174	?	?	?
JOHN MERRICK (2)	5–25–45/6–18–45	North Carolina, 174	N	?	?
JOHN MCLOUGHLIN (1)	2–44	Oregon, 548	H	40–48	53–55
JOHN MCLOUGHLIN (2)	3–12–44	Oregon, 548	N	48	48
JOHN MITCHELL	1–24–44/2–2–44	Bethlehem-Fairfield, 2061	H	50	48
JOHN MORTON	2–43	Permanente, 58	?	32	57
JOHN MURRAY FORBES (1)	1–1–43	South Portland, 254	C	30	36
JOHN MURRAY FORBES (2)	4–43	South Portland, 254	?	43	?
JOHN P. ALTGELD (1)	9–1–25–44	Calship, T–17	?	?	?
JOHN P. ALTGELD (2)	10–9–44	Calship, T–17	H	45	50
JOHN P. ALTGELD (3)	12–14–15–44	Calship, T–17	H	?	?
JOHN P. ALTGELD (4)	2–26–45	Calship, T–17	N	38	38
JOHN P. GAINES	11–24–43	Oregon, 723	N	40–45	?
JOHN P. HOLLAND	6–5–43	Oregon, 589	C	41	?
JOHN PAGE	3–22–45	Calship, 29	?	47–52	52
JOHN PAUL JONES (1)	9–3–43	Calship, 4	?	72–88	82
JOHN PAUL JONES (2)	12–43	Calship, 4	N	?	?
JOHN PAUL JONES (3)	5–14–45	Calship, 4	?	?	?
JOHN RINGLING	2–21–45	St. Johns, 58	N	43	38
JOHN S. CASEMENT (1)	7–22–43	Calship, 187	H	41	50
JOHN S. CASEMENT (2)	4–20–44	Calship, 187	?	?	?
JOHN SERGEANT	1–25–45/2–11–45	Bethlehem-Fairfield, 2050	H	22–32	42
JOHN SHARP WILLIAMS	2–26–44	Delta, 58	H	15	36

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit Air	Water
John Straub (1)	1-12-44	Oregon, 808	H	26-38	37-38
John Straub (2)	3-22-44	Oregon, 808	C	45	42
John T. Holt	3-44	Bethlehem-Fairfield, 2206	H	?	?
John Vining (1)	2-43	Delta, 19	H	?	?
John Vining (2)	1-2-44	Delta, 19	C	13	38
John Vining (3)	4-44	Delta, 19	?	?	?
John Vining (4)	7-26-44	Delta, 19	?	76-88	73
John W. Cullen	1-15-44	Oregon, 638	?	?	?
John W. Weeks (1)	5-18-43	Oregon, 617	?	?	?
John W. Weeks (2)	1-18-44	Oregon, 617	?	?	?
John W. Weeks (3)	5-3-44	Oregon, 617	C	54	42
John W. Weeks (4)	8-14-44	Oregon, 617	?	?	?
John Whiteaker	2-20-23-43	Oregon, 631	N	56	55
Jonathan Harrington	3-7-44	Oregon, 561	H	40	41
Jonathan Trumbull	7-8-43	Delta, 18	?	66-75	60
Jose G. Benitez	4-27-44	Houston, 115	N	47	55
Joseph C. Lincoln	5-45	New England, 3035	H	?	?
Joseph Francis	10-11-12-43	Calship, 246	H	48	49
Joseph G. Cannon	10-44	Permanente, 447	?	?	?
Joseph Gale	5-43	Oregon, 594	?	74	?
Joseph Goldberger	11-43	Delta, 78	?	?	?
Joseph H. Hollister	3-43	Calship, 118	?	?	?
Joseph Habersham	2-1-45	Southeastern, 26	H	56	56
Joseph Henry (1)	2-43	Kaiser-Vancouver, 45	C	?	?
Joseph Henry (2)	4-19-20-43	Kaiser-Vancouver, 45	H	42	46
Joseph Henry (3)	7-1-20-43	Kaiser-Vancouver, 45	?	?	?
Joseph Henry (4)	5-4-44	Kaiser-Vancouver, 45	N	60	40
Joseph Hewes	10-31-44/11-4-44	North Carolina, 26	N	68	70
Joseph Holt	3-2-44	Permanente, 432	H	66	68
Joseph L. Meek (1)	4-1-44	Oregon, 596	H	0	17
Joseph L. Meek (2)	6-12-44	Oregon, 596	N	45	44
Joseph M. Medill	3-45	Jones-Panama, 5	?	?	?
Joseph McKenna	5-21-45	Calship, 35	?	?	?
Joseph N. Nicollet	1-14-16 & 27-44	Delta, 61	H	32	?
Joseph N. Teal (1)	3-43	Oregon, 581	C	?	?
Joseph N. Teal (2)	11-28-43	Oregon, 581	C	?	?
Joseph R. Lamar (1)	1-9-44	Jones-Brunswick, 107	H	50	68
Joseph R. Lamar (2)	2-26-27-44	Jones-Brunswick, 107	H	38	41
Joseph R. Lamar (3)	3-22-44	Jones-Brunswick, 107	H	34	?
Joseph R. Lamar (4)	5-26-44/6-9-44	Jones-Brunswick, 107	N	45-46	52-71
Joseph R. Lamar (5)	10-16-18-44	Jones-Brunswick, 107	H	55-68	62-65
Joseph Reynolds	2-25-44/4-22-44	Calship, 241	H	62	21
Joseph Smith	1-9-44	Permanente, 1119	H	34	50
Joseph Squires	6-29-44	New England, 3028	H	?	?
Joseph Story	3-23-44	Calship, 80	?	31-34	37
Joseph Warren	4-5-12-43	New England, 266	C	46	39
Joshua B. Lippincott (1)	1-29-30-44	Bethlehem-Fairfield, 2289	H	?	?
Joshua B. Lippincott (2)	10-44	Bethlehem-Fairfield, 2289	?	?	?
Joshua L. Chamberlain	4-44	New England, 229	H	?	?
Joshua W. Alexander (1)	1-44	Bethlehem-Fairfield, 2154	H	?	?
Joshua W. Alexander (2)	1-3-45	Bethlehem-Fairfield, 2154	H	?	?
Josiah G. Holland (1)	12-43	Calship, T-5	?	?	?
Josiah G. Holland (2)	4-7-44	Calship, T-5	?	?	?
Josiah Parker	3-44	Delta, 13	?	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
JOYCE KILMER	6-7-44	Bethlehem-Fairfield, 2244	?	?	?
JUAN DE FUCA	8-11-44	Kaiser-Vancouver, 41	?	?	?
JUAN FLACO BROWN	4-44	Calship, 167	H	?	?
JUDAH P. BENJAMIN	9-13-44	Alabama, 237	?	?	81
JULESBURG	9-12-44	Alabama, 252	?	?	?
JULIA L. DUMONT	3-2-44	Permanente, 2718	?	?	?
JULIA P. SHAW	1-45	New England, 3083	H	?	?
JULIEN POYDRAS	1-24-44	Delta, 59	H	47	54
JULIUS OLSEN	5-45	Houston, 128	?	?	?
JUNIUS SMITH	12-44	St. Johns, 69	H	?	?
JUSTIN S. MORRILL	5-23-44	Permanente, 461	?	?	?
KASKASKIA	3-12-43	Newport News, 370	?	?	?
KEITH PALMER	10-44	Houston, 117	?	?	?
KEMP P. BATTLE	2-21-44	North Carolina, 157	?	?	?
KENESAW MOUNTAIN (1)	5-25-44	Sun, 306	?	?	?
KENESAW MOUNTAIN (2)	8-1-14-44	Sun, 306	?	?	?
KENYON (1)	4-44	Bethlehem-Sparrows, 4388	?	?	?
KENYON (2)	12-1-26-44	Bethlehem-Sparrows, 4388	?	?	?
KERNSTOWN	2-13-29-44	Sun, 333	?	?	?
KITTANNING	4-16-44	Sun, 322	?	?	?
KLAMATH FALLS (1)	2-29-44	Kaiser-Swan, 38	?	?	?
KLAMATH FALLS (2)	10-44	Kaiser-Swan, 38	?	?	?
KNUTE NELSON	3-44	Calship, 156	H	?	?
KNUTE ROCKNE (1)	3-44	Permanente, 1111	H	?	?
KNUTE ROCKNE (2)	6-12-44	Permanente, 1111	?	?	?
KOLKHOZNIK (1)	2-27-44	Permanente, 460	?	?	?
KOLKHOZNIK (2)	3-19-44	Permanente, 460	H	?	?
KUBAN	1-2-44	Oregon, 686	?	?	?
LAMBERT CADWALADER	12-43	Houston, 34	?	42	?
LANGDON CHEVES	5-26-44	Southeastern, 13	?	?	?
LAURA KEENE	12-11-43	Kaiser-Vancouver, 46	N	?	?
LAWRENCE J. BRENGLE	2-45	Bethlehem-Fairfield, 2348	H	?	?
LAWTON B. EVANS (1)	3-3-10-43	Alabama, 287	H	?	?
LAWTON B. EVANS (2)	3-26-44	Alabama, 287	N	54	50
LE BARON RUSSELL BRIGGS	2-19-45	Jones-Panama, 42	H	36	47
LEBANON	1-9-45	Walter Butler, 40	C	−16	32
LEIV EIRIKSSON	3-1-16-44	North Carolina, 59	H	?	35
LELAND STANFORD (1)	1-11-43	Calship, 53	?	?	?
LELAND STANFORD (2)	3-45	Calship, 53	?	49-58	62-64
LEWIS EMERY, JR.	12-19-22-43	Bethlehem-Fairfield, 2254	H	33	?
LEW WALLACE	3-26-43	Permanente, 485	H	17-20	37
LIGHTNING (1)	11-23-42	Sun, 202	H	?	?
LIGHTNING (2)	1-15-43	Sun, 202	H	?	?
LIGHTNING (3)	2-23-43	Sun, 202	N	?	?
LIGHTNING (4)	4-23-30-43	Sun, 202	?	?	?
LIGHTNING (5)	7-14-43	Sun, 202	?	?	?
LIGHTNING (6)	8-1-9-43	Sun, 202	C	?	?
LIGHTNING (7)	11-12-43	Sun, 202	?	?	?
LIGHTNING (8)	1-5-44	Sun, 202	?	?	?
LINCOLN STEFFENS	1-44	Calship, 93	H	?	?
LINDLEY M. GARRISON (1)	5-17-43	Oregon, 616	?	48-55	49
LINDLEY M. GARRISON (2)	12-43	Oregon, 616	?	48	?
LINDLEY M. GARRISON (3)	2-10-44	Oregon, 616	?	?	?
LINN BOYD	6-28-44	Delta, 97	?	?	?

