V

COPY

300
SS(N)606/9670
Jan 18 1962

From: Commander, Portsmouth Naval Shipyard
To: Chief, Bureau of Ships

Subj: Results of a review of radiographs of the non-nuclear area of the SS(N)606 (TINOSA)

Ref: (a) MIL STD 271A
(b) NAVSHIPS 250-637-3

1. The Shipyard has completed a review of the radiographs of the non-nuclear area of the SS(N)606 (TINOSA). This review was begun when it was discovered this past October that the quality of the radiographs of pipe joints did not meet the requirements of reference (a).

2. Radiographs of the pressure hull joints have been reviewed and, except in two isolated areas, have been found to be generally in accord with the requirements of reference (b). The sensitivity requirements were found to have been met in almost 100% of the radiographs. The film processing left something to be desired; however, all radiographs accepted were considered fully readable. The two isolated areas that had unacceptable radiographs are being re-radiographed to the requirements of reference (b).

3. In the radiographs of non-nuclear pipe joints, the requirements of reference (a), particularly as to sensitivity, have not been met. It has been the exception rather than the rule when the 2t hole in the penetrometer could be seen. Also, in some cases, approximately 20% of the total, either the wrong penetrometer or no penetrometer was used. The film processing was in many cases not of the best. In spite of these deficiencies, it is considered that the radiographs were readable and only minor defects would be missed as a result of the lack of conformance to reference (a).

4. All pipe joints in the nuclear area of the ship have been re-radiographed to the requirements of NAVSHIPS 250-1500-1 where it was possible to meet these requirements. In some cases in joints installed in the ship, it was impossible to get the right focal distance for some shots to obtain the required sensitivity. The sensitivity requirements of NAVSHIPS 250-1500-1 are the same as reference (a). These re-radiographs have resulted in repairs having to be made to about 30% of the joints. By far the greatest number of welds picked up in the re-radiographs as not meeting standards either had slag inclusions beyond standard or improperly or insufficiently fused consumable inserts.

COPY

Exh 224-15

300
SS(N)606/9670

5. Because of the high integrity required in the nuclear piping systems, the Shipyard is proceeding with repairs to the joints showing non-compliance with standards. In the non-nuclear area, this is not considered necessary. Any defects that might have been missed as a result of non-conformance to reference (a) would be of a nature that failure of the joint is highly unlikely and in no case would there be a catastrophic failure.

6. To re-radiograph all non-nuclear joints not fully meeting the requirements of reference (a) would mean an additional one-half to three-quarters of a million dollars in cost. Although this re-radiography could probably be completed within the proposed new completion date (this subject covered by separate correspondence), any appreciable amount of rework resulting from the re-radiography would jeopardize the completion date on the SS(N)605 (JACK). This rework would require pipefitters and welders. These trades are in short supply and, so far, our recruiting effort has not been successful. Additional pipefitters and welders required on the TINOSA would have to come from the JACK.

7. In view of the cost involved, the disruptive effect on scheduled work, and the lack of serious risk, Portsmouth Naval Shipyard plans to accept these past radiographs on non-nuclear piping welds without further action. Radiographs taken since November, except where adequate focal distance could not be obtained, meet the requirements of reference (a) and (b).

s/ C. J. PALMER

Copy to:
200
300
310
2301
301D-1

COPY

Exh 224-16

VI

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO

31 July 1962

Report of Conference

Subj: Report of Conference on Non-Nuclear Pipe Welding for Submarines

23 and 24 July 1962 — Bureau of Ships, Washington, D.C.
Room 3601, Main Navy Building

Ref:
(a) BUSHIPS ltr 9480, Ser 648X-310 of 9 February 1962
(b) Code 640 Memo, Ser 640-M49 of 23 February 1962
(c) BUSHIPS ltr 9890/2050.5 Ser 1500I-3402 of 12 July 1962
(d) BUSHIPS ltr 9890/2050.5 Ser 1500I-1745 of 16 July 1962
(e) BUSHIPS dispatch 122300Z of July 1962
(f) BUSHIPS ltr 9480, Ser 648X-1259 of 13 July 1962

Encl:
(1) Agenda for Conference
(2) List of Attendees
(3) Elements of problem common to all
(Carbon Steel pipe Welding, Copper-Nickel pipe Welding, and Monel pipe Welding)
(4) Summary Data on Problems
(5) Modification to Acceptance Standards
(6) BUSHIPS dispatch 2421170 of July 1962
(7) Summary of Actions Taken as Result of February Conference

Exh 224-17

1. Background.

a. In late 1961, representatives of Code 1500 discovered, during audits of specification compliance, that gross non-compliance existed in the areas of non-destructive testing (especially radiography) and adherence to standards for welding of piping and quality of non-ferrous castings. This non-compliance was found to exist in Naval and private shipyards and in plants of equipment manufacturers. Since that time, Naval Inspectors, Supervisors of Shipbuilding, and Shipyard Commanders have insisted on strict compliance. This has led to an increase in the cost of shipbuilding. This is not necessarily an increase in cost to the Government because specifications and standards have not changed; the Government is insisting that the contractor meet the obligations of his contract. Also, in some instances, the completion dates of ships are jeopardized.

b. In February 1962, a conference was held in the Bureau of Ships to review the problems and develop courses of action. This conference was held in response to reference (a). Reference (b) is the summary report of actions agreed upon. Enclosure (7) is a resume' of the actions taken since the February conference. Briefly summarized, these are:

(1) Non-destructive testing requirements and acceptance standards for non-ferrous castings were reviewed and revised. Reports now indicate that NDT requirements and rejection rates are acceptable.

(2) Numerous actions have been taken in the area of carbon steel pipe welding but none have been effective in reducing the rejection rates to an acceptable level.

(3) Several actions have been taken in the area of copper-nickel pipe welding but none have been effective in reducing the rejection rates to an acceptable level.

(4) Welding of monel piping was not discussed during the February meeting. Code 634B has been keeping in touch with Code 1500 on this matter but has been doing very little independently. Code 1500 has a very active and complete program in this area. Results can and will be used to solve the total problem. Examples of action being taken are given in references (c) and (d).

c. The subject conference was called by references (e) and (f) to review actions taken since the February conference and to develop courses of action to solve remaining problems. The agenda for this conference is given in enclosure (1). The list of attendees is given in enclosure (2). The conclusions and courses of action developed are given in paragraphs following. A tabulation of answers to questions asked the various shipyards concerning rejection rates, etc. by reference (f) are contained in enclosure (4).

Exh 224-18

2. Conclusions.

a. Technical

(1) The elements of the problem which are common to all areas (carbon steel pipe welding, copper nickel pipe welding and monel pipe welding) are listed in enclosure (3).

(2) Carbon Steel -

(a) The high rejection rate of 25 to 40 percent is common to all shipyards. The summary of these rates is given in enclosure (4). The spread is due to the manner of analysis and degree of bookkeeping. There is a possibility that we are reaching a plateau in our rejection rate and that further improvements will be much more difficult. This is supported by the statistics which show that a relatively low percentage of unsatisfactory weld causes a high joint rejection rate.

(b) The effect of the problem on cost and especially on schedules varies with each shipyard and is affected by the workload, i.e., Mare Island schedules on the basis of this rejection rate; Newport News has a large number of welders and overpowers the rejection rate; EB has a very large workload and is falling behind.

(c) There is a requirement for shorter and easier communication channels between shipyards and the Bureau.

(d) Audit teams should continue their audits; teams should include a gualified welding engineer.

(e) The reject rate is unsatisfactory.

(f) There exists a need for development of automatic welding processes.

(g) Welding acceptance standards should be reviewed.

(h) There is still room for improving procedures in most shipyards.

(3) Copper Nickel -

(a) There is an urgent need for automatic welding and brazing processes.

(b) A large part of the problem is concerned with pipe and fittings specifications plus fabrication difficulties; i.e., backing rings and non-circularity of pipe.

(c) The electrode must be improved.

Exh 204-19

(d) We[illegible]ing acceptance standards should[illegible] reviewed.

(e) There is still room for improvement in procedures in most shipyards.

(4) Monel -

(a) This is our most serious technical problem.

(b) For non-nuclear applications, other materials may be utilized.

(c) There is an urgent need to develop automatic processes.

(d) The reject rate is unsatisfactory.

(e) Acceptance standards should be reviewed.

(f) There is still room for improvement in procedures in most shipyards.

b. Administrative

(1) Effects on cost of shipbuilding

(a) Except for the contract with Newport News Shipbuilding and Dry Dock Company for 1962 SSBN, there has been no increase in specification requirements in the areas of non ferrous castings, carbon steel pipe welding, copper nickel pipe welding, monel pipe welding. In the contract with Newport News, there has been an increase in requirements for non-destructive testing of castings (S1-0-g.) Therefore, except for the contract with Newport News, there should be no increase cost change orders initiated by the Bureau or its field activities. There may be claims initiated by the private shipbuilders.

(b) The enforcement of the specifications and standards is increasing the cost of shipbuilding. The factors involved are many and varied and the exact cost per ship cannot be exactly determined; however, the estimated cost of enforcement is $500,000 - $1,000,000 per ship.

(2) Effects on schedules (SEE enclosure 4)

(a) There will be no effect on the schedule for ships built by Newport News and Mare Island.

(b) Bethlehem Steel does not expect to delay ships because of these factors.

(c) There will be delays in ships built by Portsmouth, Electric Boat, Ingalls and New York Shipbuilding Corporation.

Exh 224-20

1 Portsmouth expects delays in all ships primarily attributable to difficulties in nickel copper welding.

2 Electric Boat will complete 616 and 617 on schedule but all follow ships will be delayed ½ to 2 months because of the items discussed at this conference.

3 Ingalls has experienced delays but expects to adhere to latest dates submitted.

4 There will be a delay in ships at Camden; however, the amount attributable to this problem cannot be exactly determined.

(3) There is need for a project type appraoch to these problems.

3. Courses of Action.

a. Acceptance standards for radiography will be modified in accordance with enclosure (5). This modification was transmitted by enclosure (6) and will be confirmed by a Category D change order. This modification was proposed by SUPSHIPS, Groton. A similar one was proposed by SUPSHIPS, Camden. This modification places the Navy's standard between the old Navy standard and the ASME. The basis for the change is that there is very little experience by ASME in the thin walled piping. Navy experience indicates that this change is acceptable.

b. The Commander, Portsmouth Naval Shipyard, was appointed Project Manager to review the common elements of the problem listed in enclosure (3) and develop recommended courses of action. All attending activities were requested to forward to their Project Manager their proposals for work which should be done within the various areas and what work could each undertake. The Project Manager will develop his proposed charter and will return to the Bureau to discuss it during the week of 30 July. After approval of the charter, BuShips will promulgate it to all concerned.

c. The Bureau will determine the equipment needs of the shipyards for welding, brazing, NDT and will expedite procurement.

d. The program for welding monel being handled by Code 1500 will be followed closely. Codes 640, 630 and 634 will assist wherever possible.

e. Audits of activities will continue with emphasis on internal audits. BuShips will audit activities with team composed primarily of personnel from field activities.

f. BuShips will develop the effect on the cost and the schedule of ships of the modification to the welding acceptance standards.

(b) (6)

, CAPTAIN, USN
DIRECTOR, MACHINERY DIVISION

Exh 224-21

AGENDA

RADIOGRAPHY, ETC. CONFERENCE

23 - 24 JULY 1962

I. Opening Remarks - RADM. Moore

A. Follow up to conference held in February 1962.
B. Seriousness of impact on cost and schedule.
C. Importance of meeting specifications and standards forming part of contract.

II. Resume of February 1962 conference and actions taken

A. Non-ferrous casting.
B. Carbon steel pipe welding.
C. Copper Nickel pipe welding.
D. Monel pipe welding.

III* Reports by Shipyards and SUPSHIPS (BUSHIPS ltr 9480; ser 648X-1259 of 13 July 1962)

A. Newport News
B. Mare Island
C. Quincy
D. Pascagoula
E. Portsmouth
F. Groton
G. Camden

IV. Discussion

V. Summary, Conclusions, Decisions (or recommendations)

* (In particular items A,B,C,D,K, and M)

Enclosure (1)

EXH 224-32

LIST OF ATTENDEES

Bureau of Ships

RADM. R. K. James	Code 100
RADM. R. L. Moore	Code 101
RADM. R. B. Fulton	Code 600
CAPT. (b) (6)	Code 601*
CAPT.	Code 640
CAPT.	Code 630
CAPT.	Code 525
CAPT.	Code 705
CAPT.	Code 1700
CDR. (b) (6)	Code 630
Mr.	Code 630
CDR.	Code 648
Mr.	Code 648
Mr.	Code 648
LCDR	Code 525
LCDR	Code 525
Mr.	Code 406

Supervisor of Shipbuilding, Camden

CAPT (b) (6)
LCDR
Mr.

Supervisor of Shipbuilding, Newport News

CAPT. (b) (6)
CDR.
Mr.

Mare Island Naval Shipyard

CAPT. (b) (6)
CAPT.
CAPT.
Mr. (b) (6)
Mr.
Mr.
Mr.

Portsmouth Naval Shipyard

RADM. C. J. Palmer
CAPT. (b) (6)

Supervisor of Shipbuilding, Groton

CAPT (b) (6)
Mr.

Supervisor of Shipbuilding, Quincy

CAPT. (b) (6)

Supervisor of Shipbuilding, Pascagoula

CAPT. (b) (6)

* Part Time
**First Day Only

ENCLOSURE (2)

EXH 224-23

ELEMENTS OF THE PROBLEM

(Common to all welding agenda items)

1. Acceptance Standards
2. Training of Welders, Radiographers and Inspection Personnel
3. Amount and Type of Radiography and Welding Equipment
4. Procedures Used for Radiography
   a. Use of X-ray vs. Iridium
5. Welding Procedures and corresponding Repair Procedures
6. Material and Specifications for Pipe and Fittings
7. Installation Procedures
   a. Maximum shop fabrication and pre-fabrication from template
   b. Location of shipboard joints
   c. Use of automatic equipment
8. Design for least number of joints
9. Welding Electrodes
   a. Specification
   b. Variation between manufacturers and lots from same manufacturer
   c. Environmental factors
10. Standards for Audits
    a. Internal audits
    b. External audits
    c. Method of reporting rates of rejection or acceptance
11. Communications between Field and Bureau and between Field Activities.

Enclosure (3)

Exh 224-24

SUMMARY DATA ON PROBLEMS

A. Carbon Steel (#2)

Shipyard	Reject Rate(#4)	Required joint Rate/day Actual Rate	Welders	(#3) Remarks
N.N.SB&D.D.CO.	32%		1470	100/100
Mare Island NSY	35%	15/OK	139	33/90
(#1) Beth.Steel Quincy	29%	15/OK	310	90/80
Ingalls, Pasc	25%	2/OK (10-15week)	60	0/100
Portsmouth NSY	53/22.5 (#5)	4.5/2	42	100/99
E.B. Div. Groton	44/17 (#5)	14/9	99	95-100/95
N.Y. Ship, Camden	40	?/OK	35	100/100

(Delay - See Item D)

#1 Figures are for surface ships.
#2 To present schedule, 22 weeks attributable delay has been incurred.
#3 This figure read as follows:

% x-ray used in shop
% irridium used on ship

#4 Base for reject rate varies to small degree due to method of counting or not counting rejects to repaired joint.
#5 This figure read as follows:

Present rate/rate 30-90 days past

B. Copper Nickel

Shipyard	Reject Rate	Req'd joint Rate/day Actual Rate	Welders	Delay	Remarks
NPTNWS	19	5.3/OK	?	No	Slag/line porosity
Mare	45	4/OK	33	No	
Quincy					No experience
Pascagoula	33-35	1/OK	50	No	None
PTSMH	37	7.5/5.5 (#1)	20	No	None
Groton	39/34	12/8	Limited	In total	Slag
Camden	25/90	75% of that req'd	37 non-nuclear	Yes	Porosity

#1 Lag affected by number of welders in training during period.

C. Monel

Non nuclear monel welding of insufficient amount to complete table, resume of discussion as follows:

Enclosure (4)

Exh 224-25

(1) Reject rate varies from 18 - 100% with average 35-50%.

(2) Most yards restricted this welding to a few qualified welders, 3-8 welders.

(3) Most serious technical problem.

(4) Slag, porosity and root cracks are items causing rejects.

(5) Required rate in major yards was in the area of 3 or less per day.

D. Delay

Shipbuilder	(Estimated, attributable to problem)
N.N.SB&D.D.CO.	None
Mare Island NSY	None
Beth. Steel, Quincy	Not applicable
Ingalls, Pascagoula	SSN-596 22 weeks
	SSN-607 22 weeks
	SSN-621 12 weeks
Portsmouth NSY	SSN-606 12-15 weeks
	SSN-605 delay expected
	SSBN-620 delay expected
E.B. Div. Groton	SSBN-616 none
	SSBN-617 none
	SSBN-623 15-30 days
	SSBN-626 1-2 months
	SSBN-628 1-2 months
	SSBN-631 1-2 months
	SSBN-633 1-2 months
	SSN-613 1-2 months
	SSN-614 1-2 months
	SSN-615 1-2 months
N.Y. Ship, Camden	SSN-603 6-8 weeks already attributed; 6-8 probable addition
	SSN-604 6-8 weeks already attributed; 6-8 probable addition
	SSN-612 6-8 weeks already attributed; 6-8 probable addition

E. Most Serious Category

N.N.SB&D.D.CO.	None leading to delay - carbon steel most serious
Mare Island NSY	Nickel copper
Beth.Steel, Quincy	Limited experience
Ingalls, Pascagoula	Copper Nickel & Nickel Copper
Portsmouth NSY	Nickel copper
E.B. Div. Groton	Carbon steel
N.Y. Ship, Camden	Nickel copper

F. Miscellaneous

Shipbuilder	Radiographer Readers	Radiographers	Sources X-Ray	Sources Irridium	Film Processing Capacity/Shift
N.N.SB&D.D.CO.	16	12	6	17	1000 (5X7)
Mare Island NSY	7	20	5	13	3200 (X-Omat)
BethSteel Quincy	15	51	7	7	1300 (various)
Ingalls, Pasc.	11	49	4	14	1000
Portsmouth NSY	3(14trng)	60	11	14	200
E.B.Div. Groton	62	79	6	19	1152 (14"x17")
N.Y.Ship, Camden	6(all categories)	18	10	6	150

Exh 224-27

Radiographic Acceptance Standards *

The radiographic acceptance standards for slag and porosity in production and repair welds in non-nuclear applications shall be as follows in lieu of that specified by NAVSHIPS 250-692-2 of January 1961. These standards shall apply regardless of the base metal involved.

Porosity - Random porosity indications shall be in accordance with the requirements of Appendix IV. Porosity Charts, ASME Boiler and Pressure Vessel Code, Section VIII, 1962 Edition with the following requirements:

1. For welds 1/8" thick and greater, porosity indications 1/64 inch and less in diameter shall not be counted in determining the acceptability of the welds.

2. Randomly dispersed indications and clusters are allowed together in a single weld provided the total number of dispersed and clustered indications does not exceed the specified maximum number of randomly dispersed indications for the applicable indication size and weld thickness.

3. Aligned indications - Porosity indications shall be considered aligned if the middle indications touch a line drawn through the centers of the outer two indications.

Indications separated from each other by a distance greater than 4XD shall not be considered aligned where D is the diameter of the large of two adjacent indications.

Any four aligned indications located so that the distance between each adjacent indication is less than D shall be rejected.

Four or more aligned indications separated from each other by a distance less than 4XD shall be rejected if the total distance between the two outer indications exceeds 4XT, where T is the design material thickness.

Slag - The acceptance standard for slag shall be as given in Figure 1 with the following requirement:

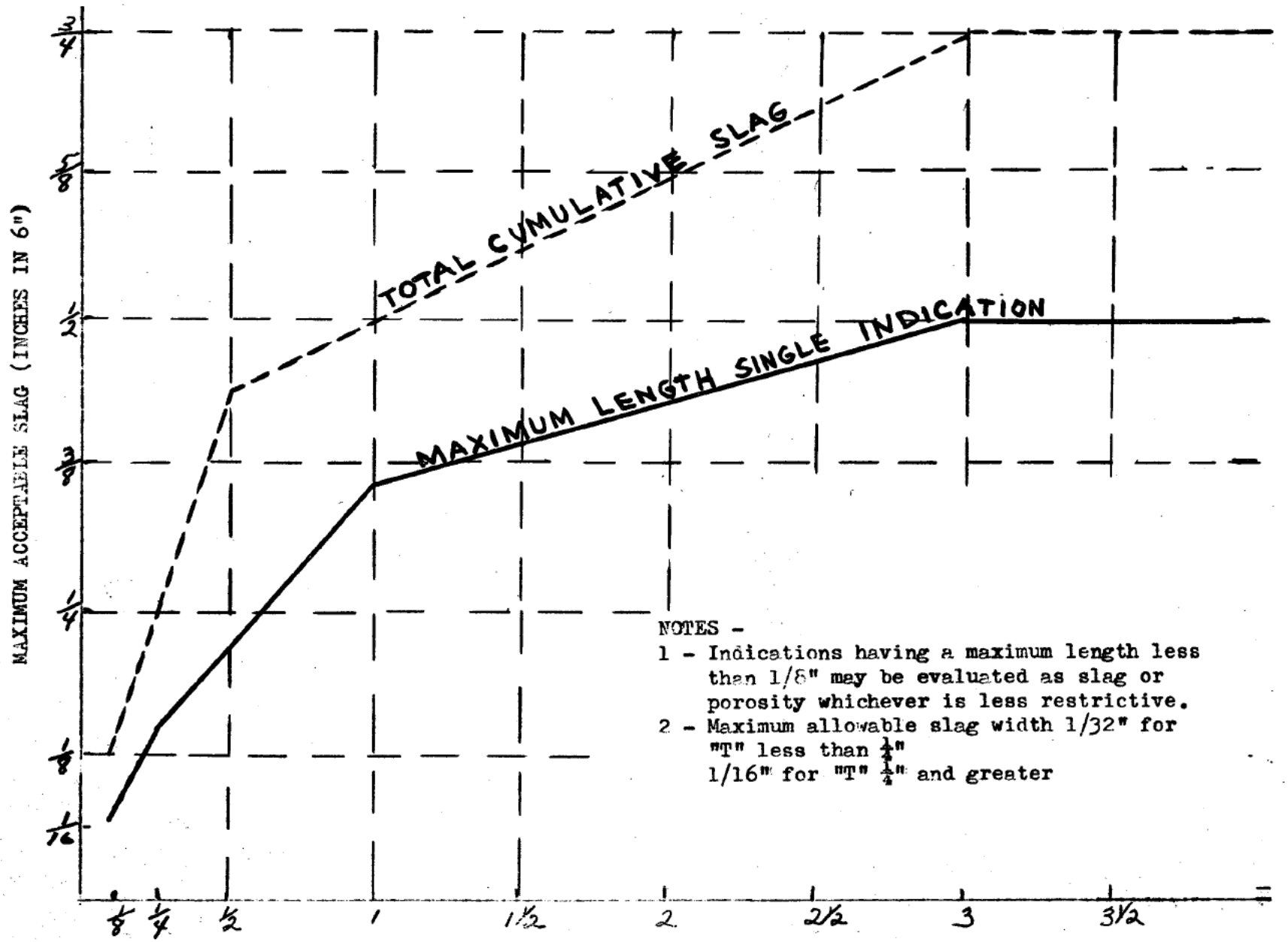
The total accumulated slag, consisting of two or more indications, shall not exceed that shown in the curve for any 6 inches of weld. However, any two adjacent indications shall be separated by at least 4XL, where L is the length of the larger indication.

* The standards have been modified from those given at the conference as underlined.

Exh 224-28

Encl (5)

SLAG ACCEPTANCE STANDARD FOR WELDS



NOTES -

1 - Indications having a maximum length less than 1/8" may be evaluated as slag or porosity whichever is less restrictive.

2 - Maximum allowable slag width 1/32" for "T" less than 1/4"
1/16" for "T" 1/4" and greater

Exh 224-29

NAVAL MESSAGE UNCLASSIFIED BUREAU OF SHIPS

S/ R. K. (b) (6) CAPT. R. E. (b) (6) CODE 630 X-65846

Typed By: S. K. (b) (6) DEFERRED 24 JULY 1962

242117Z

(Date/Time Group GCT)

FROM: BUSHIPS
TO: NAVSHIPYD PTSMTH
NAVSHIPYD MARE
SUPSHIP GROTON
SUPSHIP QUINCY
SUPSHIP CAMDEN
SUPSHIP NEWPORT NEWS
SUPSHIP PASCAGOULA

UNCLAS

A. PROPOSED RADIOGRAPHIC ACCEPTANCE STANDARDS, UNDATED; QUICK COPY GIVEN ADDRESSEE REPS BUSHIPS RADIOGRAPHIC CONFERENCE 24 JULY 1962.

1. EFFECTIVE IMMEDIATELY REFERENCE A IS AUTHORIZED FOR PIPING SYSTEMS ONLY, IN THE NON-NUCLEAR AREA. IT IS NOT APPLICABLE TO COMPONENTS AND PIPING INSTALLED IN REACTOR COOLANT AND ASSOCIATED SYSTEMS AS DEFINED IN SECTION 3 OF NAVSHIPS 250-1500-1 DATED NOVEMBER 1960.

2. CATEGORY D CHANGE ORDER FOLLOWS.

CERTIFIED TO BE A TRUE COPY.

/s/ R. E. (b) (6)

R. E. (b) (6), CAPTAIN, USN

COPY TO:

630	634B
640	648
525	525A1
600	100
101	
1500	

UNCLASSIFIED
COPY

Exh 224-30

SUMMARY OF ACTION TAKEN AS RESULT OF FEBRUARY CONFERENCE

I. Non-Ferrous Castings (Tin Bronzes)

A. Problem

1. Large backlog of castings requiring radiography - caused by:

a. SSN 593 - "Motherhood" clause
b. SSBN 616 - "100%" clause

2. Rejection rate - Actual rates difficult to come by - but - general agreement that rates were high enough to jeopardize ship completion and cost.

B. Remedies

1. Revised S1-0-g of Specs for Ships by Change Order and made changes in Standards (MIL-STD-271A) as follows:

a. Developed requirement for "Shot Schedule" (Amount of Radiography)
b. Generally, lowered acceptance standards by one class (based on an analysis of work done by MATLAB, NYK). (Rejection Rate)
c. Clarified instructions concerning interdendritic shrinkage and "Mottled" effect.

2. Had committee investigate materials - lack of success - Conferees recommended AL bronzes; found that we can't use because of corrosion, in addition increased emphasis on foundry practice has increased ability to meet standards.

3. Decided long range program unnecessary because of general acceptance of revised S1-0-g.

C. Possible Remaining Problems

1. Sensitivity of radiography for castings "as cast" or "as finished".

D. For other Non-ferrous castings (CuNi, Monel, AL bronze) use steel standard with addendum -- This is an easement.

II. Carbon Steel Pipe Welding

A. Problem

1. High rejection rate - primarily attributable to porosity.

Enc 229-31

2. Sensitivity requirements for radiography - shipyards cannot meet 2-2T for in-field radiography.

B. Remedies

1. Authorized use of 70 10 electrode - but required control of sulfur in rod and in fittings.

2. Modified radiography sensitivity requirements by changing Table X of MIL-STD-271A.

3. Work on acceptance standards:

a. Clarified acceptance based on Slag.
b. Checking welding on World War II built ships.
c. Had material reviewed by industry group (ASME affiliated).
d. Code 634B conducted survey of segments of industry.
e. Held meeting with EBASCO.
f. BuShips reviewed samples of radiography of welds from shipyards.
g. Code 700 (705 - 740) has training program for shipyards in radiography.

C. Unresolved Problems

1. Sulfur limits of fittings and how the amount is determined for lots on hand.

2. Continued unacceptable rejection rate.

III. Copper Nickel Welding

A. Problem

1. High rejection rate.

B. Remedies

1. Developed new electrode (187) for purpose.

2. Changed acceptance standards by modifying steel standards to make applicable.

C. Remaining Problem

1. Too high rejection rate.

Encl (7)

Exh 224-32

D. Work yet to be done

1. More work on electrode

2. Use inert gas welding

3. Reconsider sil brazing

IV. Monel

A. Problem

1. High rejection rate.

B. Remedies

1. Use modified standards

2. 1500's letter

C. Remaining Problems

1. High rejection rates.

Exh 224-33

VII

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO

SS(N)59301/9090
NObs 4268, 4269
4355, 4356
4374
Ser 525-2172
12 September 1962

From: Chief, Bureau of Ships
To: Commander, Portsmouth Naval Shipyard (55 copies)
Commander, Mare Island Naval Shipyard (40 copies)
Supervisor of Shipbuilding, U. S. Navy, Groton
(30 w/encl (1) 80 copies)
Supervisor of Shipbuilding, U. S. Navy, Pascagoula
(30 w/encl (1) 80 copies)
Supervisor of Shipbuilding, U. S. Navy, Camden
(30 w/encl (1) 80 copies)

Subj: SS(N)593 Class; Category D Change No. 321; Radiographic Acceptance Standards for Welded Joints, Modification of

Ref: (a) Shipbuilding and Boat Building Contract Manual dated January 1962
(b) BUSHIPS message 242117Z dated 24 July 1962

Encl: (1) Mod. Requisition No. Change 321

1. Enclosure (1) is forwarded for appropriate action. Refer Chapter 12 of reference (a) for information.

2. General Description of Change:

In accordance with agreement at Bureau of Ships conference 23-24 July 1962, modification to Radiographic Acceptance Standards for welded joints was authorized by reference (b).

The Radiographic Acceptance Standards for slag and porosity in production welds shall be as outlined in enclosure (1) in lieu of that specified by NAVSHIPS 250-692-2 of January 1961. These standards shall apply to the non-nuclear area Pd1 Class piping regardless of the base metal involved. It should be noted that the Figure 16 forwarded herewith has been slightly altered from the Figure 16 supplied conference participants and authorized by reference (b).

S2711

Exhibit 224-34

SS(N)593C1/9090
NObs 4268; 4269
4355; 4356
4374
Ser 525-2172

3. No change in weight should result from this change.

(b) (6)

W. J. CARTIN
By Direction

Copy to: (w/encl (1))
INSURV (2)
INSURVPAC (2)
INFOCONSULANT
COMSUBPAC
SPCC (2)
ESO (2)
COS CURCY (2)

Exhibit 22435

"The acceptance standards for slag and porosity in production and repair welds shall be as follows: These standards shall apply regardless of the base metal involved.