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Lorenzo de Zavala	1-20-44	Houston, 64	H	56	47
Lou Gehrig	2-44	South Portland, 210	H	39	55
Louis Bamberger	2-21-45	St. Johns, 72	H	40	67
Louis Kossuth (1)	4-4-7-45	Bethlehem-Fairfield, 2286	H	39	50
Louis McLane	10-43	Calship, 109	?	45-50	50
Lucius Fairchild	4-17-44	Oregon, 796	N	80-90	80
Lucy Stone	1-16-31-44	Permanente, 474	H	?	?
Lundy's Lane (1)	4-1-44	Kaiser-Swan, 22	?	?	?
Lundy's Lane (2)	8-44	Kaiser-Swan, 22	?	?	?
Lunsford Richardson	10-16-20-44	Jones-Brunswick, 159	H	?	?
Lyman Abbott	5-7-45	Walsh-Kaiser, 5	?	?	?
Lyman Beecher	3-3-44	Marinship, 7	?	63	56
Lyman Hall	9-43	Southeastern, 5	H	?	?
Lyon's Creek	3-45	Sun, 393	?	?	?
M. E. Lombardi	1-21-45	Sun, 193	H	?	?
M. M. Guhin	2-3-44	Oregon, 615	?	?	?
Mahlon Pitney	9-43	Bethlehem-Fairfield, 2092	?	?	?
Maiden Creek	2-5-44	Gulf, 16	?	?	?
Mannington	5-43	Barnes-Duluth, 3	?	?	?
Marengo	1-22-45	Walter Butler, 43	C	?	?
Marie M. Meloney (1)	10-17-43	Bethlehem-Fairfield, 2226	H	?	?
Marina	1-27-44	Pusey and Jones, 1075	H	?	?
Marine Eagle (1)	12-18-43	Sun, 340	?	?	?
Marine Eagle (2)	4-26-44	Sun, 340	?	?	?
Mark Twain (1)	2-13-20-43	Oregon, 233	H	?	?
Mark Twain (2)	5-24-44	Oregon, 233	?	72	65
Markay	6-18-43	Sun, 232	H	?	?
Mark Hopkins	4-24-44	Marinship, 9	C	72	59
Mary Wilkins Freeman (1)	5-13-44	New England, 2192	?	?	?
Mary [illegible]ns Freeman (2)	9-23-44	New England, 2192	?	?	?
Matthew B. Brady	1-14-45	Permanente, 1117	N	22	44
Matthew P. Deady	3-43	Oregon, 545	?	54-59	62-68
McClellan Creek (1)	3-2-44	Alabama, 254	N	16	35
McClellan Creek (2)	1-30-45	Alabama, 254	H	32	38
Mechanicsville (1)	10-44	Kaiser-Swan, 32	?	?	?
Mechanicsville (2)	2-45	Kaiser-Swan, 32	?	?	?
Melville Jacoby	3-20-44	Walsh-Kaiser, 3119	C	22	24
Midwest Farmer (1)	5-29-44	Oregon, 760	C	64	?
Midwest Farmer (2)	11-30-44	Oregon, 760	?	?	?
Minot Victory	12-11-44	Oregon, 1203	C	39	44
Mission Santa Cruz (1)	3-4-44	Marinship, 26	?	?	?
Mission Santa Cruz (2)	4-17-44	Marinship, 26	?	?	?
Molino Del Rey (1)	3-44	Sun, 283	?	?	?
Molino Del Rey (2)	8-1-25-44	Sun, 283	?	?	?
Monmouth	10-1-19-44	Sun, 248	?	?	?
Monocacy	2-20-44	Sun, 290	?	?	?
Montana (1)	12-13-26-42	Sun, 225	?	?	?
Montana (2)	1-14-44	Sun, 225	C	30	?
Mormacmoon (1)	8-20-42	Ingalls, 253	H	57	80
Mormacmoon (2)	2-2-43	Ingalls, 253	H	56	51
Mormacswan (1)	7-21-43	Federal, 158	H	66	56
Mormacswan (2)	10-43	Federal, 158	N	47-70	50-70
Mormacswan (3)	3-27-30-44	Federal, 158	H	51	54
Mormacswan (4)	12-44	Federal, 158	H	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	con tion	Temperature Degrees Fahrenheit	
				Air	Water
MORMACTERN	3-44	Consolidated-Wilmington, 227	?	?	?
MORRISON R. WAITE	5-8-44	Permanente, 503	?	50-63	53
MOSES BROWN	2-7-44/3-29-44	Walsh-Kaiser, 6	H	?	?
MOSES CLEAVELAND	5-5-43	Kaiser-Vancouver, 44	H	39	34
MOSES ROGERS	6-43	Permanente, 492	H	?	?
MOUNT KATMAI	1-17-45	North Carolina, 195	C	28	?
NAHODKA	12-44	Oregon, 712	?	?	?
NASHBULK	4-1-2-45	Welding Shipyard, 19	?	?	?
NATHAN TOWSON	3-27-45	Bethlehem-Fairfield, 2158	H	42	41
NATHANIEL BACON (1)	3-43	Alabama, 241	?	54-69	62-68
NATHANIEL BACON (2)	1-22-44	Alabama, 241	N	?	?
NATHANIEL BACON (3)	8-44	Alabama, 241	?	?	?
NATHANIEL CROSBY	4-44	Oregon, 756	?	?	?
NATHANIEL J. WYETH	4-26-43	Oregon, 639	?	?	?
NECHES	4-29-43	Sun, 221	?	?	?
NEGLEY D. COCHRAN (1)	12-15-44	St. Johns, 56	?	?	?
NEGLEY D. COCHRAN (2)	3-45	St. Johns, 56	?	?	?
NEHALEM (1)	8-44	Kaiser-Swan, 47	?	?	?
NEHALEM (2)	4-19-45	Kaiser-Swan, 47	N	?	?
NEW LONDON (1)	7-5-25-43	Kaiser-Swan, 7	N	?	50-91
NEW LONDON (2)	9-5-7-43	Kaiser-Swan, 7	N	?	54-92
NEW LONDON (3)	9-9-43/10-43	Kaiser-Swan, 7	N	?	54-90
NEW LONDON (4)	2-17-44	Kaiser-Swan, 7	?	?	?
NEW LONDON (5)	5-26-44	Kaiser-Swan, 7	?	?	?
NEWBERG (1)	12-10-44/1-10-45	Kaiser-Swan, 52	?	?	?
NEWBERG (2)	2-45	Kaiser-Swan, 52	?	?	?
NICHOLAS GILMAN (1)	1-3-4-43	Houston, 9	H	40	?
NICHOLAS GILMAN (2)	1-44	Houston, 9	H	55-60	54-60
NICHOLAS GILMAN (3)	2-19-45	Houston, 9	?	?	?
NICHOLAS HERKIMER (1)	12-20-43/2-4-44	Southeastern, 14	H	50-55	45
NICHOLAS HERKIMER (2)	2-19-24-44	Southeastern, 14	N	?	?
NORTHFIELD	9-12-43	Kaiser-Swan, 9	H	?	?
NORWICH VICTORY	5-2-45	Calship, V-53	H	58	?
NOVOROSSISK	12-2-25-43	Oregon, 688	?	?	?
O. B. MARTIN	2-45	Todd-Houston, 131	?	?	?
OBERON	1-10-44	Federal, 184	?	?	?
OCEAN MAIL (1)	3-1-16-43	Sun, 199	H	?	?
OCEAN MAIL (2)	3-43/4-43	Sun, 199	H	?	?
OCEAN MAIL (3)	10-43	Sun, 199	H	?	?
OCEAN MAIL (4)	2-28-44	Sun, 199	?	?	?
OLIVER EVANS	2-17-44	Permanente, 1109	?	?	?
OKLAHOMA	8-28-44	Sun, 198	?	?	?
OPEQUON	1-20-44	Sun, 312	?	?	?
ORAN M. ROBERTS	10-17-44	Houston, 74	H	?	?
OREGON TRAIL (1)	2-12-44	Kaiser-Swan, 34	?	?	?
OREGON TRAIL (2)	7-5-44	Kaiser-Swan, 34	?	?	?
OSCAR S. STRAUS	12-12-44	Delta, 79	H	?	?
P. T. BARNUM	8-43	Calship, 188	H	?	?
PALO ALTO (1)	10-9-43	Sun, 279	?	?	?
PALO ALTO (2)	4-18-44	Sun, 279	?	?	?
PAN-MAINE	4-44	Federal, 141	H	?	?
PAN-PENNSYLVANIA	3-17-28-44	Welding Shipyard, 13	H	?	?
PAN-RHODE ISLAND	4-44	Federal, 189	H	?	?
PARK BENJAMIN	3-28-44	New England, 3008	C	25	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
PEDRO MENENDEZ	4–45	Jones-Panama, 54	H	?	?
PEREGRINE WHITE (1)	1–25–44	New England, 248	H	40	45
PEREGRINE WHITE (2)	10–44	New England, 248	H	?	?
PEROTE	11–44	Sun, 286	?	?	?
PERRYVILLE	10–26–44	Sun, 263	?	?	?
PETER CARTWRIGHT	2–22–44	Calship, 57	H	?	?
PETER DONAHUE	2–23–24–44	Marinship, 12	H	65	62
PETER J. MCGUIRE	12–30–44/1–2–45	Permanente, 6	H	?	?
PETER V. DANIEL	12–15–43	Calship, 86	H	?	?
PETERSBURG	11–1–20–44	Sun, 296	?	?	?
PHILIP F. THOMAS	4–45/5–45	Bethlehem-Fairfield, 2229	H	?	?
PHILIP P. BARBOUR	1–44	Calship, 85	H	?	?
PHILIP KEARNY	12–44	Marinship, 5	H	?	?
PHILIP SCHUYLER	6–12–44	Oregon, 184	N	86	67
PHINEAS BANNING (1)	8–43	Calship, 136	H	?	?
PHINEAS BANNING (2)	12–11–43	Calship, 136	H	60	64
PIERRE S. DUPONT	1–26–45	Oregon, 576	C	8	30–32
PIO PICO	1–12–28–45	Calship, 121	H	?	?
PLATTE	4–7–43	Bethlehem-Sparrows, 4329	?	?	?
PLATTSBURG	5–11–44	Kaiser-Swan, 24	?	?	?
POCOHONTAS (1)	8–21–43	North Carolina, 49	C	67–70	29
POCOHONTAS (2)	2–44	North Carolina, 49	H	55	62
POLAND VICTORY (1)	7–44	Oregon, 1003	?	?	?
POLAND VICTORY (2)	12–31–44	Oregon, 1003	H	?	?
PONCE DE LEON	9–44	St. Johns, 1	?	?	?
PRINCE L. CAMPBELL	2–18–44	Oregon, 771	H	?	?
PUEBLO	8–44	Sun, 256	?	?	?
QUEBEC (1)	2–43	Kaiser-Swan, 2	?	?	?
QUEBEC (2)	5–31–44	Kaiser-Swan, 2	C	72	66
R. C. BRENNAN (1)	6–15–43	Oregon, 695	N	?	?
R. C. BRENNAN (2)	7–22–43/8–7–43	Oregon, 695	H	?	?
R. C. BRENNAN (3)	11–11–43	Oregon, 695	?	?	?
R. C. BRENNAN (4)	5–23–44	Oregon, 695	C	54	?
R. C. BRENNAN (5)	12–19–44	Oregon, 695	N	36	60
R. C. STONER (1)	9–44	Sun, 239	H	?	?
R. J. REYNOLDS	1–3–45	Jones-Brunswick, 162	?	?	?
R. M. WILLIAMSON	2–17–45	Houston, 78	H	?	?
RAINIER	6–21–44	Kaiser-Swan, 54	?	?	?
RALPH BARNES	9–44	Oregon, 815	?	?	?
REGINALD A. FESSENDEN (1)	4–10–44	Delta, 75	H	52	54
REGINALD A. FESSENDEN (2)	1–45	Delta, 75	?	?	?
RENALD FERNALD	10–44	New England, 2215	C	48	60
REUBEN SNOW	1–12–44	Pacific Bridge, 5	?	?	?
RICHARD CASWELL	6–43	North Carolina, 48	H	?	?
RICHARD H. ALVEY	1–16–23–44	Bethlehem-Fairfield, 2040	H	?	?
RICHARD HARDING DAVIS	8–1–44	Oregon, 671	?	?	?
RICHARD J. CLEVELAND (1)	1–28–44	Calship, T–4	H	24	34
RICHARD J. CLEVELAND (2)	3–23–44	Calship, T–4	?	?	?
RICHARD J. REISS	10–17–43	Great Lakes-River Rouge, 290	H	?	?
RICHARD JORDAN GATLING	7–31–45	Permanente, 419	N	81	60
RICHARD M. JOHNSON (1)	3–17–44	Delta, 60	H	?	?
RICHARD M. JOHNSON (2)	9–44	Delta, 60	?	?	?
RICHARD M. JOHNSON (3)	12–13–44	Delta, 60	C	38	42
RICHARD MANSFIELD	3–31–44	Oregon, 608	?	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
RICHMOND MUMFORD PEARSON (1)	3-31-43	Delta, 29	?	?	?
RICHMOND MUMFORD PEARSON (2)	4-23-43/5-14-43	Delta, 29	H	30-39	40-42
RICHARD OLNEY (1)	3-43	Delta, 37	?	?	?
RICHARD OLNEY (2)	3-43	Delta, 37	?	66-73	66-70
RICHARD RUSH	1-24-45/2-5-45	Oregon, 621	N	60-65	66-68
RIVER RAISIN (1)	10-31-43	Kaiser-Swan, 15	?	?	?
RIVER RAISIN (2)	7-7-44	Kaiser-Swan, 15	?	?	?
ROBERT C. STANLEY	11-10-43	Great Lakes-River Rouge, 294	H	?	?
ROBERT C. TUTTLE	6-4-43	Sun, 194	C	9	?
ROBERT E. CLARKSON (1)	1-25-45	Todd-Houston, 161	?	13	?
ROBERT E. CLARKSON (2)	6-13-45	Todd-Houston, 161	N	55	48
ROBERT EDEN	5-30-44	Bethlehem-Fairfield, 2165	?	?	?
ROBERT ERSKINE	10-20-43	Bethlehem-Fairfield, 2159	H	?	?
ROBERT G. INGERSOLL (1)	10-11-43	Calship, 226	?	?	?
ROBERT G. INGERSOLL (2)	1-29-44	Calship, 226	?	?	?
ROBERT HOWE	7-43	North Carolina, 57	?	?	?
ROBERT LOWRY (1)	4-11-44	Delta, 55	?	?	?
ROBERT LUCAS	4-22-44	Permanente, 1560	?	?	?
ROBERT MORRIS	8-1-44	Calship, 7	?	?	85
ROBERT NEWALL (1)	10-10-20-43	Oregon, 684	H	?	?
ROBERT NEWALL (2)	12-43	Oregon, 684	?	?	?
ROBERT NEWALL (3)	1-6-44	Oregon, 684	H	?	?
ROBERT NEWALL (4)	4-44	Oregon, 684	?	?	?
ROBERT ROGERS	2-25-44	New England, 281	H	52-62	57-58
ROBERT S. LOVETT	2-45	Todd-Houston, 155	H	?	?
ROBERT STUART	10-44	Calship, 131	?	?	?
ROBERT TOOMBS	6-45	Southeastern, 7	H	?	?
ROBERT TREAT	5-16-44	New England, 276	?	?	?
ROBERT TREAT PAINE	4-44	Bethlehem, Fairfield, 2019	H	54-58	63-64
ROBERT TRIMBLE	5-2-44	Jones-Brunswick, 109	?	?	?
ROCKLAND VICTORY	3-18-20-45	Oregon, 1017	H	?	?
ROGER GRISWOLD (1)	1-12-44	Delta, 43	H	38	58
ROGER GRISWOLD (2)	2-8-25-44	Delta, 43	N	25-45	36-49
ROGER GRISWOLD (3)	5-29-45	Delta, 43	N	60	52
ROGER MOORE	3-4-44	North Carolina, 81	H	?	?
ROUGE RIVER	12-44	Alabama, 316	H	53-63	64-65
ROSEBUD (1)	6-44	Alabama, 258	H	?	?
ROSEBUD (2)	12-44	Alabama, 258	?	?	?
RUFUS C. DAWES	10-43	St. Johns, 12	H	?	?
RUSSELL H. CHITTENDEN	10-2-4-44	Calship, 297	H	79	75
S. M. BABCOCK (1)	10-14-43	Oregon, 590	H	38	46
S. M. BABCOCK (2)	1-7-27-44	Oregon, 590	N	38	46
SABINE SUN	1-23-45	Sun, 234	?	?	?
SACAJAWEA (1)	4-18-44	Oregon, 612	?	?	?
SACAJAWEA (2)	5-43	Oregon, 612	H	?	?
SACAJAWEA (3)	2-44	Oregon, 612	N	48-52	52
SAG HARBOR	10-1-25-44	Sun, 337	?	?	?
SAGUARO	4-1-22-45	Kaiser-Swan, 119	?	?	?
SALAMONIE	12-5-41	Newport News, 372	?	?	?
SALVADOR BRAU	3-1-44	Jones-Panama, 25	?	?	?
SAMARINDA (1)	11-27-43	Calship, 249	?	?	?
SAMARINDA (2)	4-44	Calship, 249	?	?	?
SAMAROVSK	4-44	Calship, 236	?	?	?
SAM BUFF	8-44	Bethlehem-Fairfield, 2269	?	?	?