Porosity - Random porosity indications shall be in accordance with the requirements of Appendix IV, Porosity Charts, ASME Boiler and Pressure Vessel Code, Section VIII, 1962 Edition with the following requirements:

1. Indications shall be prorated for lengths other than that shown in the standard.

2. For welds 1/8 inch thick and greater, porosity indications 1/6 inch and less in diameter shall not be counted in determining the acceptability of welds.

3. Randomly dispersed indications and clusters are allowed together in a single weld provided the total number of dispersed and clustered indications does not exceed the specified maximum number of randomly dispersed indications for the applicable acceptance standard.

4. Aligned Indications - Porosity indications shall be considered aligned if the middle indications touch a line drawn through the centers of the two outer indications.

Any four aligned indications located so that the distance between each adjacent indication is less than D shall be rejected.

Four or more aligned indications separated from each other by a distance less than 4 X D shall be rejected if the total distance between the two outer indications exceeds 4 X T, where T is the design material thickness.

Slag - The acceptance standard for slag shall be as given in Figure 16 with the following requirement:

The total cumulative slag, consisting of two or more indications, shall not exceed that shown in the curve for any 6 inches of weld. Any two adjacent indications shall be separated by at least 4 X L, where L is the length of the larger indication."

4. Changes in Schedule A: None.

5. Plans: None.

Exhibit 22436

1. Mod. Requisition No. Change 321; applicable to:

A. SS(N)605, 606 under Project Orders, 20745 and 20744 with Portsmouth Naval Shipyard.

B. SS(N)594, 595 under Project Orders 30723 and 30727 with Mare Island Naval Shipyard.

C. SS(N)596, 607 and 621 under Contracts NObs 4269 and 4374 with Ingalls Shipbuilding Corporation.

D. SS(N)603, 604 and 612 under Contracts NObs 42688and 4356 with New York Shipbuilding Corporation.

E. SS(N)613, 614 and 615 under Contracts NObs 4355 with Electric Boat Division, General Dynamics Corporation.

2. General Description of Change:

The radiographic acceptance standards for slag and porosity in production and repair welds in non-nuclear applications shall be as outlined in this change order and supersedes that specified by NAVSHIPS 250-692-2 of January 1961. These standards shall apply regardless of the base metal.

3. The Self-Contained Specifications dated 9 July 1958 for building the above mentioned ships is modified as follows:

a. Section S9-1-h, Piping, Class P-1, Inspection, page 114, delete the following:

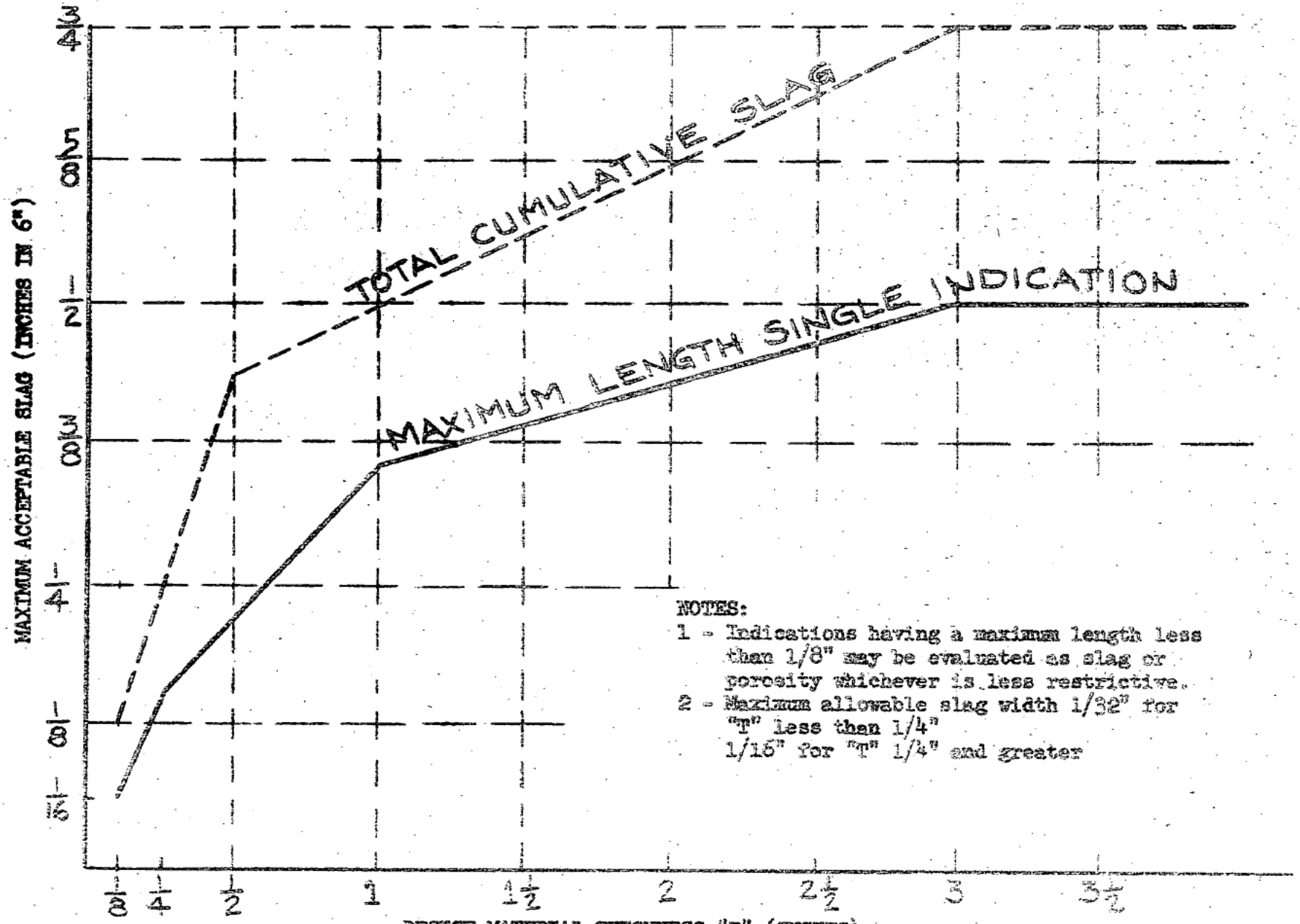
(1) line 25 thru 27, "Radiographs shall be compared with Group 1 in NAVSHIPS 250-692-2, 'X-ray standards for productinn and repair welds'."

(2) Phrase "of January 1961 except as follows" including paragraphs (1), (2), (3) and Figue 16 all added by change order 284 of 3 May 1962.

b. Section S9-1-h, Piping, Class P-1, Inspection page 114, line 24 after "ing the hydrostatic test of the piping." add:

Exhibit 224-37

SLAG ACCEPTANCE STANDARD FOR WELDS



NOTES:

1 - Indications having a maximum length less than 1/8" may be evaluated as slag or porosity whichever is less restrictive.

2 - Maximum allowable slag width 1/32" for "T" less than 1/4"
1/16" for "T" 1/4" and greater

FIGURE 16

Exhibit 22-38

1960
Ser 634B-284

19 Jun 1960

REPORT ON TRAVEL

Subj: Review of inspection procedures for HY-80 submarine hull welds

Person making Visit: [redacted] (b) (6) GS-13, Code 634B

Date	Place Visited	Persons consulted
12-13 April 1960	Portsmouth Naval Shipyard	CAPT. , Planning Officer CDR. Design Supt. [redacted] Asst. Prod. Officer F. Code 250 H. Code 250A I. (b) (6) Code 375 E. , Code 375A D. Weld. Engr. C. Foreman Welder R. Chief Qtrm. Welder
14-15 April 1960	Electric Boat Division Groton, Conn.	Supervisor of Shipbuilding, USN CAPT. (b) (6) Supervisor CDR. (b) (6) Inspection Officer [redacted], Asst., Quality Control [redacted], Head Inspector Head Hull Inspector Hull Inspector [redacted] Boat Division (b) (6) Welding Engr. Head, Radiographic Dept. Asst. Radiographer [redacted] Ch. Inspector Head, Quality Cont. Div. Quality Cont. Div.

1. Purpose. This visit was to review the procedures used for non-destructive inspection of the HY-80 submarine hull welds and to review production radiographs to determine quality level of the hull weld radiographs.

2. Background. As the basis of the findings during recent review of the radiographic inspection procedures and production radiographs at the Mare Island Naval Shipyard it was considered desirable to visit other submarine building activities to review the non-destructive inspection procedures used for inspection of the Hy-80 hull welds. The information obtained will be of value in development of the inspection requirements by the HY-80 welding task group.

Exh 224-39

3. Brief. The radiographic facilities, procedures, production radiographs, and methods of control of inspection and the magnetic particle inspection methods were reviewed in each activity visited. The following is a summary of findings.

Portsmouth Naval Shipyard - Radiographic inspection is done by the Shipyard Laboratory when requested by Shop 24. The production radiographs taken prior to obtaining the present Iridium 192 sources were of very poor technical quality. The radiographs taken with Iridium 192 sources although better, showed lack of control of techniques and processing and do not represent 100% coverage of the hull butts and seams. The review of the radiographs for defects appeared good although many areas could not be interpreted because of poorquality. Until recently no adequate identification method was used and most radiographs taken on the SS(N)593 and 602 cannot now be identified with location on the submarine hull. Shipyard personnel advised that 100% coverage of hull butts and seams cannot be obtained due to obstructions inherent to construction and removal would delay production. It was recommended that steps be taken to insure closer control of the radiographic taking and processing techniques to provide better quality radiographs and to insure complete radiographic inspection of the hull welds as required by specifications. Since the Shipyard radiographic procedures have not been qualified, it was requested that steps be taken to qualify in accordance with MIL-STD-271 and NAVSHIPS 250-1500-1.

Electric Boat Division - The radiographic inspection of the submarine hull welds was at high quality. The production radiographs aside from occasional minor items were excellent and represented almost complete coverage of the head welds. The radiographs are reviewed for defects by qualified personnel in the E.B. radiographic laboratory, the shipyard inspection office and the Supervisor's office. The identification method is good and all radiographs can be identified within close limits as to location. An accurate cross check is maintained at all production inspection, both radiographic and magnetic particle. The E. B. Div. radiographic procedures have been qualified in accordance with the MIL-STD-271 requirements.

4. Action Required. Following completion of the review in each activity a meeting with yard personnel was held and the findings were discussed. No further Bureau action is required at this time. On receipt of Portsmouth Naval Shipyard radiographic qualification tests necessary action will be taken to expedite review and report of tests.

Exh 224-40

5. Detailed Discussion.

Portsmouth Naval Shipyard - All radiographic inspection including taking the radiographs, processing and review is under cognizance of the Shipyard Laboratory. When a welded joint is ready for inspection, Shop 26 notifies the laboratory and the radiograph is taken as time permits. In order not to delay production the radiograph is taken as quickly as possible and in general time is not taken to remove obstructions such as scaffolding, braces etc. The completed films are processed and reviewed in the X-ray laboratory. In the case of welds requiring repair, the films are sent to Shop 26 where they are taken to the job for location of the defect. The repaired weld is radiographed. If there is disagreement on interpretation between the laboratory and Shop 26, the radiograph may be referred to the Shipyard Welding Engineer. It was stated, however, that this situation does not occur very often. Shop 26 may request reradiograph of a weld if they do not consider a radiograph of good quality.

Radiographic Procedure - The radiographs initially taken on the SS(N) 593, 603 and 606 hull welds were made with X-ray using calcium tungstate screens and coarse grain medical type film. About October 1959, iridium 192 sources were obtained and Dupont 506 fine grain film was adopted as a standard with no screens. Cobalt 60 is used for radiography of thicknesses of plating 2-1/4 inches or over. In general butts were not flock shot but on the SSB(N)602 some flock shots were taken with cobalt 60 sources.

Quality of radiographs - The radiographs taken using X-ray and medical film were of very poor quality. The films were grainy and the exposure varied across the film. The radiographs in general showed penetrameters of the old type. Many films were water streaked and showed pressure marks and the calcium tungstate screens had been patched with scotch type so that the image of the tape was superimposed in many cases across the weld area. In a number of instances the films were taken with cables, wire baskets or other obstructions superimposed across the weld area. Shipyard personnel advised that the production schedule did not permit removal of many obstructions.

Identification - Logs are kept of radiographs taken on each hull. Each component such as butt weld, seam weld, pipe joint, etc. is assigned an item number in sequence as radiographed and each radiograph taken of the item is numbered or lettered sequentially. Individual radiographs are identified only with the hull number, item and sequence number. Logs are kept to identify the item with the component radiographed and to record the radiographic procedure used. Until recently identification of the radiograph to a particular hull location was maintained only until the radiographs had been reviewed and necessary repairs made. Correlation of radiographs to hull location can no

Exh 224-41

longer be made for subsequent inspection purposes. Last fall on the 593, 603 and 605 hull welds a more uniform system was established by starting butt inspection at the 12 o'clock position looking forward numbering the films sequentially counterclockwise, and seams starting at one end. Shipyard personnel did not consider that accurate identification within a couple of feet of a location is possible after the initial inspection is completed and ink location marks on the hull have been obscured. A set of sketches of hull structure have been prepared by Shop 26 for use in connection with future inspection records. The radiographs are filed as completed in boxes, roughly by date, and it was difficult to locate particular radiographs for review.

Review of radiographs - All radiographs are reviewed for compliance with acceptance standards by one of three experience men in the radiographic laboratory. Survey of random production radiographs indicated the shipyard review to be good with regard to detection of defects. However, in a number of instances technically poor radiographs had been accepted for final weld inspection. Radiographic personnel advised that production schedules precluded retaking of radiographs in most instances. The viewing facilities were in general poor and not conducive to accurate reading of films.

Repair of defects - The rejected areas found are marked and the films are sent to the shop for identification on the hull and repair. The defective areas are are air gouged and repair welds are made. The weld area are preheated with 24" strip heaters and after repair the heater is left until the heat evens out, then allowed to cool in air or under asbestos protection depending upon surrounding atmospheric conditions. It was reported that the incident rate of cracks in butts and seams is approximately 15 per hull and about 1-2% repair due to slag type defects. Repair welds are radiographed.

Radiographic Sources Available - Iridium 192 sources, 2-100 curie, 1-50 curie, 1-30 curie; cobalt 60 sources, 1-10 curie source; X-ray, 1-250 KV Triplett Barton machine and 2-GE 250 KV machines.

Magnetic particle inspection - Magnetic particle inspection is made by welders in Shop 26 trained for inspection by an instructor qualified by the Shipyard Laboratory. All butts and seams are magnetic particle inspected on inside and outside surfaces using AC yoke inspection units. Code 303 spot checks the inspection on butt and seam welds and on high pressure tanks.

Exh 224-42

Electric Boat Division. E. B. Division radiographic inspection is made in accordance with Shipyard Standard Procedure 3.20 Rev. A., Inspection Instruction No. 20. The responsibility for exposing, identifying, location marking, developing and evaluating radiographs is assigned to the Radiographic Section of the Welding Department. They are also responsible for originating and maintaining radiography records and custody of all radiographs. The Inspection Department requests radiographic inspection of final production welds in duplicate one copy of which is kept by the Inspection Dept. as a check. The completed films are processed and reviewed by either the Head of the Laboratory or his assistant. The films are never taken to the job in order to avoid damage to the films. In the case of weld repairs a tracing paper overlay is made of the film and this is used in locating the defect on the job. A four copy record sheet is kept of all radiographic inspection. This sheet includes a complete description of the welded joint covering all details of the welding procedure which is of invaluable assistance in review of the films. The details on inspection of each film is made by the Radiographic Department on this record sheet and reason for each rejection are given in detail. When the Radiographic Department has reviewed the films, repaired joints and retaken as necessary, the radiographs are submitted to the E. B. Div. Inspection with the record sheet. The Inspection Department evaluates all final production films to assure compliance with all requirements for identification, technical requirements, quality of radiograph, and acceptability of evaluation. Following review by the Inspection Department all final production films are submitted to the Supervisor of Shipbuilding for review. The films are all reviewed and the Supervisor's office is currently keeping an accurate record of the quality of all radiographs with view to future use of a sampling inspection by the Supervisor rather than 100% inspection. The copies of the record sheet are kept as a permanent record in the folder with the film, and in Radiographic Dept., Inspection Dept. and Supervisors files.