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TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
SAMBUR	12-4-43	Calship, 247	?	?	?
SAMBLADE	9-43	Calship, 230	H	?	?
SAMCALIA (1)	12-13-43	Calship, 252	?	?	?
SAMCALIA (2)	2-44	Calship, 252	?	?	?
SAMDON	12-28-43	New England, 2210	C	16	34
SAM HOLT	10-43	Calship, 218	H	?	?
SAM HOUSTON II (1)	2-4-44	Houston, 70	H	38	42
SAM HOUSTON II (2)	5-31-44	Houston, 70	?	?	?
SAM JACKSON	5-30-44/6-1-44	Oregon, 632	?	?	?
SAMMONT	4-45	Calship, 255	?	?	?
SAMPAN	10-45	Calship, 234	H	?	?
SAMPEP	11-15-43	Calship, 242	?	?	?
SAMPFORD	3-44	Permanente, 2099	?	?	?
SAMSON (1)	12-43	Calship, 219	?	?	?
SAMSON (2)	1-45	Calship, 219	H	?	?
SAMTREDY (1)	4-44	Calship, 251	?	?	?
SAMTREDY (2)	2-45	Calship, 251	?	?	?
SAMTROY	4-17-44	Bethlehem-Fairfield, 2282	?	?	?
SAMTYNE	2-45	New England, 2222	H	?	?
SAMUEL ADAMS	2-3-44	Calship, 8	C	32	34
SAMUEL ASHE	10-30-42	North Carolina, 20	C	?	?
SAMUEL CHASE (1)	5-2-44	Bethlehem-Fairfield, 2010	?	?	?
SAMUEL CHASE (2)	3-45	Bethlehem-Fairfield, 2010	?	?	?
SAMUEL CHASE (3)	4-11-45	Bethlehem-Fairfield, 2010	H	?	?
SAMUEL CHASE (4)	6-45	Bethlehem-Fairfield, 2010	?	?	?
SAMUEL COLT	4-12-44	Oregon, 585	?	38-43	42
SAMUEL D. INGHAM (1)	5-43	Oregon, 622	?	?	?
SAMUEL D. INGHAM (2)	11-7-43	Oregon, 622	N	40	42
SAMUEL D. INGHAM (3)	1-12-44	Oregon, 622	C	?	?
SAMUEL D. INGHAM (4)	3-31-44	Oregon, 622	H	12-20	38
SAMUEL DEXTER (1)	11-43	Delta, 42	?	?	?
SAMUEL DEXTER (2)	1-21-44	Delta, 42	H	40	48
SAMUEL F. B. MORSE	5-43	Bethlehem-Fairfield, 2379	H	52-66	50-51
SAMUEL GRIFFIN	3-24-44	Houston, 10	?	42-52	39
SAMUEL J. TILDEN	6-30-43	Oregon, 597	?	70-62	70
SAMUEL JOHNSTON	5-18-45	Bethlehem-Fairfield, 2033	C	55-64	50-66
SAMUEL MCINTYRE	7-2-43	Bethlehem-Fairfield, 2150	?	?	?
SAMUEL NELSON (1)	1-20-44	Calship, 87	H	36	34
SAMUEL NELSON (2)	2-29-44	Calship, 87	H	38	41
SAMUEL NELSON (3)	3-26-44	Calship, 87	N	49	51
SAMUEL PARKER	2-44	Oregon, 593	H	?	?
SAMUEL SAMUELS (1)	12-21-43	Walter Butler, 22	C	7	?
SAMUEL SAMUELS (2)	1-11-44	Walter Butler, 22	?	?	?
SAMUEL SEABURY	12-42	Oregon, 572	?	?	?
SAMYTHIAN	1-14-44	New England, 2212	C	18	?
SAMZONA	3-14-44	Oregon, 761	?	?	?
SAN ANTONIO	12-1-16-44	Sun, 255	?	?	?
SANTA BARBARA	7-5-44	Federal, 239	?	?	?
SANTA CECILIA	4-8-44	Federal, 233	?	?	?
SANTA CRUZ	7-1-43	Bethlehem-San Francisco, 5360	H	?	?
SANTA ISABEL	4-43	Newport News, 373	?	?	?
SANTA MARIA (1)	12-42	Federal, 235	H	?	?
SANTA MONICA	2-43	Federal, 155	H	?	?
SCHENECTADY (1)	1-16-43	Kaiser-Swan, 1	C	23	38

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Schenectady (2)	8–43	Kaiser-Swan, 1	?	?	?
Schenectady (3)	9–43	Kaiser-Swan, 1	?	?	?
Schuyler Colfax (1)	2–24–44	Calship, T–20	H	30	60
Schuyler Colfax (2)	3–25–44	Calship, T–20	H	53	54
Schuyler Colfax (3)	6–11–44	Calship, T–20	N	56	?
Schuyler Colfax (4)	2–2–45	Calship, T–20	C	38	40
Schuyler Colfax (5)	2–10–45	Calship, T–20	N	38–40	40
Schuyler Colfax (6)	4–45	Calship, T–20	?	?	?
Sea Angler	2-9-11–44	Western Pipe, 121	N	?	?
Sea Bass	1–5–44	Western Pipe, 80	H	55	52
Sea Kay	1–44	Sun, 231	?	?	?
Sea Porpoise (1)	4–6–44	Ingalls, 332	H	50–67	37–67
Sea Porpoise (2)	7–3–45	Ingalls, 332	N	65	65
Sea Serpent (1)	12–31–42	Sun, 206	?	?	?
Sea Serpent (2)	5–15–43	Sun, 206	?	?	?
Sea Serpent (3)	6–21–43	Sun, 206	?	?	?
Sea Serpent (4)	7–18–43	Sun, 206	?	?	?
Sea Serpent (5)	8–9–43	Sun, 206	?	?	?
Sea Serpent (6)	9–20–43	Sun, 206	?	?	?
Sea Serpent (7)	10–2–44	Sun, 206	?	?	?
Sea Tiger	12–7–44	Ingalls, 409	H	65	?
Seamobile (1)	7–44	U. S. Shipbuilding, 5	H	?	?
Sebastain Cermeno	3–43	Marinship, 11	?	?	?
Sebastian Vizcaino	3–23–44	Calship, 105	H	?	?
Sedalia Victory	3-18-24–45	Bethlehem-Fairfield, 2441	H	?	?
Sevastopol	1–7–44	Oregon, 670	C	?	?
Seven Pines	6–27–44	Sun, 259	?	?	?
Sewell Avery (1)	5–21–43	American-Lorain, 827	N	?	?
Sewell Avery (2)	12–44	American-Lorain, 827	?	?	?
Shabonee	9-1-5–44	Bethlehem-Sparrow, 4386	?	?	?
Shooting Star (1)	8–14–42	Sun, 205	?	?	?
Shooting Star (2)	2–23–43	Sun, 205	?	?	?
Shooting Star (3)	4–43	Sun, 205	?	?	?
Shooting Star (4)	5–22–43	Sun, 205	?	?	?
Shooting Star (5)	8–13–43	Sun, 205	?	?	?
Shooting Star (6)	8–31–43/9–9–43	Sun, 205	?	?	?
Shooting Star (7)	10–4–43	Sun, 205	?	?	?
Shooting Star (8)	3–14–44	Sun, 205	?	34–38	45–52
Sidney Edgerton	5–23–44	Oregon, 754	?	?	?
Sidney Sherman	3–25–44	Houston, 66	?	?	?
Silas Weir Mitchell (1)	2–45	Bethlehem-Fairfield, 2125	?	?	?
Silas Weir Mitchell (2)	5–31–45	Bethlehem-Fairfield, 2125	C	49	59
Silverbow Victory	10–9–44	Oregon, 1024	?	?	?
Simon Newcomb	3–4–44	Calship, 158	N	54	52
Simon Willard	4–18–44	Alabama, 284	?	50–52	57
Skagway Victory	10-1-28–44	Oregon, 1032	?	?	?
Skull Bar	1-1-8–45	Alabama, 267	?	?	?
Smoky Hill	12–44	Kaiser-Swan, 38	?	?	?
Solon Turman	5–43	Consolidated-Wilmington, 231	?	?	?
Somme	5–15–45	Sun, 434	?	?	?
South Mountain	12–44	Sun, 303	?	?	?
Sovetskaya Gavan	2–44	Oregon, 708	?	?	?
Spottsylvania	4–1–44	Sun, 297	?	?	?
Stag Hound (1)	9–42	Sun, 204	?	?	?

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
STAG HOUND (2)	11-25-42	Sun, 204	?	?	?
STAG HOUND (3)	1-19-43	Sun, 204	H	?	?
STAG HOUND (4)	2-9-43	Sun, 204	?	?	?
STAGE DOOR CANTEEN	5-45	Bethlehem-Fairfield, 2252	?	?	?
STANFORD NEWEL	3-8-44	Oregon, 685	?	?	?
STANVAC CAPE TOWN	7-5-42	Bethlehem-Fore River, 1486	H	54	44
STEELTON	2-16-43	Great Lakes-Ashtabula, 525	?	?	?
STEPHEN A. DOUGLAS	4-14-43	Oregon, 178	N	44-70	44
STEPHEN B. ELKINS (1)	1-15-18-44	Oregon, 618	H	?	?
STEPHEN B. ELKINS (2)	4-11-14-44	Oregon, 618	H	?	?
STEPHEN C. FOSTER (1)	3-14-43	Houston, 37	C	32	30
STEPHEN C. FOSTER (2)	12-7-43	Houston, 37	H	38	47
STEPHEN F. AUSTIN	3-22-44	Houston, 26	N	52	54
STEPHEN H. LONG	7-21-43	Calship, 215	?	86	70
STEPHEN HOPKINS	5-20-43	Permanente, 2283	H	?	?
STEPHEN JOHNSON FIELD	3-20-44	Calship, 34	H	?	?
STEPHEN R. MALLORY	1-11-44	Jones-Panama, 22	C	34-50	53
STONEY CREEK	12-1-21-44	Kaiser-Swan, 21	?	?	?
SUCHAN	5-16-44	Calship, 180	?	?	?
SUL ROSS	3-45	Houston, 127	?	?	?
SURPRISE (1)	7-4-42	Sun, 203	?	?	?
SURPRISE (2)	10-27-42	Sun, 203	?	?	?
SURPRISE (3)	5-30-43	Sun, 203	?	?	?
SURPRISE (4)	6-30-43	Sun, 203	?	?	?
SURPRISE (5)	8-12-43	Sun, 203	?	?	?
SURPRISE (6)	10-10-43	Sun, 203	?	?	?
SURPRISE (7)	4-44	Sun, 203	H	?	?
SUSAN COLBY	1-18-44	New England, 2213	?	3	?
SUWANEE	12-4-41	Federal, 151	?	?	?
SWAN ISLAND	4-5-45	Kaiser-Swan, 86	N	?	?
TABLE ROCK	4-22-44	Kaiser-Swan, 41	?	?	?
TAPPAHANNOCK	2-5-43/11-13-43	Sun, 226	N	?	?
TELFAIR STOCKTON (1)	12-44	St. John's, 71	?	?	?
TELFAIR STOCKTON (2)	12-44	St. John's, 71	?	?	?
THEODORE DWIGHT WELD	3-13-43	Calship, 142	C	53-58	59
THEODORE PARKER (1)	1-9-44	Calship, 143	H	44	54
THEODORE PARKER (2)	3-30-44	Calship, 143	C	43	41
THEODORE SEDGWICK	11-28-43	Houston, 29	H	55	?
THOMAS A. HENDRICKS	6-30-43/7-12-43	Oregon, 689	H	?	?
THOMAS B. KING	3-45	Jones-Brunswick, 154	?	?	?
THOMAS FITZSIMONS (1)	5-26-44	Delta, 47	?	?	?
THOMAS FITZSIMONS (2)	2-4-45	Delta, 47	N	34	40
THOMAS HILL	1-30-45/2-1-45	Calship, 177	N	?	?
THOMAS HOOKER	3-5-43	New England, 203	H	22	38
THOMAS HOWELL (1)	3-1-4-44	Oregon, 769	H	?	?
THOMAS HOWELL (2)	8-15-44	Oregon, 769	?	?	?
THOMAS JOHNSON (1)	2-5-43	Calship, 84	?	?	?
THOMAS JOHNSON (2)	4-14-43	Calship, 84	H	?	?
THOMAS JOHNSON (3)	5-43	Calship, 84	?	?	?
THOMAS JOHNSON (4)	6-45	Calship, 84	?	?	?
THOMAS KEARNS	5-18-44	Permanente, 462	?	?	?
THOMAS L. CLINGMAN	6-29-43	North Carolina, 86	H	43	70
THOMAS LYNCH (1)	12-42	Alabama, 239	?	?	?
THOMAS LYNCH (2)	12-43	Alabama, 239	?	65	68

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey, or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
Thomas MacDonough	11-14-42	Oregon, 182	H	?	?
Thomas Paine	6-8-44	Calship, 2	?	32	61
Thomas Pinckney	5-5-44	North Carolina, 32	?	64-81	65
Thomas R. Marshall (1)	2-18-43/3-5-43	Bethlehem-Fairfield, 2083	H	?	?
Thomas R. Marshall (2)	2-45	Bethlehem-Fairfield, 2083	N	67-68	66-67
Thomas Scott (1)	12-21-42	Delta, 14	H	62	70
Thomas Scott (2)	3-44	Delta, 14	?	?	?
Thomas Sim Lee (1)	8-44	Bethlehem-Fairfield, 2071	?	?	?
Thomas Sim Lee (2)	1-45	Bethlehem-Fairfield, 2071	?	?	?
Thomas Sim Lee (3)	3-45	Bethlehem-Fairfield, 2071	N	?	?
Thomas Sim Lee (4)	4-15-45	Bethlehem-Fairfield, 2071	N	48	34
Thomas Stone	3-30-44	Bethlehem-Fairfield, 2014	?	?	58
Thomas Sumter (1)	3-2-4-43	North Carolina, 10	H	24	34
Thomas Sumter (2)	2-19-44	North Carolina, 10	N	11-36	34
Thomas W. Gregory	3-13-44	Houston, 89	H	?	?
Thomas W. Owen	1-44	North Carolina, 177	?	?	?
Thompson Lykes (1)	5-11-44	Bethlehem-Sparrows, 4346	?	?	?
Thompson Lykes (2)	6-44	Bethlehem-Sparrows, 4346	H	?	?
Ticonderoga (1)	3-5-44	Sun, 268	H	42	34
Ticonderoga (2)	6-16-44	Sun, 268	?	?	?
Ticonderoga (3)	11-1-21-44	Sun, 268	?	?	?
Tillamook (1)	6-15-44	Kaiser-Swan, 48	?	86	85
Tillamook (2)	9-1-21-44	Kaiser-Swan, 48	?	?	?
Tobias E. Stansbury	8-20-45	Delta, 69	?	?	?
Tomas Guardia	12-27-44	Todd-Houston, 147	N	23	36
Trade Wind (1)	4-28-43	Moore, 216	?	58	?
Trade Wind (2)	2-3-44	Moore, 216	N	?	?
Tumacacori	3-45	Kaiser-Swan, 68	?	?	?
Turkey Island	12-44	Sun, 420	H	?	?
Valeri Chkalov	12-11-43	Permanente, 481	H	29-36	?
Van Lear Black	2-44	Bethlehem-Fairfield, 2313	H	?	?
Vera Cruz (1)	3-23-44	Sun, 253	?	?	?
Vera Cruz (2)	6-45	Sun, 253	?	?	?
Vernon L. Kellogg	2-5-44	Calship, 224	H	52	63
Victor Herbert (1)	1-30-44	Jones-Panama, 14	H	20	?
Victor Herbert (2)	5-5-44	Jones-Panama, 14	?	?	?
Virginia (1)	6-3-43	Welding Shipyard, 11	?	?	?
Virginia (2)	4-44/6-44	Welding-Shipyard, 11	H	?	?
Virginia Dare	12-42	North Carolina, 3	?	?	?
Vitus Bering	4-20-44	Permanente, 463	?	?	?
W. P. Few	6-1-45	Jones-Brunswick, 148	?	?	?
W. R. Grace	9-44	Bethlehem-Fairfield, 2245	?	?	?
W. W. Atterbury	8-30-43	Detroit, 179	H	47	50
Wagon Box	3-1-8-45	Alabama, 262	?	?	?
Walker D. Hines	12 11-15-44	Delta, 122	H	55	74
Wallace E. Pratt	2-43	Sun, 161	?	?	?
Wallowa	3-45	Kaiser-Swan, 42	?	?	?
Walt Whitman	11-43	Oregon, 232	?	47	60
Walter E. Ranger	6-5-45	South Portland, 259	C	68	61
Walter Forward	1-45	Oregon, 626	N	51-60	66-69
Walter Hines Page (1)	12-23-43	North Carolina, 90	H	33	54
Walter Hines Page (2)	4-44	North Carolina, 90	H	?	?
Walter Raleigh (1)	3-10-44	North Carolina, 55	?	20-38	39
Walter Raleigh (2)	6-13-44	North Carolina, 55	?	71-91	76

Table XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey or Report	Builder and hull no.	Sea condition	Temperature Degrees Farhenheit Air	Water
Warrior (1)	4-12-14-44	Gulf, 10	H	61	56
Warrior (2)	1-27-45	Gulf, 10	N	32	47
Washington Allston	3-7-8-44	New England, 2217	H	?	?
Wayne MacVeagh	12-16-44	Permanente, 2142	?	?	?
Webb Miller	2-17-44	New England, 2205	H	?	?
Wellesley	5-13-44/6-1-44	Bethlehem-Sparrows, 4389	N	50-75	54-76
White Oak (1)	3-13-20-44	Kaiser-Swan, 31	?	?	?
White Oak (2)	6-20-44	Kaiser-Swan, 31	?	?	?
White Plains	8-43	Sun, 265	?	?	?
White River	8-44	Alabama, 274	?	?	?
Wilbur Wright	5-25-44	Permanente, 1101	?	?	?
William A. Graham	2-21-43	North Carolina, 16	?	?	?
William A. Henry (1)	6-1-23-44	Oregon, 817	?	?	?
William A. Henry (2)	9-25-44	Oregon, 817	N	76	66
William Black Yates (1)	12-28-43	Southeastern, 24	H	34	35
William Black Yates (2)	2-28-44	Southeastern, 24	H	?	?
William Black Yates (3)	3-30-44/4-10-44	Southeastern, 24	H	?	?
William Blount	5-43	Delta, 27	?	79	79
William Bradford (1)	1-5-6-43	South Portland, 208	H	?	?
William Brewster (1)	12-30-42	South Portland, 209	C	30	?
William Brewster (2)	1-21-43	South Portland, 209	?	?	?
William Byrd	10-43	St. John's, 11	H	?	?
William Carson (1)	12-13-43	Calship, 165	H	?	?
William Carson (2)	4-10-15-44	Calship, 165	?	?	?
William Coddington	4-12-44	Rheem, 1	?	?	?
William Cushing	3-29-45	Permanente, 496	C	47	51
William D. Moseley	1-28-45	North Carolina, 73	H	11-20	9-25
William D. Pender (1)	3-15-43	North Carolina, 72	C	?	?
William D. Pender (2)	1-20-45	North Carolina, 72	?	?	?
William Dean Howells	2-45	Permanente, 489	H	?	?
William E. Borah	1-28-44	Oregon, 614	?	?	?
William E. Pendleton (1)	10-5-43	Delta, 72	H	?	?
William E. Pendleton (2)	2-16-44	Delta, 72	?	?	?
William E. Pendleton (3)	6-2-45	Delta, 72	N	62	73
William F. Cody	2-44	Calship, 50	H	?	?
William Few (1)	12-43	Bethlehem-Fairfield, 2059	?	42	?
William G. Fargo (1)	11-43	Calship, 160	?	?	?
William G. Fargo (2)	4-20-44	Calship, 160	?	?	?
William H. Aspinwall	7-6-44	Permanente, 521	H	?	?
William H. Crawford	5-5-43	Houston, 40	H	?	?
William H. Gray	9-44	Oregon, 687	?	?	?
William H. McGuffey	2-1-2-44	Oregon, 672	H	49	52
William H. Prescott (1)	7-43	Calship, 48	?	?	?
William H. Prescott (2)	2-1-44	Calship, 48	H	52	50
William H. Seward	3-20-43	Oregon, 562	N	84	81
William H. Wilmer	3-44	Bethlehem-Fairfield, 2109	H	?	?
William Harper	5-7-8-44	Delta, 32	C	62	56
William Hawkins (1)	12-17-42	North Carolina, 31	H	?	?
William Hawkins (2)	3-8-9-44	North Carolina, 31	H	?	?
William James (1)	2-24-44	Calship, 161	?	?	?
William James (2)	3-44	Calship, 161	H	?	?
William K. Kamaka	2-45	Todd-Houston, 192	H	?	?
William L. Marcy (1)	10-31-43	Calship, 113	H	50	56
William L. Marcy (2)	11-14-43	Calship, 113	H	44	54

TABLE XIV—Continued

Casualties Reported Up to 1 August 1945

Vessel	Date of Casualty, Survey or Report	Builder and hull no.	Sea condition	Temperature Degrees Fahrenheit	
				Air	Water
WILLIAM L. MARCY (3)	1-12-44	Calship, 113	H	38	51
WILLIAM L. MARCY (4)	3-4-44	Calship, 113	?	?	?
WILLIAM L. MARCY (5)	4-44	Calship, 113	H	?	?
WILLIAM L. SMITH (1)	3-43	Houston, 36	H	?	?
WILLIAM L. SMITH (2)	4-5-43	Houston, 36	H	33	48
WILLIAM M. EASTLAND (1)	3-44	Houston, 109	H	?	?
WILLIAM M. EASTLAND (2)	11-44	Houston, 109	?	?	?
WILLIAM M. MEREDITH	3-5-44	Oregon, 630	C	34	35
WILLIAM M. RAYBURN	9-44	Houston, 91	?	?	?
WILLIAM MACLAY	2-43	Bethlehem-Fairfield, 2034	H	47-60	66-72
WILLIAM MOULTRIE (1)	4-43	North Carolina, 9	?	55-65	68-74
WILLIAM MOULTRIE (2)	1-14-27-44	North Carolina, 9	H	40-50	40
WILLIAM MULHOLLAND (1)	5-7-9-43	Calship, 102	H	?	?
WILLIAM MULHOLLAND (2)	3-10-44	Calship, 102	?	64-68	69-71
WILLIAM MULHOLLAND (3)	5-29-44	Calship, 102	C	62	66
WILLIAM P. DUVAL	5-45	Jones-Panama, 60	?	?	?
WILLIAM PATTERSON (1)	3-30-44	Bethlehem-Fairfield, 2035	N	35	42
WILLIAM PATTERSON (2)	4-45	Bethlehem-Fairfield, 2035	?	?	58
WILLIAM PEPPER	10-44	Bethlehem-Fairfield, 2124	H	?	?
WILLIAM PHIPS	3-3-44	New England, 268	?	?	?
WILLIAM R. DAY	1-45	Bethlehem-Fairfield, 2091	?	?	?
WILLIAM S. ROSECRANS	4-17-43	Oregon, 570	?	43-51	42
WILLIAM T. BARRY	6-8-14-45	North Carolina, 164	C	67-79	58-59
WILLIAM T. COLEMAN (1)	4-44	Marinship, 2	H	?	?
WILLIAM T. COLEMAN (2)	8-1-44	Marinship, 2	?	?	?
WILLIAM T. SHERMAN	12-27-42	Oregon, 600	H	?	?
WILLIAM W. LORING	4-44	Jones-Panama, 28	H	?	?
WILLIAM WILKINS	3-44	Houston, 47	?	?	?
WILLIAM WIRT	3-12-43	Bethlehem-Fairfield, 2037	H	?	?
WILSON P. HUNT (1)	12-43	Oregon, 701	?	?	?
WILSON P. HUNT (2)	1-14-44	Oregon, 701	H	34	?
WINFIELD SCOTT	1-3-44	Houston, 4	H	?	47
WINSLOW HOMER	8-43	South Portland, 253	?	71-84	84
WOOD LAKE	8-1-17-44	Alabama, 275	?	?	?
WYOMING VALLEY	12-1-8-44	Alabama, 271	?	?	?
Y 38	7-44	Odenbach, 13	?	?	?
Y 42	7-44	Odenbach, 17	?	?	?
ZANE GREY	4-45	Sun, 120	?	?	?
ZONA GALE	1-29-44	Calship, 222	H	?	?

EXHIBIT II

Summary of Research Investigations

1 May 1946

Report
RESEARCH ADVISORY COMMITTEE

Introduction

As a result of structural failures in welded ships, numerous research investigations were started at the instigation of the Board convened 20 April 1943 by the Secretary of the Navy to investigate the design and methods of construction of welded steel merchant vessels, and by other governmental and private agencies to determine the relative importance of the various factors thought to contribute to these failures.

The several research investigations which have been undertaken to determine the cause, or causes, of failure in welded steel ships may be classified as follows:

1. DESIGN
2. FABRICATION
3. MATERIALS

The Board appointed a Research Advisory Committee to take cognizance of, coordinate and evaluate all research work which was considered to have a bearing on the problem. The following report presents the results of the Committee's activity.

1. *Design*

a. GENERAL

Although static structural tests made on riveted ships prior to the advent of welding in shipbuilding had confirmed the general validity of the basic analytical methods used in calculating the stresses in the main hull girder, there were several factors involved which were considered sufficiently significant to justify making similar experiments on welded ships. These factors included: the possibility that there might be a difference in the overall behavior between riveted and welded construction as affected particularly by the differences in rigidity and geometry of riveted and welded joints; the fact that photoelectric studies showed appreciable stress concentration at hatch corners where so many cracks occurred on Liberty ships; and the further fact that modern developments of strain gages made possible the measurement of highly localized strains and the determination of unusual stress distributions that might not have been discovered in previous experiments.

The desirability of subjecting welded ships to the static structural test received further impetus from the large number of hull structural failures recorded particularly during the winters of 1942–43 and 1943–44. These failures were not limited to any one type of vessel, but occurred in ore carriers and tankers, as well as dry cargo vessels, particularly Liberty ships.

b. STRENGTH OF THE MAIN HULL GIRDER

Outstanding examples of the static structural tests carried out on rivited ships were those of the *Wolf*[a,1], *Cuyama*,[2] *Preston* and *Bruce*.[3] These ships were all of the naval destroyer type with the exception of the *Cuyama* which was a Navy tanker. None of these vessels had a structure comparable to that of the usual merchant cargo vessel, and all except the *Cuyama* were of relatively light scantlings with thin plating. No similar data appeared to be available for vessels of the merchant type.

In the investigation to determine the structural behavior of welded ships, at least a dozen vessels of several types have been subjected to the static structural test. Among the vessels thus tested were the Great Lakes ore carriers *Cadillac, John Hutchinson, Champlain, Frank Purnell*,[4] the Liberty ship *Philip Schuyler*[5] and the *T2* tanker *Shiloh*.[6]

These static structural tests of welded ships under known bending loads, particularly that of the *Philip Schuyler*,[5] have yielded the following important results:

i. The internal resisting moment computed from measured strains agreed with the applied bending moment.
ii. The longitudinal stresses in the side shell were proportional to the distance from the neutral axis.

[a]Reference number listed in Bibliography.

iii. The longitudinal stresses in the deck and bottom shell were not uniform but the mean value closely approximated the theoretical nominal stress. The causes of these nonuniformities were variations in restraint and shirking of load caused by buckling of the plating.

iv. A torsional moment applied to a Liberty ship produced only negligible stresses. The applied torque was approximately twice the value believed to be encountered at sea[7].

v. Tests on ore carriers where a welded and a riveted structure were present in each ship indicated a similar stress distribution in the two types of structure.

vi. A test showed that the Liberty ship deck house contributed very little to the overall hull strength.

c. HULL STRUCTURAL DETAILS

For operational reasons, it is necessary to introduce into the ship's hull numerous openings, erections, foundations and so on. At every point where such a structural discontinuity is introduced, uniform straining of the material under a bending load is interrupted and concentrations result.