Radiographic Procedure - The radiographs are made on type AA film using Iridium 192 sources with lead screens for material thicknesses less than 1-1/4 inches and cobalt 60 for thicker materials. All radiographs were single exposure and no flock type inspection is done.

Quality of Radiographs - Films viewed were of excellent quality. Approved penetrameters were visible on all films. In all except a few films where there was interference from framing, the exposure and sensitivity was consistent across the film. The films were free from developing defects such as streaks or water spots and through handling techniques the films were free of scratches.

Exh 224-43

Identification - Films were marked with the boat number, section, seam or butt number, film number (such as S16A, where S-starboard, 16-film number, A-first repair). All films were correlated by measurement as to location on the hull. E. B. Div. personnel reported that the radiographs could be later identified with the hull location to within a few inches. All films of individual butts or seams are filed together and through the copies of the radiography report in the files and with the film, particular radiographs can be readily located for later review.

Review of Radiographs - The viewing facilities for review of radiographs was good. Survey of production radiographs showed the review to be good and in all instances where radiographs were of defective quality the shots had been retaken.

Radiographic sources available - Iridium 192 sources, 10 sources ranging from approximately 3 curies to 450 millicuries; Cobalt 60 sources, 7 sources ranging from 4 curies to 500 millicuries; X-ray, 1-250 kv Triplett and Barton machine.

Magnetic Particle Inspection - Magnetic particle inspection is done by the E.B. Div. Inspection Department. All magnetic particle inspection supervisors have completed commercial courses in magnetic particle inspection. All men doing the inspection work are given shipyard courses in magnetic particle inspection and must pass a comprehensive written examination. Inspection is done using AC yoke inspection units except where accessability requires use of D.C. prods. All yokes are checked daily using drilled test blocks.

Records - A complete record is kept by the inspection department of the radiographs and magnetic particle inspection of all welds including date inspection, and result of inspection. At any time the status of any weld inspection can be immediately given from card records. Prior to launching the Design Department makes - complete list of all hull penetrations below the water line which is double checked to insure complete inspection and acceptance.

(b) (6)

Copy to:
Electric Boat Div.
NAVSHIPYD PTSMH
630
634B
525

Prepared by (b) (6) , X64224
Typed by (b) (6) 10 Jun 1960

Exh 224-44

IX

UNCLASSIFIED

SSN593/bn
4700
Ser: 04
18 January 1962

REGISTERED MAIL - UNCLASSIFIED

From: Commanding Officer, USS THRESHER (SS(N)593)
To: Commander Portsmouth Naval Shipyard, Portsmouth, New Hampshire

Subj: Defective Welds

Ref: (a) COM PNSY conf message 082145Z of January 1962

1. Reference (a) reported the existence of defective welds in reactor plant systems in this ship requiring repairs prior to the resumption of operations. These repairs are now in progress.

2. It is understood that the underlying reason for the existence of the reported defective welds was poor quality control due in part at least to inadequate weld radiography.

3. If the information given above is accurate, it would seem that defective welds might also exist in areas other than those pertaining to the reactor plant. As a matter of fact, one of the defective welds presently being repaired is located in a carbon steel b(1) Not only was this weld found to be defective, but it has proven to be one of the most difficult to repair even though the line was removed from the ship and the weld repair undertaken in the shop. Other areas of particular concern to this Commanding Officer are the hull and steam and salt water systems.

4. It is requested that the originator be advised as to what assurance there is that substandard welds do not exist in THRESHER in areas other than the reactor plant systems.

DEAN L. AXENE

Copy to:
COMSUBLANT
DEPCOMSUBLANT
COMSUBDEVGRU TWO

UNCLASSIFIED

Exh 224-45

X

C O P Y

UNCLASSIFIED

PORTSMOUTH NAVAL SHIPYARD
PORTSMOUTH, N. H.

In reply refer to:
300
SS(N)593/4710
Ser 024-62
Jan 23 1962

From: Commander, Portsmouth Naval Shipyard
To: Commanding Officer, USS THRESHER (SS(N)593)

Subj: Defective Welds

Ref: (a) C.O. THRESHER conf ltr SSN593/bn 4700 Ser 04 of 18 Jan 1962

1. Reference (a) requested what assurance the Shipyard could give that there are no substandard welds in areas other than the reactor plant in the USS THRESHER (SS(N)593).

2. Basically, the same welding techniques and procedures, and the same radiography procedures were used on the THRESHER as were later used on the TINOSA. It can reasonably be assumed that the quality of the welding and radiography is the same for the two ships.

3. The Shipyard has reviewed the radiographs taken of the welds in areas other than the reactor plant systems in the TINOSA, and has found that the radiographs of the hull welds were of the required sensitivity, and that the welds accepted met the required standards. As for the radiographs of the welds in steam and salt water systems, the radiographs did not meet the sensitivity and discrimination requirements of the specification. However, it is the opinion of the Shipyard that any defects in the welds missed by the lack of sensitivity of the radiographs would be minor in nature and that failure from such defects is highly unlikely and in no case would catastrophic failure occur. This opinion is borne out by the number of Portsmouth built submarines that are operating and have operated successfully that were built to no better quality assurance standards than those used on the THRESHER.

4. In order to ascertain that the quality of radiographs of THRESHER piping is no worse than those reviewed of the TINOSA piping, and to assure that no major defects have been missed, the Shipyard is, at present, reviewing THRESHER radiographs of the main steam piping, main circulating water piping, and ASW headers. This review should be completed by 26 January 1962. The THRESHER will be kept informed of the results of this review.

s/ C. J. PALMER

Copy to:
COMSUBLANT
DEPCOMSUBLANT
COMSUBDEVGRU TWO

UNCLASSIFIED

C O P Y

Exh 224-46

XI

NNNNKKKKKKKKKKKKKKKKKKKKPDB189TCB263
PP RBEPD
DE RBEGXC 006
ZNR
P 131410Z
FM DEPCOMSUBLANT
TO CHUSHIPS
INFO CNO
CINCLANTFLT
COMSUBLANT
COMSUBPAC
BT
UNCLAS
SUBMARINE SALT WATER PIPING SYSTEMS
A. CNO LTR SER 1356P43 OF 25 AUG
1. RECENT INSTANCES OF FLOODING IN SUBMARINES BECAUSE OF DEFECTIVE SEA WATER PIPING OR FLEXIBLE HOSES ARE CAUSE FOR GRAVE CONCERN.
2. CRITICAL REVIEW OF DESIGN PRINCIPLES AND FABRICATION TECHNIQUES AND PUBLISHING OF CORRECTIVE MEASURES RESULTED FROM BARBEL FLOODING INCIDENT. ALTHOUGH RECOGNIZING THAT NATURE OF PROBLEM WAS SUCH THAT IMMEDIATE AND COMPLETE

SEP 13 16 34

PAGE TWO RBEGXC 006
SOLUTION NOT POSSIBLE TYCOM MUST EMPHASIZE THAT IN SPITE OF CORRECTIVE MEASURES LANTFLT SALT WATER PIPING INCIDENTS CONTINUE TO OCCUR WITH ALARMING REGULARITY. FOR EXAMPLE SUBSEQUENT TO BARBEL INCIDENT:
A. SKATE SHOCK TESTS - SILBRAZE JOINT FAILURES OCCURRED ON EACH SHOT. CAUSE ATTRIBUTED TO FAULTY DESIGN.
B. THRESHER FIRST BUILDERS TRIALS - ONE QUARTER INCH SALTWATER VENT LINE JOINT FAILED, CAUSE ATTRIBUTED TO USE OF STEEL VICE MONEL PIPE.
C. THRESHER SECOND BUILDERS TRIALS - ONE INCH ID TRIM SYSTEM PRIMING LINE FAILED DUE LACK SILBRAZE INSERT RING.
D. ETHAN ALLEN BUILDERS TRIALS - THREADED PLUG BLEW OUT OF TRIM LINE PRIMING LINE STRAINER. b(3) 10 USC 130
CAUSE ATTRIBUTED TO USE OF IMPROPER STRAINER INCORPORATING PLUG WITH TAPERED PIPE THREADS.
E. SNOOK FIRST BUILDERS TRIALS - THREE GREASE LINES PASSING THROUGH AFTER ENGINEROOM BULKHEAD CARRIED AWAY. CAUSE ATTRIBUTED TO FAULTY WORKMANSHIP ON FLARED FITTINGS. ONE AND ONE QUARTER INCH NIPPLE IN HPAC COOLING WATER DISCHARGE

Exh 224-47

PULLED OUT OF PIPE BOSS AT TEST DEPTH.
CAUSE ATTRIBUTED TO USE OF STAINLESS VICE MONEL PIPE.
SUBSEQUENT INSPECTION DURING TRIAL REVEALED LEAKING
SILBRAZE JOINT IN FIVE INCH LINE.
3. RECENTLY FOLLOWING INCIDENTS HAVE OCCURRED BECAUSE OF
FLEXIBLE HOSE FAILURES:
A. IN LANTFLT. ARGONAUT FLOODED AFTER ENGINE ROOM AND
GROUNDED b(3) 10 USC 130 WHEN RETAINING RING ON
AEROQUIP FLEX HOSE FITTING FAILED.
B. IN PACFLT, CAIMAN FLOODED FORWARD ENGINE ROOM WHEN FOUR
INCH FLEX HOSE BURST NEAR TEST DEPTH.
4. WE HAVE BEEN FORTUNATE THUS FAR IN THAT CASUALTIES
HAVE BEEN HANDLED PROMPTLY AND CORRECTLY AND THAT, EXCEPT
IN CASE OF ETHAN ALLEN, b(3) 10 USC 130 HAS NOT BEEN
INVOLVED. CONTINUED DEPENDENCE UPON SUCH TENUOUS AND
FORTUNATE CIRCUMSTANCES, PARTICULARLY WHEN CONSIDERING
ADDITIONAL HAZARDS IMPOSED UNDER WARTIME CONDITIONS,
IS OBVIOUSLY UNACCEPTABLE. COMSUBLANT APPRECIATES EFFORTS
EXPENDED AND RESULTS ALREADY ACHIEVED BY BUSHIPS IN
IMPROVING SITUATION. HOWEVER, IT IS CONSIDERED THAT URGENCY

OF PROBLEM AND INHERENT DANGER OF DISASTER MUST BE BROUGHT M
MORE FORCIBLY TO ATTENTION OF ALL CONCERNED AND THAT
CORRECTIVE/PREVENTIVE ACTION MUST BE PURSUED EVEN MORE
AGGRESSIVELY THAN HAS BEEN DONE. TO THIS END, IT IS
REQUESTED THAT BUSHIPS TAKE THE FOLLWING ACTION ON A TOP
PRIORITY BASIS:
A. IMPRESS ON ALL BUILDING YARDS THE SERIOUS CONSEQUENCES
OF LAXITY IN DESIGN AND FABRICATION OF SUBMARINE PIPING
SYSTEMS. AS EXEMPLIFIED IN ETHAN ALLEN, A SEEMINGLY MINOR
DEPARTURE FROM THE RULES CAN PRODUCE COMPLEX CASUALTIES
WHICH IMPERIL THE LIVES OF SUBMARINERS AND/OR RENDER
THE SHIP UNABLE TO PERFORM HER MISSION.
B. EXPEDITE ACTION TO ELIMINATE IMPROPERLY DESIGNED CONNECTIONS
FROM ALL OPERATING SUBMARINES.
C. EXPEDITE REPLACEMENT OF STEEL RETAINING RINGS ON FLEX HOSES
WITH MONEL AND REVIEW FLEX HOSE FAILURES TO DETERMINE WHAT
FURTHER CORRECTIVE ACTION MAY BE REQUIRED TO PROVIDE RELIABLE
INSTALLATIONS.
D. EXPEDITE DEVELOPMENT OF RELIABLE NON-DESTRUCTIVE TEST METHOD
FOR SILBRAZE FITTINGS. THIS IS URGENTLY NEEDED TO ENABLE OPERATING

Exh 224-48

FORCES TO LOCATE AND REPAIR DEFECTS.
E. IN NEW DESIGN, REDUCE WHEREVER POSSIBLE POTENTIAL HAZARD OF SALTWATER SPRAY DAMAGE TO ELECTRICAL EQUIPMENT BY PHYSICAL SEPARATION, SHIELDING OF SALTWATER LINES, PROVISION OF WATERTIGHT CLOSURES FOR ELECTRICAL EQUIPMENT, OR OTHER APPROPRIATE MEANS.
BT
13/1410Z

Exh 224-49

XII

COPY

May 25, 1961

CD DE CR 65/26

P 252316Z
FM USS THRESHER
TO COMSUBLANT
INFO CNO
DEPCOMSUBLANT
COMSUBDEVGRU 2
NSY PTSMH NH
COM USNAES PTSMH NH
BUSHIPS
BT
UNCLASSIFIED

TRIALS OF (b)(1) PROPULSION PLANT COMPLETED SATISFACTORILY. FIRST OF 2 SCHEDULED INSTRUMENTED DIVES TO (b)(1) SATISFACTORILY COMPLETED. PRELIMINARY ANALYSIS OF DATA OBTAINED APPEARS TO PRECLUDE NECESSITY FOR ADDITIONAL INSTRUMENTED DIVE. WHILE AT (b)(1) FEET TRIM PRIMING LINE CARRIED AWAY FROM TRIM SUCTION LINE WHICH CONTAINED SEA PRESSURE. RESULTANT FLOODING NOT SIGNIFICANT DUE IMMEDIATE RECOGNITION AND ISOLATION. FAILED SILBRAZE JOINT CONSIDERED TO BE OF POOR QUALITY ALTHOUGH FAILURE WAS APPARENTLY DUE DIRECTLY TO CYCLING OF SEA VALVES WHICH PRODUCED NOTICEABLE WATER HAMMER IN TRIM SUCTION LINE. LATER WHILE AT PERISCOPE DEPTH AND PRESSURE TESTING TEMPORARY REPAIR TO ABOVE CASUALTY A 4 INCH SILBRAZED JOINT IN THE TRIM SUCTION LINE WAS FOUND TO HAVE FAILED. NO FLOODING INVOLVED. CAUSE NOT KNOWN BUT MAY BE RELATED TO FIRST CASUALTY. IN VIEW OF HIGHLY SUSPECT TRIM SYSTEM AM RETURNING TO PORT. WILL CONDUCT FEASIBILE TRAILS ENROUTE
SCP-4
BT
26/Ø52ØZ

BUSHIPS .... COG RTD/CKD..E (b) (6)

2 5 2 3 1 6 Z / / MAY '61

NNNN

Exh 224-50

VIII

USS SNOOK (SS(N)592)
c/o Ingalls Shipbuilding Corp
Pascagoula, Mississippi

SSN592:00:be
4700
Ser 253
Sep 11, 1961

FOR OFFICIAL USE ONLY

From: Officer in Charge, USS SNOOK (SS(N)592)
To: Chief of Naval Operations
Via: Deputy Commander Submarine Force, U.S. Atlantic Fleet

Subj: Silbraze Joints in Sea Water Systems; report of failure of

Ref: (a) OIC SNOOK Progress and Readiness Report No. 10, serial 251 of 7 September 1961
(b) PCO SNOOK ltr ser 211 of 18 July 1961 (NOTAL)
(c) PCO SNOOK Progress and Readiness Report No. 5, ser 115 of 19 April 1961
(d) PCO SNOOK Progress and Readiness Report No. 2, ser 23 of 15 February 1961

1. A preliminary report of failures sustained during initial builder's trials in silbrazed joints in SNOOK's sea water piping systems was made in reference (a). A more detailed report is submitted herewith.

2. On 28 August 1961, during the conduct of SNOOK's initial deep dive to test depth, a short length of one and one quarter inch diameter sea water piping in the port air conditioning and air compressor cooling system (lower level engine room) blew out from a silbrazed joint. At the time of the casualty, the ship was at battle stations and damage control parties were alerted. Additionally, socket wrenches had been inserted in the remote control upper level sea and stop valves preparatory to the cycling of these valves at test depth in accordance with a test requested by the Officer in Charge in reference (b). Under these fortuitous circumstances it was possible to quickly shut the sea and stop valves and to drive the ship to the surface b(3) 10 USC 130 Tanks were blown but, of course, at the depth in question, propulsive power is necessary to obtain rapid ascent. Little water was taken on board and, since the open pipe was low in the bilge, no electrical damage due to salt water spray was sustained (earlier in the trials a copper tube from a grease connection had blown out and caused an electrical fire in test gear temporarily installed for the measuring of shaft torque. Electrical problems resulting from salt water spray from blown sea connections are exceptional hazards in that they could result in the loss of main propulsion). Upon surfacing it was discovered that another silbraze joint on a five inch sea water line in the starboard air conditioning plant was leaking at the rate of about one gallon per minute -- but, again, into the bilge and away from electrical equipment such as the main circulating water pumps. The circumstances of the initial deep dive were such that the ship had been at test depth less one hundred feet for about an hour without incident. The casualty occurred within only a few minutes of reaching test depth. Tests required at test depth were not completed.

Exh 224-51

3. As a result of the casualties described above, and following a visual inspection of engine room piping by the crew, subsequent submerged events on the trial agenda were conducted at depths not exceeding two hundred feet. Following these trials, the ship returned to port for repairs and reexamination of salt water systems prior to second builder's trials. During this period it was discovered that the four inch length of one and one quarter inch diameter pipe that blew out of its silbrazed joint was stainless steel instead of the prescribed copper-nickel. This improper use of material occurred in spite of the inspections discussed in reference (c) and endorsements thereto. The defective five inch joint on the starboard side was cut out and subjected to a hydrostatic test in the laboratory. The joint pulled out at a pressure of about twelve hundred pounds per square inch which is about one half the pressure required to induce any failures in joints tested at Ingalls prior to the ship going to sea (the inspection and testing of SNOOK's silbrazed joints was discussed in reference (d) and endorsements thereto). The five inch joint in question had not been silbrazed using the pre-inserted ring of silver alloy technique but rather had been "face-fed". It had been radiographed as described in reference (d) and was believed, apparently, to have a sufficient bond. Sectioning after the test laboratory "pull out" reportedly showed poor bonding. As pointed out in reference (d), SNOOK's salt water systems do not, contractually, come under the requirement (applicable to deeper diving ships and reportedly under consideration by the Bureau of Ships for future ships of SNOOK's diving depth) that all larger non-welded sea water piping systems be silbrazed using the pre-inserted ring technique as opposed to the face feeding technique.

4. Following repairs to the air conditioning cooling systems, hydrostatic tests on these systems were conducted accompanied by the pounding of joints with mallets in an attempt to detect weakened or poorly bonded joints. All sea water piping in the ship was reported manually reinspected by the Supervisor using an acid spot check. No further improper materials were discovered. The salt water piping in the b(1) system was hydrostatically retested by the Contractor and two questionable joints were replaced. Second builder's sea trials were conducted without incident on 1 and 2 September. Submerged operations were limited to depths not exceeding three hundred feet.

5. During the ship's current drydocking, hydrostatic retesting and mallet pounding of silbraze joints in all sea water systems has been ordered by the Supervisor. Various silbraze joints have been selected for cutting out, pressure testing, and sectioning. A change order has been issued by the Bureau of Ships requiring the welding of all sea water bank piping passing through the reactor compartment as well as the welding of the b(1) Under this program, and presumably, barring the discovery of further defective joints, it is understood that SNOOK is being rescheduled for her deep dive during third builder's trials currently planned for the week of 17 September 1961.

6. As a result of the above experiences the following comments and recommendations are submitted:

Exh 224-52

a. In view of the uncertainties attending the integrity of silbrazed joints in general and the apparent inadequacy of available non-destructive inspection techniques for these joints, it is recommended that ships having silbrazed sea water systems make a practice of actually installing socket wrenches in the remote sea and stop check valve control stations when proceeding to deep submergence. It would seem prudent to hold frequent drills and inspections in order to ensure the presence and operability of these wrenches and their valve operating extensions as well as the competence of the crew in securing the proper system in the event of emergency. (An arbitary closure of sea water systems could inadvertently deprive a ship of propulsion at a critical juncture.

b. Consideration be given to the welding of all sea water pipe fittings from the hull box back to and including the stop check back-up valve to ensure a positive isolation capability in the event of internal piping failure. This modification is specifically requested for SNOOK.

c. Sea water piping in the vicinity of electrical equipment be inspected with an eye towards the effect of joint failure on the ability of the ship to maintain propulsion. Steps be taken to eliminate the danger of fire or propulsion failure due to salt water spray. The use of welded joints or the elimination of joints at strategic points is recommended. The importance of maintaining continuity of main propulsion while at deep depths cannot be overemphasized. It is considered that at current test depths, under many circumstances, the ability to blow tanks alone does not ensure the ability to surface the ship in an emergency.

d. All silbraze joints in salt water piping of greater than one-half inch diameter should be brazed using the pre-inserted ring of alloy technique as a mandatory feature coupled with positive inspection procedures that prohibit face feeding until after test and examination of the joint.

e. Consideration should be given, as a backfit measure, in ships of SNOOK's diving depth, for substitution of welded joints in the larger sea water piping as a logical extension of the steps now being taken for the reactor plant.

f. All joints in the sea water piping of deeper diving ships should be welded.

H. BUCKNELL

Copy to:
COMSUBLANT
COMSUBPAC
BUSHIPS
SUPSHIPS, PASCAGOULA

 Exh 224-53

XIV

FF4-12
9080
Ser: Dep 402/6449
19 Sep 1961

FIRST ENDORSEMENT on OIC SNOOK ltr ser 253 of 11 Sep 61

From: Commander Submarine Force, U.S. Atlantic Fleet
To: Chief of Naval Operations
Via: Chief, Bureau of Ships

Subj: Silbraze joints in Sea Water Systems; report of failure of

Ref: (e) DEPCOMSUBLANT msg 131410Z Sep NOT

1. Forwarded, readdressed.

2. COMSUBLANT expressed his concern with regard to recent silbraze failures in reference (e). It is vital that all proper and prudent measures be taken to preclude further silbraze incidents. With regard to silbraze systems, referecne (e) specifically requested that BUSHIPS take the following action on a top priority basis:

a. Impress on all building yards the serious consequences of laxity in designand fabrication of submarine piping systems.

b. Expedite action to eliminate improperly designed connections from all operating submarines.

c. Expedite development of a reliable non-destructive test method for silbraze fittings.

d. In new design, reduce wherever possible potential hazard of salt water spray damage to electrical equipment.

3. In consonance with the foregoing, the following comments are made concerning recommendations contained in paragraph 6 of the basic letter.

a. Concur that frequent drills and inspections should be conducted to insure presence of wrenches and operability of valves. This is considered to be a wise normal operating precaution. The question of actually installing the wrenches when proceeding deep is a matter within the purview of individual ship operating policy and should not, in the opinion of COMSUBLANT, be dictated as a required operating procedure.

Exh 224-54

b. Concur that, within the framework of BUSHIPS overall program to improve integrity of submarine sea water systems, consideration should be given to welding sea water pipe fittings from hull through back-up valve.

c. Concur.

d. Concur for new pipe installation. This has already been implemented by BUSHIPS for new construction.

e. Concur that, within the framework of BUSHIPS overall program, consideration should be given to this measure.

f. It is recommended that BUSHIPS investigate feasibility in terms of cost, time, and ship arrangements, of doing this.

4. As stated in reference (e), COMSUBLANT appreciates the efforts expended and results already achieved by BUSHIPS in improving reliability of silbraze connections. It is reiterated, however, that corrective/preventive action must be pursued even more aggresively than has been done. The most important single requirement for the submarines built prior to promulgation of rigid control on silbrazing is the development of a certain non-destrcutive test method for locating and repairing unsatisfactory joints. Further, a comprehensive study should be conducted and a determination made as to what corrective measures need be made to reduce the possibility of sea water line failure in submarines built prior to strict rules.

(b) (6)

L. R. DAEPTT
Deputy

Copy to:
COMSUBLANT
COMSUBPAC
BUSHIPS
SUPSHIPS PASCAGOULA
OIC SNOOK (SSN592)

Exh 224-55

XV

DEPARTMENT OF THE NAVY
Office of the Chief of Naval Operations
Washington 25, D. C.

UNCLASSIFIED

Op-433H/mz
Ser 01098P43
2 Mar 1959

From: Chairman, Ship Characteristics Board
To: Distribution List

Subj: New design features being incorporated in USS THRESHER (SSN 593) (U)

Encl: (1) Memorandum for Admiral Burke ser 07-43 of 13 Jan 1959
(2) Memorandum for Admiral Burke ser 022-43 of 18 Feb 1959
(3) Transcript of Presentations and Discussions of a Special Meeting of the Ship Characteristics Board, Fleet and Submarine Force Commanders

1. In early January 1959 Chief of Naval Operations noted that there were items in the submarine shipbuilding program, particularly with regard to THRESHER, about which doubt had been expressed in some quarters. These items, in general, were associated with the use of low carbon high alloy steel in the hull, the modification of equipment for greater depth, and the elimination of self noise.

2. All of these items were reviewed at length and were discussed with members of the scientific community and with leading shipbuilders. A visit to Portsmouth Naval Shipyard and to THRESHER on the building ways during working hours provided background information for a special meeting of the Ship Characteristics Board.

3. The results of the various explanatory visits and discussions were presented on 27 January 1959 to a special meeting of the Ship Characteristics Board, Fleet and Submarine Force Commanders, and representatives of the naval shipbuilding industry. Following the presentations, open discussions were conducted by those present. The presentations and discussions are of sufficient general interest to warrant further distribution for information. Enclosure (1) was an interim report to the Chief of Naval Operations. Enclosure (2) is a report to the Chief of Naval Operations on the status of the THRESHER building program at this time. Enclosure (3) is a transcript of the salient points brought out at the special meeting together with presentations and discussions.

DENYS W. KNOLL
Chairman, Ship Characteristics Board

Authenticated:
(b) (6)

Distribution:
(See page 2)

CDR, USN

UNCLASSIFIED

Exh 224-56 (I)

UNCLASSIFIED

Op-433H/mz
Ser 01098P43
2 Mar 1959

Distribution:
SNDL 21 (Fleet Commanders in Chief) (5)
SNDL 24G (Submarine Force Commands) (10)
SNDL 26P (Submarine Groups) (5)
SNDL 28K (Submarine Flotillas, Squadrons and Divisions) (10)
BUSHIPS (5)
BUSHIPS (Code 1500) (5)
BUORD (2)
BUPERS (2)
BUAER (2)
BUMED (2)
Op-00
09
30
31 (2)
311 (2)
34
341
43
341
43
433 (20)
45
455
51
515
55
90
91
93
Portsmouth Naval Shipyard (5)
Mare Island Naval Shipyard (5)
SUPSHIPS Groton (5)
SUPSHIPS Newport News (5)
U.S. Naval Engineering Experimental Station
David Taylor Model Basin
RADM C. O. Triebel - JCS
RADM C. C. Kirkpatrick - CHINFO
RADM W. S. Post - JCS
RADM B. A. Clarey - OSD
CAPT E. T. Wilkinson - COMSUBDIV 102
CAPT (b) (6) - Op-31
CDR W. R. Anderson - CO USS NAUTILUS (SSN 571)
CDR J. F. Calvert - CO USS SKATE (SSN 578)

UNCLASSIFIED

Exh 224-57

UNCLASSIFIED

OP-43/jed
Memo No. 07-43
13 JAN 1959

MEMORANDUM FOR ADMIRAL BURKE

Subj: New design features being incorporated in THRESHER, SS(N) 593

1. Pursuant to your directive, the following is an interim report of information ascertained to date concerning the new design features planned for THRESHER:

a. At present there is no item of concern in the construction of THRESHER relative to new designs planned for this ship. Risks being taken appear to be conservative. There is no design feature now contemplated, the failure of which would result in a non-operational ship. These findings are corroborated by an independent study conducted by President of INSURV concurrent with my exploration.

b. Discussions have been held with President of INSURV, BUSHIPS planners and designers, technicians at David Taylor Model Basin, Dr. (b) (6) of APL, and Commander, Portsmouth Naval Shipyard and his staff who are building THRESHER.

c. There is considerable urgency for the expeditious completion of the acceptance trial of SKIPJACK, since any problems encountered in the operational tests will provide valuable guidance for modifications in THRESHER and POLARIS submarines.

d. Lessons learned with THRESHER will become known too late to incorporate in POLARIS submarines 603-607, since THRESHER completion date is only six months ahead of SSB(N) 603.

e. Number of significant new developments in THRESHER is not unique for a prototype.

f. HY80 steel requires greater shipfitting work but if HY80 steel is not used THRESHER would be 75 feet longer, 900 tons heavier, 4 knots slower, and, with RT steel, it would have less resistance to shock and impact.

g. There appears to be less risk in proceeding from a 700 to a b(1) foot depth with THRESHER than existed when NAUTILUS was being constructed as the first ship for 700 in lieu of 400 foot depth.

i. As suggested, I will discuss with Mr. (b) (6) on Wednesday or Thursday, 14-15 January, the broad features of new designs planned for THRESHER.

j. A special meeting of the SCB is scheduled for week of 26 January, at which representatives of the Operating Forces, commanding officers of submarines, scientific advisors and technicians will be invited to attend to hear formal presentation of the technical facts which have been ascertained, as briefed above.

(S) DENYS W. KNOLL

Copy to:
OP-04

Enclosure (1) to SCB ltr ser 01098P43 of 2 Mar 1959

UNCLASSIFIED

UNCLASSIFIED

Exh 224-58

UNCLASSIFIED

OP-43/jed
Memo No. 022-43
18 FEB 1959

MEMORANDUM FOR ADMIRAL BURKE

Via: OP-09

Subj: New design features being incorporated in THRESHER, SS(N) 593

Encl: (1) Memo No. 07-43 of 13 JAN 1959
(2) Verbatim transcript of special meeting
(3) List of people who attended special meeting

1. Enclosure (1) was an interim report on the action taken with regards to the new design features planned for THRESHER. Enclosure (2) is the transcript of the special SCB meeting which considered this subject. The greater part of these verbatim minutes is being reproduced and will be distributed to all members of the SCB and the representatives of the fleets, bureaus, and naval activities who attended the meeting. Enclosure (3) is a list of the people who attended the special meeting.