Until the short base length (less than 1 inch) strain gage became available, experimental measurements of strain concentrations in ships were not possible. The need for accurate determination of concentrations was not as great in the riveted ship as in the welded ship. The monolithic character of the welded ship resulting from the method of fabrication can produce joints, particularly at structural discontinuities, that have high stress concentrations and severe restraint, thereby tending to inhibit plastic flow. This condition did not exist generally in the riveted ship. The danger of high concentrations at points of structural discontinuities in the welded ship is further aggravated by welding usually present at such points. Welding produces a complex metallurgical condition which is supplemented by the existence of locked-in stresses and this is frequently further aggravated by additional discontinuities in the form of defects in the weld. That stress concentrations of dangerous magnitude actually exist at structural discontinuities in welded ships has been amply demonstrated by the numerous fractures that started at such points, e.g., hatch corners, sheer strake cut-outs, defective welds, etc., and frequently propagated through the hull structure, thereby endangering the ship. Based on these considerations, the need for determining experimentally the magnitude of concentrations at structural discontinuities in welded ships and studying how these concentrations might be reduced became increasingly apparent.

The static structural tests of the Liberty ship *Philip Schuyler*[5] and the T2 Tankers *Ventura Hills*,[8] *Fort Mifflin*[9] and *Antelope Hills*[25] included measurements to evaluate concentrations. Most of the data on concentrations were obtained through the use of short base length electric strain gages at almost the very point of maximum concentration. Some important results regarding concentrations were as follows:

i. Stress measurements made in the plane of the deck 2 inches forward or aft and 2 inches outboard on the Liberty ship square hatch corner gave stress concentration factors not exceeding 2.0 with transverse stresses equal to about one-quarter of the principal value. Stress concentration factors on the fillet weld inside the square hatch corner at deck level were approximately 3.0.

ii. Stress concentration factors at the inside radius of the rounded hatch corners of a Liberty ship at deck level were of the order of 2.0. (A stress concentration of 3.4 was found in a similar corner at sea under dynamic conditions.)

iii. Under an alternating bending moment of low amplitude, the elastic strain concentration factors at the inside of the Liberty ship hatch openings at deck level were practically independent of the type of corner reinforcement and were of the order of 2.5. Approximately the same strain concentration was recorded when the maximum hogging bending moment was relaxed in the static test.

iv. The concentration factors given in paragraphs i, ii, and iii, above refer to elastic conditions. Stress concentration factors are used except in cases where the transverse strains were not measured, thus making it impossible to convert strain to stress, in which cases strain concentrations are used. When plastic deformations occur, the ratio of peak to average strain may have quite a different value. The behavior of typical structural details under plastic conditions needs much more extended study, but it appears that the main superiority of rounded over square hatch corners lies in their capacity for distributing the plastic action over a greater extent of metal, thereby reducing the local peak values of strain. (The rounded corners also have a similar distributing action in the elastic range.)

v. Measurements made at a point 3¼ inches away from the round hatch openings in the deck of a T2 tanker, gave a stress concentration factor of approximately 2.0.

vi. Appreciable stresses have been found in the material not normally considered part of the main hull strength girder such as the plating between hatches, hatch coamings and deck houses. These stresses reached values equal to those in the main hull girder immediately adjacent to the line of attachment.

vii. In the case of the superstructure of the T2 tankers, the stresses at various points in the fashion plate at the after end of the mid-ship deck house were comparable in magnitude to the stresses in the main deck amidships.

viii. Longitudinal stresses in the hatch coaming of the order of those in the strength deck were found near the ends of the hatch coaming on a Liberty ship and on an ore carrier.

ix. On the longitudinal bulkheads of the T2 tankers points of stress concentration existed where the center portion of the sloping faces of the corrugated bulkheads crossed the web of their vertical T-bars. Strains were measured 2 inches away from the intersection in question. A stress concentration factor of 2.0 was found, relative to the stress computed by analytical methods. Reinforcing brackets tried on one installation to relieve this condition indicated that the brackets reduced the stress intensity by approximately 40 percent. Transition plates tapering the bottom corrugation into the line of the web reduced the stress intensity at the lowest point of concentration by approximately 25 percent.

2. *Fabrication*

a. RESIDUAL WELDING STRESSES

Residual welding stresses are defined as the welding stresses produced in unrestrained members.

It was the considered opinion of the majority of technical shipbuilding personnel in the spring of 1943 that a prime factor causing the failure of welded ships was the existence of stresses locked in the hull structure, particularly in the welds and adjacent material. This opinion was based on the occurrence of cracks in welds made under high restraint and when the proper sequence had not been followed. The cause of these cracks was believed to be high residual stresses resulting from the welding operation. It was also believed that such high residual stresses were present to a degree in all welds and when they were combined with the working stresses of the ship, hull fractures resulted. For this reason, it was considered highly important that a prescribed welding sequence be followed in order to avoid, or at least minimize, residual stresses. In consequence, when this research program was started, emphasis was placed on a study of welding stresses.

In the investigation to determine the magnitude and distribution of residual stresses in typical ship weldments and actual ship subassemblies, a method of relaxing steel plugs, with and without welds, to which were affixed resistance wire strain gages was developed. Weldments consisting of 1 inch thick ship plates ranging in size from panels 4 feet x 6 feet to ship subassemblies 27 feet x 57 feet were investigated[12,13]. The magnitude and distribution of residual stresses were determined as a function of such variables as: manual and submerged melt welding;[14] welding sequences[12,13,14,15]; electrode[13,16,17,18,19,20]; restraint (¼ inch and ½ inch plates were also investigated)[14,15,19,20,21,22]; preheat[14,15]; peening[13,15]; mechanical loading along a butt weld;[13] and controlled low temperature stress relief[13,16]. Some salient results from these investigations were:

i. The magnitude and general pattern of the residual welding stresses existing in very large weldments (up to 27 feet x 57 feet) can be obtained in panels as small as 4 feet x 6 feet. These stresses were sufficiently reproducible either in Unionmelt or manual welding to enable significant effects of different controlled variables to be determined. In butt welds of free subassemblies, the longitudinal residual stresses along the center line of the weld reached a magnitude of approximately 47,000 p. s. i. in tension throughout the length of the weld except in the 9 inches adjacent to each end where they decreased to zero at the ends. The transverse residual stresses were low tension (usually less than 10,000 p. s. i.) except near the ends of the weld where they changed to compression, reaching values of from 20,000 to 30,000 p. s. i. at the very ends.

ii. Residual stresses in the welds of *free* subassemblies were generally not affected by the welding procedure or assembly sequence used. The above must not be construed to mean that proper welding and erection sequences are not important in fabrication as serious difficulties with weld cracking and distortion may occur if these are disregarded.

iii. It has been found that residual welding stresses can be relieved by the application of external load causing plastic flow of the weld metal and adjacent area. The same effect may be obtained in simple butt-welded joints with the plastic flow produced by thermal rather than mechanical methods; the effectiveness of this process in reducing the stress in complex joints has not so far been demonstrated.

iv. Peening the last pass of the welds will materially reduce the magnitude of residual welding stresses. On the basis of investigations performed, it does not appear that peening other passes than the last will effect reductions of final residual stresses. However, general experience has shown that peening intermediate and root passes is helpful in preventing weld cracking and in controlling distortion.

v. Preheating ship steel up to 375°F. does not reduce residual welding stresses significantly.

b. LOCKED-IN STRESSES

Locked-in stresses include residual welding stresses and the stresses resulting from other fabrication and assembly processes.

As a result of the fabrication of ships by welding, it was believed that high stresses could be locked into the structure generally. It was suggested that this was due to temperature differences existing when subassemblies were joined to the hull structure and/or to abnormal assembly sequences. The occasional ship containing such high locked-in stresses was then thought to present a case of potential structural failure. Accordingly, a research program was initiated to investigate locked-in stresses in the decks of a large number of ships.

The above program included. stress determinations in the decks of recently completed Liberty ships and several that had been in service[23a,23b,23c]; the history of the changes of the locked-in stresses starting from completed deck subassemblies and tracing these stresses through construction, launching, outfitting, loading, as well as during the first voyage of two Liberty ships;[24] the effect of the static structural test on the locked-in stresses in three type T2 tankers[25,26]; the stress effects due to temperature gradients through the hull structure;[27] the magnitude and distribution of locked-in stresses in the decks of 21 Victory ships constructed in three Pacific Coast yards;[28] the stresses produced by welding a large hot deck subassembly into a cooler hull structure;[29] and the use of X-ray diffraction measurements for determining stresses in hot rolled plate[30,31]. Some important results of these studies were:

i. Stresses at selected points in the deck welds of completed Liberty ships[b] were determined.[c] Longitudinally along the welds, these stresses were tensile and ranged from 20,000 to 50,000 p. s. i. with an average value of 36,000 p. s. i. Stresses transverse to the welds reached a maximum value of 11,000 p. s. i. in tension with an average value very close to zero. It was also determined that the stresses were not reduced appreciably in service. Therefore, it was concluded that high locked-in stresses were present in all welded ships. It was also concluded that locked-in stresses did not contribute materially to the failure of welded ships.

ii. The locked-in stresses in the fore and aft

[b]The computed tensile deck stresses resulting from the existing bending moments were essentially the same in all tests and ranged from 2,200 p. s. i. to 4,700 p. s. i. with an average value of 3,400 p. s. i.

[c]It should be noted that it is impossible with present strain gage techniques to determine locked-in stresses at structural discontinuities, e.g. hatch corners.

direction at selected points (away from welds) in the deck area abreast of No. 3 hatch of completed Liberty and Victory ships were found to be generally compressive. The ships having riveted gunwales had higher compressive stresses than those having welded gunwales. In the Victory ships these locked-in stresses ranged from 8,800 p. s. i. in tension to 16,600 p. s. i. in compression. Locked-in stresses near the gunwale of completed Victory ships were generally tensile and reached a maximum value of 5,900 p. s i. Higher values of locked-in tensile stresses were observed at other locations in the deck.

iii. Welding a large section (14 feet x 55 feet) into the deck of a Liberty ship with no temperature difference between the section and the deck resulted in a general increase in stress of about 5,000 p. s. i. Welding a large section (14 feet x 55 feet) into the deck of a Liberty ship with the section approximately 75°F. warmer than the deck resulted in a maximum increase of 15,000 p. s. i. These experiments were conducted using an unorthodox welding sequence selected to produce high stresses. The initial locked-in deck stresses (based on an estimated tensile deck stress resulting from the bending moment) determined at selected points abreast of No. 3 hatch ranged from 700 p. s. i. in tension to 6,700 p. s. i. in compression.

c. ADDITIONAL ASPECTS OF WELDING

Large welded structures have been fabricated and tested, and the effect of such variables as electrodes, preheat and postheat was studied. A detailed discussion is included in the section covering "materials."

An investigation of the cracking tendency of commercial E-6010 electrodes deposited under high restraint disclosed considerable variation within the applicable specifications.[20]

3. *Materials*

a. FUNDAMENTAL FACTORS AFFECTING STEEL BEHAVIOR

The incidence of serious failures of large welded steel structures both during service and in construction has resulted in the need for a better understanding of the fundamental factors affecting steel performance. Lack of reliable information in this field has led designers to over-design in the interest of safety, a procedure which in many cases enhances the possibility of failure.

At the present time the mechanism of metal fracture is not well understood[32,33]. Since some plastic deformation, even though highly localized, usually precedes fracture even in the case of cleavage or so-called "brittle" fractures of structures, a full understanding of the phenomenon of flow is essential in considering the fracture problem. Perhaps the best theory yet formulated involves the concepts of resistance to flow and resistance to fracture;[34] the theory postulates that if the stress required for fracture is greater than that required for flow, plastic deformation will occur; conversely, if the stress required for flow is greater than that required for fracture, rupture will take place. Flow may terminate in either shear or cleavage separation with the former characterized by high ductility, a fibrous or silky appearing fracture generally at 45° to the direction of applied load, and high energy absorption; and the latter by relatively low ductility, a granular or crystalline appearing fracture generally normal to the direction of applied load and in most cases low energy absorption. Cleavage fracture may occur, and often does, after appreciable flow; the term refers to a mode of separation and is not intended to apply only to completely brittle fracture without measurable deformation, although this case is obviously included.

It is to be emphasized that resistance to flow and resistance to fracture are extremely complex quantities influenced by a number of factors, the interrelationship of which is at present unknown.

The principal factors which must be considered in attempts to explain the low ductility (notch sensitivity) of structures fabricated from medium steel of the type used in ship construction may be conveniently listed as follows:

State of Stress—Constraint
Temperature
Velocity—Strain Rate
Metallurgy

Factors influencing the state of stress are.

(1) Configuration of the structure;
(2) Size of the structure;
(3) The presence of discontinuities, i.e., notches incidental to the structure;
(4) Locked-in stresses;
(5) System of applied loads—static or dynamic.

Combinations of these factors which produce a high degree of restraint are usually associated with low ductility. Lowering the temperature for a given set of conditions increases the probability for brittle fracture. Increasing the strain rate for a given set of conditions has been found to increase the tendency for brittle fracture. Recent studies have indicated a probable relationship between temperature and strain rate[35,36].

The phenomena listed above may be classified under the general heading "mechanical."

The following factors may be considered under the general heading "metallurgy":

(1) Prior deformation and resulting stress and strain anisotropy;
(2) Cyclic loading—fatigue;
(3) Composition:
 a. Structure—grain size and the distribution and size of disperse phases;
 b. Solid solution effects—including those produced by gases;
(4) Precipitation phenomena such as strain aging;
(5) Corrosion effects.

The metallurgical and mechanical factors must be considered together in attempting to explain the sudden failure of large structures. The complexity of the situation becomes evident when all of the above variables are considered in combination.

b. EXPERIMENTAL INVESTIGATIONS AND RESULTS

Based in part on the results of the investigations dealing with welding stresses, it became apparent that these stresses were not the important factors contributing to structural failures. In consequence, it was evident that the research investigations should cover other phases of the problem.

A random selection of a substantial number of steel samples was made from the stock and scrap piles of shipyards constructing merchant vessels. In addition numerous samples were submitted by steel mills from heats rolled to ABS and USN specifications. 1,588 tensile tests from these samples showed that the physical properties of practically all the steel tested fell within the permissible range set forth in the specification standards. These tests, however, do not take cognizance of the selection methods set forth in the specification and all of the steel may therefore be considered to be in satisfactory compliance with the specification standards.

Upon review of the brittle characteristics of the fractured material removed from ships that had failed, questions regarding the stress conditions to which this material has been subjected were raised. It was felt that the hull steel must have been subjected to a complex multiaxial state of stress since shear flow had been inhibited as manifested by the low degree of ductility in way of the fracture. When steel samples removed from areas close to these fractures were subjected to the standard tensile tests, they exhibited satisfactory strength and ductility.