2. The special meeting was divided in two parts:

a. A series of presentations which BUSHIPS was requested to present to give the highlights of the new design features in THRESHER, the manner in which they were being developed and the effects on the boat, if any one item should fail to prove successful.

b. An open discussion period.

3. The special meeting confirmed the highlights which were forwarded to you in enclosure (1). In addition:

a. The use of HY80 steel in new submarines requires continuing attention. Both the Commander Naval Shipyard Mare Island and Commander Naval Shipyard Portsmouth, N.H., who are working with this steel, have confidence that it will produce successful, reliable submarines. They state this without equivocation even though:

(1) Methods of fabrication and welding are very complex.
(2) Uniform results are difficult to insure.
(3) Ideal conditions are required for all phases of fabrication.
(4) It is hard to guarantee permanent quality with low carbon high alloy steel. In this regard, the comments of Mr. (b) (6) on the use of this steel are significant: "Stop, look, listen."

4. As a result of the special meeting of the SCB, it is concluded:

a. The Bureau of Ships should circulate periodically to the fleet significant reports on the new things that are being developed for ships, some of the problems being encountered, the manner in which problems are being solved, and the ultimate capabilities that the successful development of the item will achieve. This is highly desirable to prevent the generation of rumors concerning new equipment and

Exh 204-59

to have the confidence of the Operating Forces in all the new things that we are planning for the newer ships.

b. The Ship Characteristics Board, particularly the Chairman and the Staff, will continue to monitor the use of HY80 steel; visit Naval Research Laboratory, Naval Engineering Experiment Station, Annapolis; be briefed by the special expert metallurgists which BUSHIPS has on contract from Babcock and Wilcox for the purpose; and submit to the CNO periodically reports on any further deficiencies or developments in the use of HY80 steel.

5. As a result of a discussion with the President, INSURV, the Chairman, SCB has been advised that subsequent to the preliminary acceptance trials of SKIPJACK (fabricated with a type of HY80 steel) a comprehensive radiographing of SKIPJACK hull will be conducted to see if cracks have developed in the hull during acceptance tests.

6. To date the cracks that have appeared in HY80 steel are not such as to cause the loss of a boat. Rather they are surface cracks or cracks in the supporting webbing on the inside of the pressure hull that could possibly cause further casualty during a depth charging at test depth. In addition, these are cracks that are not apt to grow and where they have appeared in the past they have been corrected by chipping out and rewelding.

7. The consensus of the representatives who attended the special meeting of the Ship Characteristics Board was that excessive risks were not being taken in the construction and in the number of new developments now incorporated in THRESHER. Captain (b) (6) attended the meeting and expressed his concerns to the Board and in amplification of his previous remarks emphasized that his primary interest was that we were not building more submarines faster, and that the construction of a prototype like 593, which is a good boat, might be holding up the construction of many submarines which would have lesser capabilities than THRESHER. The representatives from OP-91 were interested in the number of items that could be identified as new developments which from now into the future should be their primary responsibility for development and probably be funded by RDT&E funds. It is difficult at this time to identify the number of real development items in THRESHER, as distinct from redesign of previous equipment to meet new requirements, which are not strictly development items.

8. Copies of the conference report, with covering letters, are being prepared for forwarding to Captains (b) (6)

(S) DENYS W. KNOLL, RADM, USN
DIRECTOR, FLEET DEVELOPMENT AND
MAINTENANCE DIVISION

Copy to:
OP-04
ENCLOSURE (2)

Exh 224-6c

UNCLASSIFIED

TRANSCRIPT OF A SPECIAL MEETING OF THE
SHIP CHARACTERISTICS BOARD, FLEET AND
SUBMARINE FORCE COMMANDERS, AND REPRESENTATIVES OF
THE SHIPBUILDING INDUSTRY TO REVIEW THE BUILDING
PROGRAM OF USS THRESHER (SSN 593)

Held in Room 4E442, the Pentagon, at 0900
Tuesday, 27 January 1959

RADM Denys W. Knoll, USN, Chairman

Enclosure (3) to SCB ltr ser 01098P43 of 2 Mar 1959

UNCLASSIFIED

Exh 224-61

UNCLASSIFIED

Submarine Shipbuilding
Conference
27 January 1959

Present

RADM [illegible] M. Morgan	BUSHIPS
RADM L. R. Daspit	Op-31
RADM W. [illegible]. Ferrall	COMSUBPAC
RADM L. V. Honsinger	BUSHIPS
RADM F. Virden	Op-30
RADM [illegible]. Rivero	Op-93
RADM C. O. Triebel	JCS
RADM C. C. Kirkpatrick	CHINFO
RADM R. L. Moore Jr.	PortsNavShipYd
RADM D. W. Knoll	Op-43
RADM F. Hilles	Op-34
RADM W. S. Post	JCS
RADM B. [illegible]. Clarey	OSD
CAPT (b) (6)	BUMED
CAPT	BUSHIPS
CAPT	Op-90
CAPT	Op-09
CAPT	COMSUBLANT
CAPT	Op-341
CAPT	USNEES
CAPT	BUSHIPS
CAPT	Op-303
CAPT	Op-91
CAPT	BUAER
CAPT	Op-93
CAPT	Op-303
CAPT	Op-403
CAPT	BUORD
CAPT	USNEES
CAPT	Op-552
CAPT	Op-91
CAPT	Op-51
CAPT	Op-433
CAPT	COMSUBRON 7
CAPT	BUSHIPS
CAPT	Op-341
CAPT	Op-311
CAPT	BUORD
CAPT	COMSUBDIV 102
CAPT	BUPERS
CAPT	DRMB

UNCLASSIFIED

Exh 224-62

UNCLASSIFIED

CDR (b) (6)	Op-455
CDR	Op-311
CDR	BUSHIPS
CDR	CINCLANTFLT
CDR	DTMB
CDR	PortsNavShipYd
CDR	BUSHIPS
CDR	BUSHIPS
CDR	BUSHIPS (Code 1500)
CDR	BUSHIPS
CDR	Op-433
CDR	COMSUBLANT
CDR	Op-515
LCDR (b) (6)	BUSHIPS
LT	BUPERS

UNCLASSIFIED

Exh 234-63

The meeting started at 0900, 27 January 1959.

RADM KNOLL: Will the meeting please come to order?

I want to welcome the people here from out of town, and also those from the Fleet. Perhaps we do not have meetings of this sort often enough to keep the operating forces, the people in the shipyards, material bureaus, and interested people in OPNAV acquainted with what is being developed, and how things are proceeding.

The genesis of this meeting was a group of operators calling on Admiral Burke and expressing some concern that the THRESHER was being developed with too many new advances in one boat, the failure of any one or two or three of which might end up with a submarine being alongside of the dock and unable to get under way. In other words, it would leave the Navy without a reliable submarine.

Some of the areas which were cited as requiring investigation were a comment to the effect that they were putting light-weight diesel engines in the boat; second, a b(1) depth was being required in the new submarines; third, b(1) fourth, the use of HY80 steel in the hull; fifth, the b(1) b(3) 10 USC 130 the pressure hull fittings and valves being inadequate for (b)(1) and the impossibility of developing satisfactory ones before the THRESHER was ready.

Because of all this, the onus was on the Chairman, Ship Characteristics Board to do a preliminary checking of the data available, by visits to various activities, by talking to various people, and as a result of this we felt there was sufficient information to call this meeting and acquaint the Board and the operating forces, with the present status of THRESHER.

I hope as the result of this meeting today that any operators here who have any doubts or any areas they want clarified, the people are here to answer them, and as a result of this we will make a report to the Chief of Naval Operations. We will also send to the operating forces a review of what we have done, and the present status of this project.

With this we will proceed. BUSHIPS has prepared an excellent presentation, and I would ask that until they have completed the presentation we not get into general discussion. There will be plenty of time later for discussion.

With that, BUSHIPS will start their presentation.

Exh 224-64

RADM MORGAN: Our first speaker is Commander (b) (6) who will talk to you relative to the various features of the several ships under consideration, 585, 578 and 593.

PRESENTATION ON COMPARISON SKATE, SKIPJACK AND THRESHER - by CDR (b) (6) BUSHIPS:

Good morning, gentlemen.

In comparing the salient features of the current submarines in the design and shipbuilding program, it appears most important to note that behind the three classes of submarines in this program are important differences in the basic requirements.

In the SKATE (SSN-578), the major emphasis was to design a small, compact submarine that would be economical to build. In the SKIPJACK (SSN-585) there was a distinct shift in emphasis, which stemmed from the operating forces' enthusiasm over the ALBACORE performance. The effort here was to produce a submarine having high submerged speed, great maneuverability, and the best possible sonar performance at high speed. The THRESHER (SSN-593), emphasized again the achievement of the best possible submerged performance, but in addition the Chief of Naval Operations required that we provide in this submarine increased operating depth, much improved noise characteristics, and a high performance sonar installation.

Now if we examine the salient features of the three attack submarine classes in the light of these requirements, we find the SKATE (SSN-578) a small, compact design that is patterned after the TANG class of submarine, twin screw, having moderate speed, some 20 knots -- actually here we were required to meet a speed equivalent to that of the GUPPY submarines, but we did better than this. It has a moderate depth capability, 700 feet, the same as we had in the TANG class. Since it is compact and small we would be forced to say that by today's standards the crew and officer habitability is marginal.

The SKIPJACK (SSN-585), has an ALBACORE hull form, and is single screw. We have given much attention to reduction of superstructure and removal of topside appurtenances, and have a submarine capable of high submerged speed, b(1) which represents a (b)(1) increase in speed over that available in SKATE. It has better maneuverability than SKATE, and this design will provide good habitability.

The THRESHER (SSN-593), the most recent attack submarine design, has the ALBACORE hull form, and is single screw. We have given further

Exh 224-65

attention to the reduction of the superstructure. It is completely removed, and we have reduced the size of the sail. we have achieved again a high submerged speed, b(1) and have good maneuverability. Now in addition, in order to meet the other requirements imposed by the Chief of Naval Operations, we have a greater submerged depth, b(1) as compared to 700 feet in SSN-585 and SSN-578. We have reduced noise greatly through the use of b(1) and have provided a greatly improved sonar in the AN/BQQ-2, which occupies the entire bow.

PRESENTATION - "ANGLED TORPEDO TUBES" by CDR (b) (6) BUSHIPS:

To provide the required sonar installation in THRESHER, it was mandatory that the entire bow be given over to the sonar transducers. This provided the quietest possible location for the sonar and the best position for scanning. The torpedo tubes therefore vacated their usual bow position. This eliminated interference between the torpedo tube structure and the sonar structure and removes the torpedo tube shutters from the bow area, which reduces flow noise in way of the sonar.

The torpedo tubes in THRESHER (SSN-593), are located amidships. There are four tubes provided on the third platform, which are angled out ten degrees relative to the ships' centerline, and they penetrate the pressure hull structure in way of the transition cone. Before we accepted the angled torpedo tube concept, we ran a test of an angled torpedo tube in the NEOSHO (AO-143), off Newport in the summer of 1957. The NEOSHO installation had a torpedo tube installed about fifteen feet below the water line. It was angled out ten degrees relative to the ships' centerline, the same as in the submarine installation, and from this angled tube installation we fired twenty test launchings. They were fired at ship speeds of from five to twenty knots, and both hydraulic ejection type torpedoes and swim-out torpedoes were fired.

Of the twenty launchings, eighteen were completely successful, there being two swim-out torpedoes that remained in the tube due to torpedo malfunctions; their motors did not start. These two had to be ejected hydraulically. All torpedoes were examined after recovery and there was no evidence whatsoever of damage.

This test proved conclusively, in our opinion, that the angle torpedo tube installation is feasible and practical.

The angled torpedo tubes are being designed by Portsmouth Naval Shipyard. The design provides for extremely large factors of safety to insure safe operation at all depths up to maximum depth, and the factors of safety include allowances for impulse or shock loadings

that might be encountered even at maximum operating depth. Portsmouth is constructing one additional torpedo tube for test purposes and these will be given hydrostatic pressure tests of both the static and impulse type to prove the adequacy of the design.

The THRESHER tube installation will include power hoisting, which is not essential to the reload procedure. It will have power ramming and transverse transfer, and the torpedo firing functions will be concentrated and centralized in a torpedo firing console. Improvements in reloading details will, when combined with power handling facilities and the firing console, simplify and speed up torpedo reload and firing operations.

PRESENTATION - "STRUCTURAL DESIGN AND MATERIALS" by CDR (b) (6) BUSHIPS:

Now as to deeper operating depth, we recognize that it is not within our province to justify the need for deeper operating depth, but for the benefit of members of the Board or those present who may not have been here when the requirement for operating depth for THRESHER (SSN-593) was discussed at length, we will briefly review the advantages of deeper depth, and will discuss the structural design and materials required to achieve the deeper depth.

The b(1) operating depth represents the first major step forward that we have made since we went to a 700 foot operating depth on the TANG class of submarines. If we consider that the first 100 feet of water is of little use to a modern attack submarine, then effectively we have b(1) the operating depth in going from 700 feet to b(1) and have thereby b(1) the volume of water available to the submarine for maneuvering. This increase in depth might therefore be credited to submarine maneuverability, since maneuverability without maneuvering room is of little value.

The increase in hull plating thickness and the use of stronger, tougher steel, necessary to achieve the greater depth, give us greater resistance to damage at all depths. The sonar performance will be improved through the ability to use the sonar at deeper depth.

The capability of diving deeper will give the THRESHER the ability to operate at higher speeds without propeller cavitation.

Now as to the question of what price must we pay in structural design and in materials to achieve this deeper depth? It seems that recently it has become fashionable to associate advances in capabilities with scientific break-throughs. In this respect, b(1) the operating depth of our submarines lacks glamor. No scientific break-throughs have been required. The design of deeper depth structure is entirely

Exh 224-67

within the present state of the structural design art. It has not been necessary to develop new structural theories or techniques to design this structure, and therefore no novel or untried structural details are incorporated in THRESHER.

It has not been necessary to reduce the factors of safety that we have used in past designs as pertains to hull strength -- that is, we have not reduced the ratio of collapsed depth to operating depth. As a matter of fact, with the b(1) operating depth we have a greater depth safety margin available. Note that in SSN-593 there is b(1) of water available beyond the operating depth in which the submarine can recover control in case of an emergency situation, while in SSN-578 and SSN-585 there is only some b(1) of water available for recovery of control in an emergency situation prior to reaching collapse depth. Certainly this is a factor to be considered in the operation of a high speed, highly maneuverable attack submarine. For example, at b(1 knots with a b(1 degree down angle there is available some b(1 seconds for the SSN-578 or SSN-585 submarine to recover control after it passes its operating depth and before it reaches its collapse depth. That is it takes only b(1 seconds to transit the b(1) depth safety margin in this situation. This time would be doubled in the case of THRESHER with a b(1) operating depth and a b(1) collapse depth.

Achieving the deeper depth requires the use of higher strength steels. We must use HY80 in lieu of the high tensile steels which we first used in the heavy hull boats of World War II, and have used up through the SSN-578 class. This steel permits a reasonable plate and frame thickness. This saves weight and keeps the sizes of these structures within the fabrication capabilities of our shipbuilding facilities.

If we attempted to use high tensile steel for the b(1) structure, we could not build the submarine because the sizes of structure required would be beyond the capacity of our shipbuilding fabrication facilities.