Large welded and unwelded medium steel flat plates and welded joints simulating the gunwale connection of ships have been tested in tension. Such specimens have exhibited tensile strengths equal to or slightly higher than coupon values for the same steels with moderate reductions in ductility[37,38,39]. These tests also indicated that cleavage fractures could be preceded by considerable plastic deformation.

As a result of the above investigations, it became apparent that it was not possible to reproduce ship failures by uniaxially loading large welded tensile specimens free from stress raisers. Therefore, an experimental program involving uniform biaxial loading was initiated. Tubes with and without welds were subjected to biaxial tensile loads at various temperatures[40,41,42,43,44]. These tubes contained no mechanical notches. Two sizes of tubes made from the same heat of semi-killed steel were tested and the following results have been obtained:

i. At room temperature it was found that the smaller tubes (3½ inches diameter x ¼ inch wall) predicted generally the behavior of larger tubes (20 inches in diameter x ¾ inch wall), but at low temperature (−40°F) this was not the case.

ii. The larger tubes (all of which were welded) tested at low temperature showed great reduction in strength and ductility when compared with results from the standard tensile test. This lack of ductility at −40°F was comparable to that found in fractured ships.

iii. A large tube, furnace treated at 1,100°F after welding and tested at −40°F, showed a significant increase in strength and ductility over a similar tube tested at the same stress ratio and temperature but *not* heat treated after welding.

Supplementing the investigation on the large tubes and, in part, to explain certain experimental difficulties of this investigation, a test program was started involving the static bending of flat plates at various temperatures with and without longitudinal weld bead deposits[41,45,46]. These plates were approximately 10 inches square and ¾ inch thick. Identical steel plates having various types of electrode deposits were tested. In all cases a comparison between welded and unwelded plates tested at low temperature showed that the ductility of welded specimens was decreased significantly.

When additional information became available through the cumulative record, particularly from the serious structural failures of welded ships, it became increasingly evident that the common origin of the fractures was in defective welds and structural discontinuities in the hull, such as hatch corners, sheer strake cut-outs, etc. These fractures propagated rapidly through the plates of the hull structure with little or no evidence of ductility. The fractures were of the cleavage type. Deck failures have occurred when the computed nominal stresses were well below the yield point of the material as determined by the usual tensile test.

It was therefore decided to investigate factors contributing to the brittle cleavage failure of large structures that contained stress raisers. This was accomplished through a study of the load-carrying capacity and ductility of large plates (¾ inch thick x 72 inches wide) containing a central transverse notch, when tested to failure at various temperatures[47,48,49]. A number of different medium carbon steels, including rimmed, semi-killed and fully killed types, falling within present ship steel specifications (USN and ABS) were investigated. Through the use of such large specimens it was expected that the type of fracture obtained in ships could be reproduced in the laboratory. Furthermore, it was desired to determine the differences in behavior of the several steels when tested in large specimens and to relate this behavior to smaller specimens (such as notched bar impact tests) of the same steel. In addition, it was expected that these investigations would produce results that could be applied toward modifying present ship steel specifications to insure material best suited for welded fabrication and safe ship operation. At the present writing, these investigations are still in progress. Based on the work completed, the following results appear significant:

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i. Wide (72 inch, centrally notched specimens of ¾ inch ship plate tested statically at temperatures ranging from −40°F to +110°F have failed at *nominal* stresses on the net section approximating the yield point of these steels as determined from the standard tensile test. These stresses were essentially the same whether the fracture occurred by shear or cleavage. The cleavage fractures, particularly those at the lower temperatures, exhibited low ductility comparable to that observed in ship failures.

ii. The transition temperature at which the mode of fracture changed from shear to cleavage in these speciments (+20°F to +110°F) was determined to be within the temperature range in which ships operate. The change from shear to cleavage was associated with a very large reduction in the ability of the specimen to absorb energy.

iii. Generally the types of steel were discriminated as to transition temperature in the same order in the large internally notched plate tests as predicted by the notched bar impact tests; however, the transition for the large plates occurred at much higher temperatures.

In conjunction with the tests of centrally notched flat plates, a related study of a large welded structural specimen closely patterned after a ship hatch corner was made [50,51]. Due to its geometry, this specimen had a high degree of restraint and a severe notch condition.

The purpose of this test was to investigate the behavior of a welded structure containing a structural discontinuity and also to study the effects of variations in steel and welding procedure. In this manner it was expected that the structural behavior of a welded component constituting an important part of the ship's hull could be evaluated. It was also proposed to compare similar hatch corners fabricated by riveting as well as by welding.

Although this investigation is still incomplete, at the present writing the following results have been obtained and appear significant:

i. It has been possible to load these hatch corner specimens in tension so as to produce an elastic stress distribution closely approximating that found in a Liberty ship.

ii. On the basis of a single specimen design which has a high degree of restraint and a severe notch condition, the type of steel, testing temperature (32°F to 120°F) and type of welding electrode (E6020, HTS, Austenitic 25Cr–20Ni) had little effect on the *nominal* breaking strength of the specimen (23,000 p.s.i. to 27,800 p.s.i.). The energy absorbed by a specimen failing with shear fracture was greater than that for a specimen failing by cleavage.

iii. All hatch corner specimens tested at 32°F failed by cleavage. Rimmed, semi-killed and fully killed medium carbon steels were included in these tests.

iv. Two hatch corner specimens welded with a 400°F preheat have been tested. One failed at a *nominal* breaking stress of 32,600 p. s. i., while the other failed at *nominal* stress of 32,800 p. s. i. An identical specimen but welded without preheat failed at a *nominal* breaking stress of 24,000 p. s. i. All specimens failed by cleavage when tested at 70°F. The energy absorbed by the preheated specimens was very much greater than that absorbed by the specimen that was not preheated. This confirmed data obtained on small specimen tests.[46]

v. Two riveted specimens, fabricated using semi-killed steel and having the same basic design as the welded specimens, have been tested at 70°F. One failed at a *nominal* breaking stress of 20,900 p. s. i. while the other failed at a *nominal* stress of 20,600 p. s. i. Both specimens failed with cleavage fractures. The energy absorption of these specimens was very much less than that of a welded hatch corner specimen fabricated from the same steel and tested at the same temperature.

A research project has been initiated to correlate the results of the large centrally notched plate investigation and the hatch corner studies with small laboratory tests[52,53]. This investigation was initiated with the expectation that it could be demonstrated that such tests could be used to predict the behavior of large fabricated structures. It should be pointed out that the development of a laboratory test for this purpose may be of significance in the establishment of improved specifications for ship steel. So far this investigation has yielded the following important results:

i. The discrimination of the steels on the basis of transition temperature using the standard notched bar impact tests has approximated that obtained in the large internally notched flat plate tests, but at much lower temperatures for the small specimens.

ii. Notched bar impact tests on rimmed, semi-killed and fully killed types of ship steel have shown that the transition from ductile to brittle behavior occurs at a relatively low temperature for fully killed steel, at a temperature as high as 90°F. for some heats of rimmed steel, and at intermediate temperatures for semi-killed types. However, some semi-killed steels also had high transition temperatures and correspondingly greater notch sensitivity. (Notch sensitivity may be defined as the property of a material which reflects its reluctance to absorb energy in the presence of notches and other strain inhibitors, such as low temperature and high rates of strain.)

An additional study, involving the steels mentioned above in which an explosive was statically detonated in direct contact with welded or unwelded plates, has provided a method for determining the behavior of specimens under high strain rates and a complex state of stress.[54] Preliminary results from this test were as follows:

i. Explosion tests have discriminated unwelded shipbuilding and high tensile steels in the same general order as predicted by the notched bar impact tests and large internally notched flat plate specimens.

ii. Welded joints have shown a significantly lower energy absorption and extent of deformation when compared to unwelded plates of the same steel. It should be noted that these results correlate with the results obtained in the static weld bead bend tests at low temperatures referred to previously.

Other investigations of welded structures include a study of a highly restrained fabricated box girder and that of butt welded I-beams. These structures are being tested in flexure. The box girders made from 1½ inch thick plates are being investigated to determine the effect of high restraint and residual stresses on the physical behavior of such structures. The butt welded I-beams are being tested to determine differences in performance when tested under dynamic and static conditions. No broad observations can be drawn from these investigations as yet.

On a number of ships, hairline cracks have been observed in the vicinity of the hatch corners. Due to the stress concentration occasioned by the hatch corner discontinuity, it appeared reasonable that these could have been fatigue cracks caused by the cyclic loads to which a ship had been subjected in service. Upon subsequent loadings having higher stress amplitudes and increased strain rates occasioned by rough seas, it was expected that such a hairline crack might act as a trigger to start a fracture propagating through the structure particularly at low temperature. Welded ships have suffered structural failures after only a short period of sea service or with no service at all. However, it appeared that fatigue might in some cases be a contributing factor to failure.

A research project was initiated to determine the effect of cyclic loading on the behavior of ship steel specimens containing longitudinal welds and cut-outs with and without welded reinforcement plates and doublers.[55] As yet no significant conclusions can be drawn from this work.

In order to verify the hypothesis stated above relative to the propagation through the ship structure of fractures that originate in fatigue cracks, it was decided to initiate an investigation involving a study of the fatigue behavior of specimens containing severe stress raisers.[56] These specimens were 12 inches wide x ¾ inch thick and were made from rimmed steel and normalized fully killed steel. The specimens were centrally notched in a direction transverse to loading. The configuration of the notch was identical to that used in the large static tension test previously mentioned. Specimens were tested at various temperatures ranging from −40°F to +120°F. As an index of performance, it was decided to use the number of cycles required to propagate a crack beyond the root of the initial notch approximately 0.6 inch in each direction. All specimens were subjected to an alternating load giving a *nominal* stress of 16,000 p. s. i. in tension to 16,000 p. s. i. in compression on the net section. The following results from this investigation appeared significant:

i. The testing temperature had no appreciable effect upon the fatigue life of any of the steels tested.
ii. The fatigue life was approximately twice as long for the normalized plates of killed steel as for the rimmed as-rolled steel specimens.

Other cyclic loading tests involving combined stresses have yielded results which do not appear conclusive.

4. *Conclusions*

The following conclusions have been drawn on the basis of the available data. Additional data which are expected from research still continuing may necessitate revision or modification of some of these conclusions:

1. The brittle fractures in welded ships result from a combination of the following causes: stress raisers occasioned by poor design or workmanship; steel susceptible to low ductility fracture when subjected to conditions involving three dimensional constraint, particularly at low temperature; i.e. notch sensitive steel. Neither factor is alone responsible for all failures, but when an adverse combination of the two occurs, the ship may be unable to resist the bending moments of normal service.
2. Fractures in large welded and unwelded ship plate specimens containing stress raisers comparable to those found in ships have occurred at *nominal* stress values as low as 20,000 p. s. i. The *nominal* breaking stress has been found to be essentially the same irrespective as to whether failure occurred with high or low ductility.
3. Tests of large welded and unwelded ship plate specimens containing stress raisers comparable to those found in ships have failed in a brittle manner within the temperature range in which ships operate. These specimens were made of rimmed, semi-killed and fully killed medium carbon steels, furnished to meet existing ship plate specifications. The ductilities obtained in the laboratory tests were of the same order of magnitude as those measured in fractured ships.

4. Existing ship plate specifications are not sufficiently selective to provide material that reasonably precludes the occurrence of brittle fracture on welded structures. The material supplied in ship construction during this program complies with the existing specifications for ship steel.
5. Evidence exists which indicates that the structural performance of welded joints in ship steel, particularly under conditions involving three dimensional restraint and low temperature is greatly improved by forms of heat treatment.
6. Static structural tests of welded ships of various designs have corroborated earlier experiments with riveted ships and confirmed the validity of the basic analytical method used in calculating nominal stresses under a known bending load in the main hull girder.
7. In discontinuities like hatch corners, rounded details are superior to those showing acute notching. This is mainly attributed to the wider distribution of plastic deformation which occurs in rounded corners in the early stages of heavy loading.
8. Considerable accumulated evidence and test data indicate that locked-in stresses do not contribute materially to failure of welded structures.
9. Locked-in stresses in the decks of completed vessels are not appreciably reduced by service.
10. Welding sequence in general has no effect upon the magnitude of residual stresses in free subassemblies.

5. *Recommendations for Proposed Future Work*

The Research Advisory Committee recommends the following further investigations:

a. THE STUDY OF SHIPBUILDING MATERIALS

The work in this field may be divided into groups as follows:

i. Further studies of the effect of welding on the structural performance of ship steel. It is proposed to study the behavior of welded joints; such as butt welded flat plates, double fillet welded tee specimens, etc., under multiaxial stress at various temperatures and strain rates. This investigation is proposed since plates containing a welded joint have shown a decided reduction of energy absorption and extent of deformation when compared to unwelded plates of the same steel. By means of these tests, it is expected to study such variables as steels; electrodes; heat treatment and mechanical stress relieving. It is anticipated that a considerable amount of effort must be expended in developing satisfactory specimens and testing procedures which must show correlation with the performance of full scale structures. *(See* section *b* (ii.), *below.)*

ii. Further studies of the fundamental factors affecting flow and fracture of metals. It appears highly desirable that more information be made available relative to the conditions that obtain when cleavage and shear fractures occur in metals, particularly the conditions necessary to cause a change in the mode of fracture from shear to cleavage. *(See 3a. above.)* This work will assist in the understanding of the basic phenomena underlying the failure of materials in structures and will aid in their intelligent utilization.

iii. Further study to obtain practical tests which can be used to procure material satisfactory for the fabrication of welded structures. Present tests for evaluating the notch sensitivity of the materials are capable of selecting satisfactory steel and electrodes but not for procurement in commercial quantities.

b. THE STUDY OF THE SHIP'S STRUCTURE

The work in this field may be divided into groups as follows:

i. A study of ships at sea. Here is envisaged a research program to determine particularly the loads to which a ship's structure is subjected among waves. It is anticipated that active work under this project will not begin until a thorough study has been made of the results obtained from the present British investigation on the *Ocean Vulcan.*

In addition to the above study, in which a research crew would be stationed on board ship to operate and maintain the equipment, it is also contemplated that strain counters be installed at various locations on a large number of ships of many types. These counters would be unattended except for periodic checkups and recording of accumulated data. These counters would record the number of times a given strain has been reached at a selected point in the ship. By this procedure, it is anticipated that the maximum strains to which a ship's structure is subjected, including selected points of concentration, could be obtained.

ii. A further study of the design and fabrication of ship components (e.g. hatch corners, gunwale connections, etc.). It is proposed to study typical structural discontinuities in ships to determine magnitude of stress concentrations, areas affected by the discontinuities, and how the design can be modified to reduce such concentrations, thereby increasing the factor of safety. This investigation would be made through use of large welded full scale specimens, models, and photoelastic studies.

iii. A study of the structural performance of the ship girder incorporating improved structural details developed in (ii) above, tested statically to failure. The vessel will be subjected to the static structural test, preferably continuing to failure.

iv. A study of the effects of riveted longitudinal joints on the performance of welded ships. The generally satisfactory performance of the Liberty ships with riveted seams has raised questions as to how the riveting influenced this performance.

v. Studies of the relative merits of various structural design details when subjected to cyclic loading.

c. SUPPLEMENTAL STUDIES

Shrinkage, distortion and cracking of welded structures during assembly are effects which must be studied. The methods of obtaining sound welding practice are generally developed on the job; however, the elements of good practice need continued reconsideration and manuals need revision, even though laboratory research can make little contribution to this result.