The HY80 steel is a tougher steel that high tensile steel. It affords greater resistance to damage. We have learned that at low temperatures some steels become brittle. This is not true of the HY80 steel, for at low temperature it retains its ductility.

HY80 steel is weldable. We have encountered some growing pains, but there are no insurmountable problems in this area. Captain (b) (6) will cover this subject a little more thoroughly later this morning.

To review the advantages available to us in the deeper depth

Exh 224-68

capability and the structure of THRESHER; ---we have a greater operating range in depth, a greater resistance to damage at any depth, and a greater depth safety margin, some b(1) in the case of THRESHER as compared to b(1) for the SSN-578 and SSN-585. We have better cold temperature toughness of the steel through the use of HY80.

Our confidence in the structural design for deeper depth is not founded on theoretical calculations and design theories alone, because over the past few years we have made extensive structural tests, and these tests have given us the utmost confidence in our structural designs for deeper depth.

This morning we have Commander (b) (6) from DTMB to review some of the structural test work that has been carried on in connection with the deeper depth program.

RADM MORGAN: Before that, have you those turning circle curves?

CDR (b) (6) Yes, sir.

RADM MORGAN: Show those to the group, will you? I think they will be of interest.

CDR (b) (6): The SSN-585 will have a turning circle of 165 yards. This is about 2.0 times the ships' length. SSN-593 will have a turning circle of 214 yards, and the SSN-578 has a turning circle of 245 yards, somewhere near 2.7 times the ship's length.

The improvement in turning diameter of SKIPJACK and THRESHER as compared to SKATE is achieved through the use of the single screw and the rudders feasible on the ALBACORE hull form.

In the vertical plane, for a comparison of time it takes to transit 300 feet, SSN-585 could change depth from one hundred to four hundred feet in 30 seconds, SSN-593 in 35 seconds, and the SSN-578 in some 44 seconds.

PRESENTATION - "SUPPORTING TESTS AT DTMB" by CDR (b) (6), DTMB:

Gentlemen, in the year just past the David Taylor Model Basin verified the structural design of THRESHER, as developed by the Bureau of Ships, by a series of hydrostatic tests of selected portions of the structure.

The first slide will show the profile of the THRESHER, and indicated by model numbers YD 1, 2, and 3, those portions that were tested.

YD-1 indicates the principal stiffened cylinder. YD-2 indicates the forward transition through which the torpedo tubes penetrate, and this particular model was subjected to very careful and searching tests for that reason. Finally, the stern section of the ship, YD-3, testing the engine room with this particular conical transition.

The first model tested was the cylindrical portion which is shown in this next slide. Now bear in mind this fitting is necessary in our hydrostatic test tank to give access to the model for instrumentation. Thus the top of the model here represents the forward portion of the ship. You will note the failure in this particular area as an accordian pleat, indicating that the material has been used to its best advantage. There is no general over-all collapse, it is purely localized yielding at the weakest point in our structure. This collapse took place at b(1) feet. The design collapse depth is b(1) feet.

The next slide will show a schematic of the forward transition. You will note the angled torpedo tubes. These arrows indicate the suspected points of trouble, the structural discontinuities. Top and bottom here at the attachment to the adaptor, part of the test structure -- similarly here, the attachment of our closure bulkhead, again part of our supporting test structure.

The two trouble spots which are truly representative of the ship structure is the attachment of the cone to the cylinder in the forged transition ring.

We built this model and subjected it to b(1) feet equivalent pressure, and the structure was absolutely satisfactory. During the application of pressure we measured the rotation of the axis of the torpedo tubes, since this occasioned some skepticism at the outset, and found that in going from periscope depth to operating depth, b(1) the angular rotation was somewhat less than three minutes, giving a target error of approximately one inch for every hundred feet of range, something that can easily be corrected for in the fire control system.

Following the b(1) foot test of this structure we removed it from the tank and inspected all welds to make certain that we had not unknowingly initiated any trouble. The inspection proved to be actually unnecessary. There was no sign of difficulty, and we then started giving the low cycle high stress fatigue test, that is, we repeatedly subjected it to a variation in pressure from periscope depth to maximum operating depth b(1)

Based on a little elementary arithmetic, 20 years of operation allowing one dive a day, Sundays, weekends, holidays, no time out for leave, overhaul, upkeep, or what-have-you, it comes to 7300 cycles.

We went to 8972 cycles, and if you put that slide back on I will show you what happened. I particularly want to show you what happened at the end of the 8972 cycles. At this point leakage occurred through the bulkhead, part of the supporting test structure, and since we had to stop the test at this point because failure of this test closure, we took the opportunity to inspect all the welds and we did find some cracks had initiated.

The next slide will show you a typical section that was cut out. This represents the shell of the submarine, and this a portion of the forged ring at the transition between cylinder and cone. There is a small crack here that has started, but has been stopped by the weld material, indicating not only the toughness of the steel but also the toughness of the weld, and the 8972 cycles represents 24½ years of submarine operating life, which I believe is a fine testimonial to both the design and the material used.

However, because we had the opportunity, the forged ring connection was redesigned to a more gentle taper to eliminate as much as possible the high stress concentration at this point of discontinuity, and this again has been verified to be superior.

The next slide shows the final test, leading to collapse of this structure. This is part of the test rig, this is part of the test rig also, the forward portion, the smaller diameter, the main cylinder --

VOICE: Are those two men in the lower portion of the picture?

CDR (b)(6) : No sir, these are bolts on the slab. The size is six feet in diameter.

Notice the failure again is of the accordian pleat type, indicating excellent use of the material. This collapsed at b(1) feet. The final slide shows the test of the stern section, the engine room, and this failed at b(1) feet. This was not quite as highly localized as the other, indicating that there can be dramatic and violent failures, but the depth at which this happened was well in excess of the designed collapse.

VOICE: What scale mockup?

CDR (b)(6) : This is one-sixth, sir.

Exh 224-71

RADM MORGAN: I might add that until recently practically all of our testing of submarine hull structures, including all of those we used in World War II, were one-twelfth scale. We now have a new test tank out at DTMB where we can go to larger scales.

I can tell you this, however, that we have had nothing like the trouble we had with high tensile steel in World War II when we went to 35-pound plate.

Captain (b) (6) will tell you about this.

PRESENTATION - "HY80 WELDING" by CAPT (b) (6) , BUSHIPS:

I will tell you a little about the growing pains of HY80, frequently identified as the welding cracks in HY80.

First a word about my own qualifications to comment on this subject. I just came to the Bureau six months ago for my first tour from seven years on the practical end of shipbuilding and ship repair. Therefore, I feel I am probably a little biased in the shipyard point of view on this thing.

I have no pride of authorship in the decision to use HY80 for the submarine hull material. From what I now know I am convinced that the adoption of HY80 is a very sound decision.

I am further convinced that HY80 is a weldable material and that reliable structures can be put together by our shipyards.

As Admiral Morgan has said, our welding problems frequently evidenced by cracks has been a characteristic of the submarine construction programs in HTS, in World War II, and to a certain degree is a characteristic of our present HY80 program.

RADM MORGAN: It is a characteristic of welding any heavy gauge steel. Let's not get the notion that we don't have troubles with steel. We have trouble with all steels.

CAPT (b) (6) I might add the higher the strength of steel, the narrower the band in which variations in building practices can be accepted, the band narrows and you get into cracks and into troubles, and the cracks are one of the basic symptoms as soon as you get outside the acceptable band of practice.

Specifically, today we have one yard building a hull, the THRESHER, where the entire boat is designed for b(1) depth. I saw that boat a week ago last Friday, and I was very impressed with the attack that

Exh 224-72

the shipyard is making on their problems. They consider their problems to be completely under control today and so do I. I will discuss that more a little later.

Right now we have four yards, including Portsmouth, building hulls in which the midsection is designed for b(1) depth. In the 598 POLARIS submarines, the ends of those boats are designed only for 700 foot depth, and the midship sections, the ballistic missile part, is designed for b(1) depth. This is giving the shipyards actual practice in fabricating b(1) structures which will never be operated at greater than 700 foot depth.

One yard, Ingalls, is now working on a 700 foot HY80 hull generally similar to SKIPJACK as far as scantlings are concerned.

There has been a common pattern of experience at all yards. All yards got into weld cracking difficulties when they began to fabricate this heavy material. Portsmouth had the most spectacular troubles. On their first section they had so many cracks that it actually, I feel, turned out to be a major blessing in disguise. I think the people who had the cracks at first didn't think so, but now they realize it. As the result of this very bad cracking problem, Portsmouth reacted very promptly and now has a series of shipyard production controls which from all I saw last Friday is extremely effective.

The other yards have had their troubles in less spectacular degrees. They have reacted less rapidly, and have gradually tightened their controls until today four of the five yards consider their problems to be under control.

Electric Boat has had their cracking problems appear more gradually, therefore their reaction has been more gradual and more reluctant. Their very success on previous hulls, including SKIPJACK, has made them naturally reluctant to increase their previous level of control. As a result of all this trouble in cracking, and this fabrication of HY80 began last Spring, the Bureau of Ships arranged a symposium which was held in Washington last July, which called in all the building yards, the steel manufacturers, the electrode manufacturers, and the various research activities that we have working on problems, such as efforts to develop automatic welding processes for HY80.

Since the symposium in July, which spread a great deal of know-how among the various yards, problems have moderated and have been considered under control in all yards except Electric Boat. Electric Boat had their first and severe rash of cracking in the midship section of the 598 last October. As a result of their troubles there, and a further review of the situation in early January, a BUSHIPS visiting group has been

Exh 224-73

established, of which I am Chairman, which is now visiting all the yards for a first-hand look at current problems and practices. We visited EB and Portsmouth. The group today is in Mare Island. I will join them tomorrow at Pasacagoula, and in about two weeks we will hit Newport News.

Our objective, not only to get first-hand information on current problems and practices, but to begin a determination of areas where more precise knowledge through research will assist in faster production rates without sacrificing our present quality, to assist in determining new processes to be investigated such as extrusion or rolling of shapes for new shapes, and to see what we can do to accelerate developments for better, faster semi-automatic or fully automatic welding processes, and also to make certain that the other areas are not complacent about the quality of the structure that they are now producing.

We have set up a contract with Babcock and Wilcox to assist in this detailed technical review. Babcock and Wilcox has had very extensive experience in fabrication of heavy structures, including much work in the nuclear program.

Actually in the case of our HY80 program for the b(1)
greater depths we are stepping up to a new plateau in shipbuilding practice. We are still operating at what I consider to be a practical level of shipbuilding practice. I say this from a waterfront point of view and not from a long tenure behind a desk. Our (1)
deeper submarines now have to be approached from the viewpoint of no longer being ordinary shipbuilding structures, but ship-shaped pressure vessels. When we approach them on that basis, and I am saying this not because a shipyard commander is here, but because of what I saw with my own eyes, Portsmouth is approaching the problem in the ship fitter shop on exactly that basis; and is coming out with reliable hulls at reasonable shipbuilding prices. Its prices are high, but they have to be high to get quality structure that is going to perform and carry the loads that we have designed into this type of structure.

All high strength steels show increasing sensitivity to cracks as the strength levels rise. Joints in the highly restrained structure also show this same cracking tendency. Where there has been experience in fabricating 3, 4, and 5 inch sections of low carbon steel, it has been proven you can't throw them together on a cold day in the way you throw the hull of a steel tug together.

When you combine the high strength of the basic material such as HY80 with the highly restrained joints which are characteristic of our

Exh 224-74

submarine structure, both of those factors increase the sensitivity of the weld to crack and require a higher degree of control. All the yards, including Electric Boat, and particularly Portsmouth, are demonstrating now that these practices are within the limits of present shipbuilding equipments and present shipbuilding talent.

Just a word about the cracks which have been found. First, as to the envelope which protects the hulls from sea pressure, all the butts and seams are subject to 100 percent X-ray inspection, and all defects are removed and rewelded.

The only case where the envelope is not subjected to 100 percent X-ray inspection is in the case of joints such as involved in sea boxes and the escape trunks. In the case of SKIPJACK, which was a 700 foot boat made of HY80, during construction the butt and seam welds were subjected to 100 percent X-ray and a comparatively small amount of defects found.

The other welds in the ship were subjected to only visual inspection.

As a result of difficulties occurring last October in the 598 hull, Electric Boat and the supervisor have gone back into all accessible welds in SKIPJACK with magnetic particle inspection which is the next most severe degree of inspection, and they have found very few cracks. They have found some. In the case of the seven sea boxes in the ship, which are heavily restrained structures in the vessel, they have found cracks in five. As of two weeks ago four had been repaired. One crack was all the way through the shell of the sea box and would require drydocking of the vessel.

In the case of all the repaired welds in all yards, repairs have been one hundred percent successful.

Current experience in the case of Portsmouth production, indicates they are averaging on the order of one crack per hundred feet of welding, and this is after completion of all work, and after letting it sit for a period of at least a week.

With respect to Electric Boat's current experience, they themselves developed a new era of control as of 18 November. Reports as of yesterday, on work which they are doing currently in the b(1) sections of the 599, state that it is going ahead successfully. A recheck of the first two complete frames shows no cracks on two magnetic particle inspections after fifteen days.

Exh 224-75

The principle work involves frame connections and for these joints the geometry is such you can't get an X-ray picture that is at all reliable.

Electric Boat has encountered other cracks in auxiliary tank and negative tank areas which are now being reported on the 598 and the 599, but these are cracks in structure which was prefabricated last Spring during the period of looser controls. These cracks will keep coming to light, from thermal-stresses of the New England winter, from stresses of additional welding as foundations are installed, an example being the gyro stabilizer, but these cracks when seen on re-inspections and when cleaned out and rewelded will present one hundred percent reliable structure.

I know you all have heard many reports about these HY80 welding difficulties. During the discussion periods I hope I will have a chance to provide additional information to you on some of the reports of cracks that you have heard.

I visited and actually saw the models out at the Model Basin which have been subjected to failure. I have been down to NRL and have seen their explosion-weld testing of welding joints in HY80. I have seen enough and have been told enough to now have complete confidence in the structural integrity of HY80 welded submarines now under construction in all five of our submarine building yards.

RADM MORGAN: I am not sure whether anybody has brought this out or not. These cracks are not fatal. They may spread, and in a material that is tough and has the high toughness qualities of HY80 they are much less serious than in other materials. I can recall that in one of our submarines in World War II, with a high tensile steel hull, we found over 200 cracks. It is disturbing mentally to the submarine operator to think that there may be some crack that the naval constructors didn't find, but let me assure you that this is not a fatal situation, any more than scratching your finger cuts your hide wide open. It is something we want to avoid, we want to minimize it, and with proper controls and the use of the proper techniques that are required for massive structures, this can be achieved.

The thing that is important to remember, gentlemen, is we are not dealing with the 27½ pound plate that we had in the pre-heavy hull ships, nor with the 35-pound plate that we had in the 400 foot submarines of World War II. We have been dealing with massive structures, and it has been found that care must be taken to get good results. These procedures cost money, take time, and we have encountered reluctance in adopting them. We encountered the same reluctance in World War II in adopting the necessary prodecure for the high tensile steel. By adopting the proper procedures we got along all right.

Exh 224-76

PRESENTATION - "DIESEL ENGINES" - by CDR (b) (6) BUSHIPS:

Gentlemen, I can assure you that the engines going into the submarines under discussion this morning are tried and reliable engines that have been proved by some twenty years of submarine service.