EXHIBIT III

Survey of Shipyard Welding Practices

1 May 1945

Summary Report

WELDING ADVISORY COMMITTEE

A Welding Advisory Committee was appointed by the Board to survey conditions pertaining to the design and methods of construction of welded steel merchant vessels as employed by shipyards in the United States. Thirty-three representative yards, Government and commercial, on the East, Gulf and West coasts were visited during 1944-45. The following report is a summary of data collected.

A. *Welder Training and Advancement*

1. AVERAGE NUMBER OF HOURS IN WELDING SCHOOL.

The system of welder training in use and standard of performance required prior to graduation is not uniform. Some schools train to produce tackers only, acting on the premise that no school can produce a journeyman welder; therefore, from 3 to 6 months' work on the ship should be required before the trainee becomes a production welder. An average of 185 hours schooling for production welders exists for the East Coast schools reported. The shortest average training period was 10 hours and the longest average training period was 320 hours.

2. TRAINING EQUIPMENT AND METHODS.

Most shipyard schools did not have enough training equipment, operating up to three shifts, with two trainees per booth in one or two instances. It was generally agreed that 10 students was the maximum that could be efficiently trained under one instructor. However, some schools assigned up to 20 students per instructor. The smaller schools are not well organized and usually are operated only as welder test booths, or for priming welders to take the production welder's test. In only one school were trainees required to weld in cramped positions and on joint assemblies similar to those encountered on ship board.

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3. SPECIAL MEANS FOR IDENTIFYING WELDERS BY RATING.

	Yards
Special Means	1
Partial Means	7
No Means	25

After qualifying by test for all positions one yard grouped the welders for restricted work in accordance with the foremen's opinions and each group was identified by colored electrode buckets and helmets. In several yards, however, tackers could be identified from welders by group number on badges.

Nearly all yards interviewed agreed that whether qualified by test or not, a welder fresh from the training school should be allowed to work only on unimportant parts of the ship's structure, preferably in the flat position. The secondary structure on the building ways should be welded by more experienced or second grade welders and strength decks and the hull plating should be allocated to the most experienced or first grade welders under yard classification. In actual practice, however, this ideal is seldom attained due either to "hot ships" or disregard of this principle in placing welders.

4. TYPE OF WELDERS PRODUCED BY SCHOOL.

	Yards
Tackers	10
Welders only	4
Tackers and welders	9
Flat or restricted position	5
None	5

Only 5 yards had restricted welder qualification other than tack welder. The majority of the yards consider the all-position welder qualification test easy to pass and the training necessary to qualify preferred to the restrictions imposed when welders are only partially qualified.

5. MINIMUM EXPERIENCE BETWEEN ADVANCEMENTS.

No yard claimed to enforce any minimum period between advancement except in two instances, one where advancement was automatic due to agreement with Union, and one where the yard required a 3-month period between advancements.

6. ENCOURAGEMENT FOR IMPROVEMENT.

There is very little encouragement for improvement in workmanship particularly in piecework yards where emphasis is placed on production. Only two yards made any attempt to keep a record of the actual quality of work of the individual welder.

7. PERCENTAGE OF WELDER TURN-OVER ANNUALLY.

	Percent
Maximum	212
Average	85
Minimum	12

8. ARE QUALIFICATION TESTS RECORDED?

Qualification tests are recorded in all yards except two. The consensus of opinion of the various yards indicated that qualification tests are not sufficient evidence that a welder is capable of welding important structural joints and that welders on such structure should be picked after experience indicates they can produce welds satisfactorily.

9. ARE RECORDS SYSTEMATICALLY FILED?

Recorded qualification tests were satisfactorily filed in yard or inspection office when such qualification tests were made except in one yard. However, the system is rather cumbersome in that if a welder's work is unsatisfactory it requires a check in the files to ascertain his qualifications.

B. *Incentive for Good Workmanship After Graduation*

1. ANY MONETARY INCENTIVE FOR GOOD WORKMANSHIP?

	Yards
Yes	12
Yes, in theory	11
No	10

Nearly all piecework systems nullified any incentive for good workmanship since the emphasis was placed upon either poundage of electrodes burned or footage produced. Charges are seldom made against the welder for repairing work and advancement is based upon the ability to produce enough welds to make a wage equal to that of the next higher basic hourly rate. In yards where all welders get the same pay there can be little (and sometimes a negative) incentive for improvement as the difficult work is given to the best welders.

2. ANY PIECEWORK SYSTEM?

	Yards
Yes	18
No	15

3. IS ADVANCEMENT BASED ON GOOD WORKMANSHIP?

	Yards
Supervisor's opinion	23
Based on daily and weekly records of workmanship	2
No	8

4. WHAT SYSTEM IS SET UP FOR THIS?

	Yards
Efficiency rating	6
Union agreement	2
Cramped position test	1
Daily and quarterly records	2
None	22

C. *Supervision*

1. NUMBER OF HULLS FOR EACH WELDING SUBFOREMAN.

	Yards
1	13
2	8
3	3
Varies but lies between 1 and 10	7
Indefinite	1
No report	1

2. NUMBER OF QUARTERMEN TO ONE FOREMAN.

	Yards
None	2
Average, 1–5	16
Average, 6–10	9
Average, 11–15	4
No report	2

3. NUMBER OF LEADINGMEN TO ONE QUARTERMAN

	Yards
None	1
Average, 1–5	19
Average, 6–10	9
Average, 11–20	3
No report	1

4. NUMBER OF WELDERS TO ONE LEADING MAN.

	Yards
Average, 10–15	12
Average, 16–20	12
Average, 21–30	8
31 and over	1

5. IS A WELDING ENGINEER EMPLOYED?

	Yards
Yes	21
No	12

Only a few of the men employed as welding engineers for the various yards can be considered welding engineers when analyzed in the light of their technical training. Their title is neither indicative of their exact status in the yard organization nor does it correspond to the duties to which they are assigned.

6. WHAT IS HIS ORGANIZATIONAL RATING?

	Yards
Advisory	16
Consultant	3
Directive	2
No engineer	12

It is doubtful that any of the welding engineers have authority to enforce regulations governing quality of welds, sequence, etc., if such regulations interfere with production.

7a. WHO HAS FINAL SAY ON WELDING MATTERS?

	Yards
Hull superintendent	21
Shipfitters	3
Welding engineer	4
Welding foreman	1
Inspection agencies	2
Production manager or assistant works manager	2

Any controversial matters pertaining to welding were usually settled by the welding inspectors of the inspecting agency if such were called to their attention.

7b. WHO ESTABLISHES THE WELDING TECHNIQUE?

	Yards
Welding supervisors and foremen	21
Welding supervisors and foremen with welding engineer	2
Welding engineer	4
School instructors and coaches	4
Individual welder	1

Very few yards relied upon their welding engineers to establish the welding technique.

7c. HAS WELDING DEPARTMENT POWER TO REJECT FAULTY FITTING?

	Yards
Yes	13
No	5
Doubtful or problematic	15

It is doubtful that where welding departments have the authority to reject faulty fitting that such authority is ever exercised.

8. CONNECTION BETWEEN DRAWING ROOM AND WELDING DEPARTMENT.

In only nine yards did the welding engineer have direct contact with the drawing room.

9. WHO SEES THAT SEQUENCE IS CARRIED OUT?

Only seven yards had inspection departments set up for checking the sequence, the remainder leaving this work entirely to the welding supervision.

10. WHO HAS AUTHORITY TO CHANGE WELDING SEQUENCE?

Only eight yards of the 19 employing welding engineers gave the welding engineer the authority to change welding sequence. However, three yards had a sequence man in addition to the welding engineer who developed the sequence and made the necessary changes.

11. DOES HE SEE THAT THE CHANGE IS APPROVED?

Yes	21
Doubtful	4
Sometimes	4
No	3
Made no changes	1

It was noted that the general practice in the yards was to make numerous sequence violations on the hull structure rather than to correct the welding sequence or revise it to agree.

D. *Inspection*

1. IS RADIOGRAPHY DONE ON HULL STRUCTURE?

	Yards
Yes	3
No	30

2. IS TREPANNING DONE?

	Yards
Yes	9
Yes, but not polished	4
No	20

Plugs taken but not polished which were examined by the Committee were considered incomplete evidence of sound welds due to their extreme roughness.

In one yard, where probing was a regular practice, it was stated that originally 30 percent of plugs taken showed defective welds, but since workmen have been shown defective probes, the quality has improved until defective plugs have been reduced to 6 percent.

3. WHO REQUESTS RADIOGRAPHY AND TREPANNING?

	Yards
Welding engineer or welding laboratory	4
Inspection agencies	9
Yard welding inspectors	1
Made no subsurface inspections	19

Of the yards making subsurface inspections only four performed this service without the request of an inspection agency.

4. HAS YARD ANY INSPECTION DEPARTMENT OF ITS OWN?

	Yards
Yes	16
No	17

Some yards stated that a separate inspection department would result in divided authority and would therefore be objectionable. Apparently, it was for this reason that some inspection departments answered to the production department instead of the welding engineer.

5. TO WHOM ARE THE WELDING INSPECTORS RESPONSIBLE?

	Yards
Welding engineer	2
Yard inspection department	5
Welding supervisors	4
Production department	5
No inspection department	17

6. HAS YARD ANY WELDING LABORATORY?

	Yards
Yes	11
No	22

Welding laboratories of any consequence were usually incorporated in a well-equipped metallurgical laboratory.

7. HULL INSPECTION.

	Yards
Inspected by Navy	15
Inspected by ABS surveyors	16
Inspected by U.S.M.C.	14
Inspected by U.S.C.G. marine inspectors	11
Inspected by Army	2
Inspected by commercial companies	3

8. CAN YARD TRACE WORK TO INDIVIDUAL WELDER?

	Yards
Yes	11
Sometimes	5
Doubtful	2
No	15

Identification of the weld and welder is of little value where there is no subsurface inspection. Most methods of identification are rather cumbersome, their primary purposes being to control piecework systems and not for the identification of welders at some future date. Some union agreements will not permit identification of weld with welder.

9. HOW ARE LEAKY WELDS REPAIRED IN WATERTIGHT AND OILTIGHT STRUCTURE?

Leaky welds are usually caulked unless found by the inspection agency first, or when they are of such a serious nature that caulking would not stop the leak. Several yards made the claim that all leaky welds were chipped out and rewelded but the reaction of the inspectors as well as personal observation, casts considerable doubt on the accuracy of these statements.

10. HOW ARE FAULTY WELDS REPAIRED IN NON-WATERTIGHT STRUCTURE?

Faulty welds are repaired by rewelding in way of undercutting and insufficient reinforcement when marked by inspectors. Judging from observation of welds marked for repair, additional welds are run without further preparation for almost any kind of defect except a known crack.

E. *Production*

1a. IS THERE AN ERECTION SEQUENCE?

	Yards
Yes	33

Most erection sequences consist of material schedules.

1b. WHO PREPARES ERECTION SEQUENCE?

	Yards
Supervisor committee	2
Hull superintendent	7
Welding engineer	3
Shipfitting department	6
Hull planner	2
Naval architect	3
Not reported	10

2. IS IT BEING FOLLOWED?

	Yards
Yes	17
Generally	13
Partially	3

Most erection sequences consist of material schedules and are violated or modified where necessary to use material in order of receipt, regardless of the condition of welding. A few of these schedules were incorporated with the welding sequence.

3a. IS THERE A WELDING SEQUENCE?

	Yards
Yes	30
No	3

3b. WHO PREPARES THE WELDING SEQUENCE?

	Yards
Engineering department	2
Supervisor committee	5
Hull superintendent	2
Welding engineers	6
Shipfitting department	1
Chief hull planner	1
Welding foreman	2
Design agent or leading shipyard	2
Not prepared	2
Not reported	10

3c. HAS THE WELDING SEQUENCE BEEN APPROVED BY NAVY, AMERICAN BUREAU OF SHIPPING, UNITED STATES MARITIME COMMISSION OR UNITED STATES COAST GUARD?

	Yards
Yes	16
No	10
No reports	7

The sequence in use in a number of yards was very general without any detail.

4. IS IT BEING FOLLOWED?

	Yards
No	14
Yes	7
Generally	9
No sequence	3

None of the complicated sequences developed for welding are rigorously held to by the welders on the job. However, in two shipyards where the hull was subdivided into standard uniform panels or sections similar to subassemblies although built in place on the ways they were able to reduce the instructions to workmen to an apparent minimum. It was noted that two yards laid out the sequence on the steel structure for the guidance of the welders, thereby eliminating excuses for sequence violations.

5. HOW ARE ELECTRODES STORED AND DISTRIBUTED?

Nearly all yards stored and distributed electrodes in reasonably dry spaces, heated in the winter for the comfort of the personnel. However, 3 shipyards made a determined attempt to dehumidify certain classes of electrodes.

6. ARE CHECK TESTS MADE ON QUALITY OF ELECTRODES?

	Yards
No	23
Yes	10

Only one yard ran a torture test on mild steel electrodes and this was done by a special port hole test devised by that yard. The majority of tests consisted of standard welder qualification test for each new shipment of electrodes. However, one yard made an attempt to check the moisture content of the coating.

7. TYPES OF ELECTRODES USED.

Some yards have substituted E-6020 for horizontal work for which E-6012 has been eliminated. Judging from the record, however, this practice should be extended.

8. ARE SPECIAL PROCESSES USED?

	Yards
Union-melt	21
Lincoln weld	3
General electric	1
Unamatic	2
Flame gouging	3
Carbon arc	7
Twin arc	1
Deep fillet	2

Apparently any furtherance of these special processes would depend upon the supplying of concrete information to the various yards.

9. ARE RESTRICTIONS ON MACHINE WELDING BEING FOLLOWED?

Several of the yards visited complained of lack of information on the control of machine welding and only in the yards that had done considerable experimentation could machine welding be considered excellent. The manufacturers' claims on the possibilities of this equipment appear to be somewhat exaggerated when compared with production results. In addition it was noted that very wide variations in joint design existed in yards doing identical work; the efficiency of some being open to question.

10. PERCENTAGE OF MACHINE WELDING.

	Yards
No machine welding . .	10
Below 10 percent	11
10–20 percent . .	8
20–25 percent . .	4

11. HOW MUCH DEEP FILLET WELDING IS DONE?

Used by 6 yards.

Most yards interviewed who had experimented with this process considered it not applicable to ship construction. One shipyard, however, seemed to be enjoying considerable success with this process and this yard considered that control of the moisture content of the electrode was absolutely essential for its success in production.

12. HAS E-6012 ELECTRODE BEEN ELIMINATED ON IMPORTANT BUTT JOINTS?

Two yards were found where E-6012 electrode was being used on important hull butts although one yard reported that this electrode had been eliminated for these joints. The general consensus of opinion among the other yards was that this class of electrode was only suitable for horizontal fillet welds. Several yards were also found to be using certain brands of E-6011 and E-6013 electrodes on all types of joints to increase production resulting in large oversize convex welds with the appearance of deposits made by E-6012 electrodes.

13. IS PEENING BEING DONE?

	Yards
Generally employed	2
Used to some extent, as in restrained butts or insert plates	26
No peening used	5

Shipyards need information pertaining to this process since most of them subscribed to only very light peening.

14. ARE VERTICAL BUTT WELDS WEAVED OR STRINGER BEADED?

	Yards
Both . . .	6
Weaved	19
Stringer beaded	5
Weaved with final layer stringer beaded	2
Stringer beaded with final layer weaved	1

In view of the differences of opinion among the various yards as to the relative merits of these two techniques, more information is apparently needed in the field.

15. PLATE EDGE PREPARATION USED WITH MACHINE WELDING.

	Yards
Ground top surface . .	4
Wire brushed	5
Paint remover	2
Not cleaned	6
Not machine welded	18
Not reported	6

It was noted that two yards producing the best machine welds paid very little attention to cleanliness of surface aside from wire brushing, placing more than average emphasis upon proper machine settings.

16. METHOD USED FOR BACKING UP MACHINE WELDING.

	Yards
Tight fit	4
Copper backing strip	1
Steel backing strip	7
Flux backing . . .	3
Manual welding backing	13

It was noted that two did not strive for a tight fit, working flux in any opening and under the tack welds, with remarkably good results.

17. MAXIMUM PLATE THICKNESS USED IN MANUAL WELDING SQUARE EDGE PLATING.

Not over ¼ inch square edge preparation was used for manual welding in any yard. 3/16 inch was the maximum square edge joints manually welded without back chipping.

18. IS PREHEATING BEING DONE FOR MANUAL AND MACHINE WELDING?

	Yards
No preheating on mild steel .	29
Some on mild steel . .	4

More information apparently is needed in the field on the requirements of preheating. Very few yards are carrying out the letter of instructions now in existence.

19. ARE TRACKS USED FOR AUTOMATIC WELDING MACHINES?

Tracks are generally used with Union-melt and General Electric machines on the East and Gulf coasts. Tracks are seldom used on the West coast. Tracks are not used with Lincoln welding machines.

20. QUALITY OF EDGE PREPARATION USED FOR MANUAL WELDING.

	Yards
Excellent	3
Good	14
Fair	12
Poor	4

In a good many yards edge preparation is ruined by an excessive amount of square flame cuts in fitting on the ship after erection. The use of innumerable large tacks to compensate for inadequate strongbacking and warping make it impossible to more than partially bevel the edges prior to welding.

21. METHOD USED FOR CLEANING OUT BACK OF WELDS.

	Yards
Chipping	32
Flame gouging	1

Back chipping in restricted places and on secondary structure is very superficial in most yards. It was noted that in some yards welding procedures required back chipping in very cramped spaces and overhead positions not conducive to good workmanship.

A. Type of chisel used.

	Yards
Cape chisels at times	2
Diamond point at times	15
Round nose only	8
Not checked	10

Cape chisels resulted in as sharp corners in the grooves as those made by diamond pointed chisels.

B. Is flame gouging used?

One yard used flame gouging generally.

C. Is groove cleaned to sound metal?

	Yards
Yes	7
Fair	1
Not always	9
No	6
Not reported	10

In one yard it was noticed that the main girth butts of the vessel had been superficially chipped and then caulked to simulate a condition of sound metal.

D. Does groove follow center of weld?

	Yards
Yes	15
Not always	4
No	4
Not reported	10

E. Is a sharp V left in root of groove?

	Yards
Yes	7
No	8
Sometimes	8
Not reported	10

The standard of back chipping in most of the yards inspected could be improved.

22. IS RIVETING USED IN CONJUNCTION WITH WELDING?

	Yards
Yes	14
No	9
Not reported	10

Some yards used riveting to retain gangs already employed in the yards while others used riveting to get away from welded longitudinal seams and welded longitudinals.

23. DOES RIVETING PROGRESS BEYOND THE WELDING?

	Yards
No	7
Yes	7
Not riveted	9
Not reported	10

One yard held back on riveting until main hull structural welding was completed. The majority of the remaining yards using riveting in connection with welding removed a few rivets adjacent to the weld when riveting advanced ahead of the welding.

F. *Workmanship*

1. QUALITY OF FITTING.

	Yards
Very good	2
Good	9
Fair	16
Poor	6

Fitting was generally poor enough to be considered responsible for some of the poor welding reported. Preparation of the butts in secondary structure including framing butts never received proper attention in most yards.

2. QUALITY OF MANUAL WELDING.

	Yards
Good	17
Fair	13
Poor	3

The quality of shell welds is problematical in all yards where poor fit-up exists and there is no subsurface inspection since incomplete penetration of weld metal would break the continuity of the joint. Welds of the secondary structure (including bulwarks, framing, hatch coamings, etc.) in most yards showed bad workmanship.

3. QUALITY OF MACHINE WELDING.

	Yards
Very good	4
Good	11
Fair	8
No machine welding	10

The fit-up for machine welding varies somewhat in different yards and where no probes are taken there is no way of checking the final quality of the welds.

4. IS WELDING PROPERLY CLEANED OF SLAG?

	Yards
Yes, for inspection	15
No, for inspection	18

When the final passes of the manual welds are not cleaned it was observed that there was always a possibility of undercutting, porosities and incomplete reinforcement getting by.

It is to be noted that the majority of the yards did not clean welds for inspection purposes.

5. IS UNDERCUTTING OF WELDS EXCESSIVE?

	Yards
Yes	15
No	17
Yes, on one type of vessel and No, on another type	1

Undercutting was rather extensive in most yards but corrected in some by additional beads. One yard suggested that 3/16 inch electrodes may cause undercutting on plating below 3/16 inch thickness and it is possible that smaller electrodes, if used, would stop this undercutting.

6. ARE STARTING AND RUN-OFF TABS USED FOR MACHINE WELDING?

	Yards
Yes	13
No	10
No machine welding	10

Many yards using run-off tabs failed to obtain the desired results as the craters carried back within the trim lines. Where short unfinished joints were left to assist in fairing and the erection of the structure, the resulting manual welds used to complete the joints were sometimes saddles, causing notch effects in these butts.

7. IS COMPLETED STRUCTURE REASONABLY FAIR?

	Yards
Yes	27
No	6

In order to obtain fairness on light welded structure it was usually necessary to resort to excessive flame shrinking, a large number of rigid strongbacks or drumheadings, with the latter apparently the least objectionable practice. On heavier plating, sequence and technique when used to advantage seemed capable of maintaining the fairness of the structure.

G. *Structural Details*

1. ARE SNIPES USED WHENEVER POSSIBLE?

	Yards
Yes	12
No	21

With the present use of prefabricated members and subassemblies, it is imperative that snipes be indicated on the detail structural plans to get them on the finished ships.

2. IS UPPER EDGE OF SHEERSTRAKE FREE FROM CUTS AND NOTCHES?

	Yards
Yes	24
No	6
No structural sheerstrakes	3

Although most of the sheerstrakes were free from cuts and notches, only 3 yards were found that removed all connections, including chocks and pads.

3. ARE BULWARK DETAILS IN ACCORDANCE WITH APPROVED PLANS?

Yes, in yards where bulwarks are fitted.

4. IS BULWARK WORKMANSHIP SATISFACTORY?

	Yards
Yes, generally	10
No	2
No bulwarks	15

Most yards treat the bulwarks as secondary structure and consequently these members are not welded with the same care and workmanship as the shell plating. Most naval vessels and tankers are designed without bulwarks.

5. TYPE OF HATCH CORNER REINFORCEMENT FITTED.

	Yards
Navy standard or expansion trunks	12
Insert in deck, not slotted through coaming	2
Insert in deck, slotted through coaming	8
Doubler for deck, not slotted through coaming	4
Doubler for deck, slotted through coaming	2
No reinforcement	5

Many of the inserts and doublers used to reinforce the hatch corners were rectangular with square exterior corners.

6. ARE RIVETED GUNWALE BARS FITTED?

	Yards
Yes	14
No	16
No gunwales	3

7. ARE ARRESTER STRAPS FITTED (LIBERTIES ONLY)?

	Yards
Yes	2
No	1
Not Liberties	30

8. ARE BILGE KEELS PROPERLY SCALLOPED?

	Yards
Yes	13
No	12
Riveted	3
No bilge keel	1
Not observed	4

If bilge keel snipes are not indicated on the plans, there is little possibility of the requirements being carried out by the fitters on the job.

H. *Erection Methods*

1. ARE TACK WELDERS QUALIFIED?

	Yards
Yes	19
No	14

There is considerable confusion among inspectors as to the actual qualification for a tack welder, especially in yards doing both naval and commercial work. Most of the schools turned out tack welders on the appearance of the finished weld, rather than any test.

2. (a) WHAT REGULATIONS GOVERN TACKS?

	Yards
Navy	18
ABS	15

2. (b) WHAT TYPE TACKS ARE USED?

	Yards
Large	5
Large and close	10
Rough and close	2
Few and small	5
Varying in size and shape	2
Good	7
Fair	2

Tacks were not being made as specified or recommended and seldom are they chipped out when made in a beveled joint. The use of a large number of strongbacks and saddles in some yards eliminated tacks to a minimum whereby the entire joint was welded by a production welder without breaking continuity.

3. QUANTITY AND TYPE OF STRONGBACKS AND BRACES USED.

	Yards
Few	16
Normal	8
Large amount	8
None	1

20 of these yards used strongbacks of the rigid type without apparent difficulties.

4. ARE TACK SCARS REPAIRED?

	Yards
Fair	22
Imperfect	10
No scars	1

No yard was repairing tack scars to the extent that the outlines could not be traced except in a few instances where deep grinding was resorted to. In some yards it was noted that a great number of scars were present in the hull plating due to dragging of the welder's electrode when striking the arc and starting some distance away from the joint.

5. IS PREHEATING USED ON H.T.S.?

	Yards
Yes	10
No	4
No H.T.S. used	19

The practice of preheating on H.T.S. varies in all yards depending upon the failures experienced or the attitude of the inspecting agency. In some instances preheating being dependent upon atmospheric conditions or the weight of plating involved (this weight factor not being uniform) or upon rough tests peculiar to the yard, intended to identify high chemistry plates.

6. TYPE OF WELDING EQUIPMENT AT THE WET SLIP.

	Yards
Isolated	13
Not isolated	16
Not observed	4

Several yards do not consider isolation of welding equipment at the wet basin necessary, one having taken voltage readings between hulls and between hulls and water for check purposes, arriving at the conclusion that adequate grounding is all that is necessary.

I. *Reception of the Welding Advisory Committee*

In general, the committee was well received.

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☆ U. S. GOVERNMENT PRINTING OFFICE 1947—701.92

NONE
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Board to Investigate the Design and Methods of Construction of Welded Steel Merchant Vessels	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP
3. REPORT TITLE The Design and Methods of Construction of Welded Steel Merchant Vessels	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report	
5. AUTHOR(S) (First name, middle initial, last name)	
6. REPORT DATE July 15, 1946	7a. TOTAL NO OF PAGES 164 / 7b. NO OF REFS 73
8a. CONTRACT OR GRANT NO b. PROJECT NO c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10. DISTRIBUTION STATEMENT Unlimited	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Dept. of the Navy Washington, D.C.

13. ABSTRACT

Early in WW II, welded merchant vessels experienced difficulties in the form of fractures which could not be explained. The fractures, in many cases, manifested themselves with explosive suddenness and exhibited a quality of brittleness which was not ordinarily associated with the behavior of a normally ductile material such as ship steel. In April 1943, the Secretary of the Navy established a Board of Investigation. This is the third and final report of the Board intended to cover all phases of the Board's activity during the entire period of its existence. All salient results are discussed, findings listed and conclusions drawn.
Part I - Structural Failure History
Part II - Analysis of Factors Contributing to Structural Failures
Part III - Susceptibility to Fracture of Different Ship Designs and Structural Details
Part IV - Effectiveness of Certain Structural Alterations
Part V - Steel Quality
At the end of the report recommendations are made for future work which appears to be necessary or desirable in the solution of unfinished phases of the problem.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

NONE
Security Classification

NONE
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Ships						
Ship Structures						
Tankers						
Welding						
Hull Fracture						
Brittle Fracture						
Steel						
Shipbuilding						
Merchant Ships						
Liberty Ships						
Victory Ships						

NONE
Security Classification