The first slide shows the GM 268-A engine. We have some three thousand of these engines in fleet use, in the three, four, and eight cylinder versions. These engines have seen extensive World War II service. This is the engine that powered the auxiliary generator in the General Motors engined fleet submarines. The SKATE has the eight cylinder version of this engine, driving a b(3) 10 USC 130 auxiliary generator.

The next slide shows the engine that is going in the 585 and in the 593 submarines. This is the Fairbanks-Morse 38F-5¼ engine. We have about 400 of these in use in the Navy. These too saw extensive World War II service in fleet submarines. The seven cylinder engine, for example, powered the auxiliary generator in the Fairbanks-Morse-engined fleet submarines. This engine comes with four, five, six, seven or eight cylinders in Navy engines today. The SKIPJACK and the THRESHER have the eight-cylinder engine, which drives a b(3) 10 USC 130 auxiliary generator.

I can assure you that there are no lightweight diesel engines being installed or being planned for any new construction submarines today. Thank you.

RADM MORGAN: Next is a dissertation on what we are doing in b(1) of the 593, and when fully developed, worked out and proven, it will go into other submarines. Until it is so proven, it will not go into any submarines.

Commander (b) (6) will tell you something about noise first, and then we will talk about what we will do about the b(1)

PRESENTATION - "NOISE REDUCTION" - by CDR (b) (6)

Good morning, gentlemen.

The objective of the submarine noise reduction program is two-fold. First, we want to maximize sonar performance. This is accomplished by a simultaneous improvement in sonar design and a reduction in platform noise or sonar self-noise. Second, we wish to minimize the possibility of our submarines being detected by enemy sonar. For passive sonar

Exh 224-77

this is best accomplished by reducing the noise source which is most detectable for the given condition of operation and the given sonar involved.

In the noise program up through the SKATE class of submarine this may be characterised primarily by an attempt to b(1) and the introduction of special noise reduction overhaul techniques on this equipment.

In the present program we have branched out to use other techniques; one, we have redesigned equipment and machinery to reduce noise at the source. b(1)

The first slide will show the salient features of this program in the present attack submarines. On the left we have listed hydrodynamic noise. These items are being accomplished on all of these ships, the 585, 588, 593, and these items have resulted from extensive tests on ALBACORE and NAUTILUS which have dictated many of these changes.

Moving over to the machinery side, the first item in 585, the b(1) b(1)

(b) (6)

In the 585 we relocated the bow planes, to avoid the sonar interference. The 588. is the first attack submarine that we have introduced (b)(1) . I would like to say a word about (b)(1) before going on. The (b)(1) is a technique used to minimize the (b)(1) part in radiating noise from the ship. This is done very much like the (b)(1) and the technique is the same in air as it is in water. For example, I have here two identical steel plates, one using the technique which we are applying to the 588, which is the (b)(1) plate. The other is the bare steel, and of course under the (b)(1) or any other source this tends to give out (b)(1)

In an attempt to minimize this effect we introduced (b)(1) and under the same (b)(1) it gives out considerably less noise. (Demonstrating)

Exh 224-78

Extensive tests of this both on T-1 and ALBACORE shows us that we may expect in the case of radiated noise a detection range of about (b)(1) what we would expect without it. In the case of the ALBACORE we applied (b)(1) specifically to find its effect on self-noise with the higher speeds. We found that here again it is of great value to us. This is an additional factor which we had not expected to begin with.

b(1)

In the 593 we have done all of these things b(1) We have introduced stringent noise limits both on the ship builder and in the procurement specs for machinery and equipment, and finally, in order to use the new sonar suit most efficiently we have minimized or used the minimum powered machinery designed for SSTG operation.

Next I would like to discuss what we may expect from this program.

In order to make a valid comparison we have used the National Research Council curves that they presented in their submarine noise reduction report. This uses a fictitious sonar, if you will, for comparison purposes. It has realistic characteristics but it does not represent any actual sonar in being. Using this information then, and the actually measured curves of SKATE, SEAWOLF and NAUTILUS and the predicted curves that we may get from the ships you saw here, we have estimated both detection range of the ships' sonar and also the detectability of these ships from an enemy sonar. May I have the next slide, please?

Using these curves and the NAUTILUS and SEAWOLF curves, we come out with about (b)(1) as a comparative detection range for these ships. The SKATE is slightly better, indicating (b)(1) , the 585 about the same. In the 588 we expect an improvement of about 3 db over the 585, primarily due to (b)(1) in this case, and in the 593 a considerable improvement b(1) and the other factors.

Now in presenting the expected results in the radiated noise picture, we must look at two sonar systems. First, a system that can be mounted in a submarine, and secondly, a shore-based system. The shore-based system is considerably different, as you know. It uses a much deeper depth, it uses lower frequencies, it listens to different items of machinery, and also it has a lower ambient to work with most of the time, hence the ranges are considerably greater. May I have the next slide, please?

Exh 224-79

These factors were again reached using the same curves and the actual noise results of these three ships, predicted for the latter three. The NAUTILUS and SEAWOLF, perhaps as a base line -- and I might point out that in looking at this curve which is the shore-based equipment, the things that are the most detectable here are the b(1)

Moving down here, the most detectable items are the b(1) You note these are at full power.

Finally we move into the SKATE, which is considerably better, having much smaller horsepower and consequently the speed is somewhat less than NAUTILUS or the rest of these. In the 585, detection is a little larger -- it is going faster than the SKATE. In 588 we expect some improvement due to b(1) in part, and in 593 a considerable improvement b(1)

I would point out that the (b)(1) are effective both in the b(1)

In our noise studies we have found that there very possibly exists a definite relationship between sonar self-noise and radiated noise. For example, if a ship like the 593 did get 100-mile detection range on an enemy ship or enemy submarine it might find itself in an extremely embarrassing position if its radiated noise were high, to try and attack this ship undetected, because they would have difficulty in closing this range.

Finally, the last factor to be discussed is that of cavitation, and this factor is in connection with the deeper operating depth.

This is a curve of depth versus speed in knots, and the curve shows the inception of cavitation. The important difference here is not so much between these two curves, as it does appear as the greater operating margin which really indicates the freedom the skipper has to operate his boat or ship at any time minus cavitation. This operating margin of course is directly tied in with the maximum depth of the ship and the maximum speed that is available to him.

PRESENTATION - b(1) - by CDR (b) (6) BUSHIPS:

Gentlemen, Commander (b) (6) mentioned that we b(1) in the THRESHER. I will show you what we mean by b(1) b(1) This slide shows the general arrangement of the main

Exh 224-80

machinery. You will notice to your right are b(3) 10 USC 130 turbines, b(1) dirving into a reduction gear. Aft of the reduction gear is the bearing, then the clutch, and so on, and propeller shaft. You notice the turbines and the gears are both b(1) This is a new feature.

The next slide shows in cut-away what we did with that b(1) Here is just half of the installation you saw before. We put that b(1)

b(1)

The next is the shaft. We can't have that wobbling around and driving the propeller. Therefore we provide a (b)(1) between the dirve shaft, coming out of the hull gear and the shaft itself.

The b(1) are shown in the next slide.
b(3) 10 USC 130

b(1)

b(1)

Exh 224-81

b(1)

RADM MORGAN: One thing I would like to emphasize here is that if we have any difficulty with the development of that coupling we can leave b(1) We would have our (b)(1) which is essential. and we would lose some of the b(1) but this would probably not be of a high order of magnitude.

CDR (b) (6) : This is typical of some of the inlet connections we have tested. We realized this would be difficult. Therefore we had six designs of joints which we were going to test. Of the joints, through circumstances, the ones which arrived at the Experiment Station first were those which failed. This particular joint is on test now, and as of this moment has passed 170 hours and is probably being shock-tested. We (b)(1) with pressure on, along each of the three principal axes. It goes 170 hours and takes a shock blow, then we use another axis and shock it again, and k the third time we take the remaining axis for the mode of (b)(1) and shock it again.

b(1)

VOICE: What is the diameter of that line?

CDR (b) (6) : I believe it is b(3) 10 USC 130

RADM MORGAN: b(3) 10 USC 130

CDR (b) (6) : In case there is a failure of these bellows, and we have had none yet, the steam will come in this area here which is connected to a fail-safe feature which will cut off the steam to this particular supply line.

These are two of the exhaust joints which we have tested, and these are satisfactory. They are (b)(1) with steel ring inserts. These

Exh 224-82

are the same as industry and the power plants have used for many, many years, they have had no trouble with them. We didn't expect any trouble and we have had none as far as failure due to (b)(1)

Admiral Knoll mentioned that there had been some talk that people were worried about b(1) If we do not have a joint ready to be installed in the ship, we can mount this solidly and be no worse off than any other submarine we have now. In other words, b(1)

We can eliminate the b(1) and put in a solid pipe. Portsmouth has a pipe configuration now which by having several loops in it can actually take the vibration itself. That too is on test now.

As Admiral Morgan mentioned, we can take those bushings out in case we have any trouble with them. b(1)
b(1)

b(1)

RADM MORGAN: May I say something there? The way we feel about this is that if we encounter difficulty in any one of these areas that requires further development, and which we are going to fully test out ashore, we have a back door; b(1)

In other words, we not only have a back door but we have a front door. We can continue our work, and if it takes even as much as ten years to develop one of these things, ten years later we will have it; whereas if we don't put this in we will never have it.

CDR (b) (6) What I have here is a small demonstrator which shows what you can gain from (b)(1) This is a small motor driving gear. The propeller is not useful, but it does make it nautical.

b(1)

Exh 224-83

PRESENTATION - "COMPONENT DEVELOPMENT AND TESTS" - by CDR (b) (6) ,
BUSHIPS:

Gentlemen; the component development and test for the 593 is divided for purposes of this discussion into two categories, those to be developed by the Bureau of Ships to be furnished to the shipbuilder, and those to be carried out by the shipbuilder himself. I will confine myself to the former.

Of the deep depth items required by the ship, the Bureau must furnish 49. Of these 49, 35 to date have successfully completed pressure test. We have completed 71 percent, while the ship percentage completion itself is 23 percent.

RADM MORGAN: We started this program about a year before we did the ship, to get a head start.

CDR (b) (6) : In addition to the pressure test requirement for these items, we are requiring that any item which forms a part of the pressure hull or affects the watertight integrity or affects the operation of vital equipment be exposed to a hydraulic shock test. The hydraulic shock impluse used for these tests is the equivalent of that required to rupture the hull. This insures that any item which we have can withstand the same underwater explosion damage as the hull itself.

Of these 49 items mentioned previously, 25 require this hydraulic shock test. Sixteen have passed successful to date, for a percentage of 64 percent.

This chart shows the status to date. Of the major items under development by the Bureau, the condensers, turbines and gears, trim and drain pumps, and shaft seal. The top bar shows the ship construction itself, which is at present 23 percent. The keel was laid in May. She is due to complete in December of '60.

The condensers are being built now; the contract was let last February. They are at present about 70 percent complete. These condensers are a beefed up version of those presently in our nuclear boats. There will be a complete pressure test conducted by the manufacturer prior to delivery. These tests should commence in May for delivery to the ship, as shown by the dotted line, on the required date in June.

The turbines and gears were contracted for at the same time as the condensers. They are at present 80 percent complete. Starting

Exh 224-84

309104 8-59

early in May, the turbines and gears will undergo a complete operational test by the manufacturer, General Electric. During these tests the gears and turbines will be mounted b(1) as they will be in the ship. These tests will complete and the units will be delivered to the shipbuilder for installation in the ship about August. The trim and drain pumps were contracted for last August. At present, they are about 50 percent complete. These are required on the ship in July, and late in May or early June the contractor will complete the pumps and put them through complete operational tests. The shaft seals are under test at present at EES. This bar here represents the test program. We are at present 75 percent through the program. We are testing both a solid ring and a split ring type seal. We expect to have the test complete in March and they are not required on the ship until next January.

For the shipbuilder portion of the component development, Commander Jackson, the Design Superintendent at Portsmouth, is here to present their program. Commander Jackson.

RADM MORGAN: Before you go into this, I would like to emphasize again that we have a back door. If any one of these components fails to meet the requirements, we can always put in the 700 foot component and restrict the ship to 700 feet until that component has been worked out. We can then install it, and have our full depth. In other words, we have a back door, and we have a front door.

PRESENTATION - "SUPPORTING WORK AT PORTSMOUTH NAVAL SHIPYARD" - by CDR (b) (6) , PORTSMOUTH NAVAL SHIPYARD:

Good morning, gentlemen. In order that all the components which will be new on the 593 are ready, we have developed a very elaborate scheduling system to insure that each item which will be required will be available in time to support the shipbuilding schedule of the 593. This schedule was developed as a result of our experiences on the 563 Class, TANG Class, which was also constructed at Portsmouth. When we finished that ship, we said, "The next time we go through this, the thing we must do is make an elaborate schedule and maintain it, so we have developed items when we need them."

We have given an informal name of "PROJECT PRESSURE" to this program at Portsmouth. The schedule includes all the items that will be on the 593. They will include new items that see increased pressure. There will be items that are being designed to reduce noise, and any other new development. Since Commander (b) (6) talked to you about the noise, I will confine my remarks to only those equipments that will see increased pressures.

Exh 224-85

The name "PROJECT PRESSURE" is not necessarily associated with the increased depth, but the amount of pressure that is put on the entire program to insure that we meet our schedule. Most of this pressure stems from the shipyard commander, but I can assure you that it is placed upon the program at all levels. Everybody in the shipyard is extremely interested in developing good equipments and on time.

Our approach to this is such: The first thing we do is take a look at the item and say, "Is there some way we could eliminate this so it will not be needed on the ship?"

One of the things that we have come up with as an example will be shown on the first slide here. As you all know, operating submarines have a lot of trouble with bridge equipments, items that have to go on the bridge. One concept is to make a little suitcase, which weighs about 30 pounds, is 12 by 13 by 6 inches thick. It will include all the usual pieces of equipment that go on the bridge, gyro repeater, rudder indicator, speakers, contact makers. The officer of the deck, when he goes on the bridge, will carry this up and connect it at an amphenol plug. Before you submerge, the OD will pick it up and take it down with him again.

With this concept -- none of these items will ever see increased pressure. However, in the event that the ship's force decide they cannot operate with this, we are designing equipments that can be installed on the bridge. We already have a speaker that has satisfactorily passed all the tests.

The next slide will show you how we approach the testing. Each item that will see increased pressure is subjected to a very thorough testing program. This can be broken down into mechanical shock. Each one of the equipments is put on the shock machines in three different planes, and subjected to the standard shock for high intensity mechanical shock. The next program is to hydrostatically test them to the collapse pressure. It is very significant to note that of all the items to date we have tested, we have not had a single failure due to static pressure. We have the third test, which consists of superimposing a hydraulic impluse upon the hydrostatic pressure; that is associated with the operating depth. This hydraulic impulse is equivalent to that which would split the hull of the submarine in an adjacent area. We have had some failures of contact makers and other electrical fittings, due to the hydraulic impulse. These items have been reworked and subsequently successfully passed the test. It is interesting to note that some of the things we developed to withstand b(1) have been well received. One of the items, I might say, is the running lights we developed for the THRESHER. We

Exh 224-86

3091048-59

took them up to their test pressure, they satisfactorily passed, so we went on and now we can say that they would operate satisfactorily (b)(1) These lights are now installed on the SWORDFISH, ALBACORE and NAUTILUS for service evaluation.

The next slide will show you the categories in which we are making these tests: Pipe flanges, that will be associated with salt water piping. Pipe fittings, also associated with salt water piping. Electrical fittings, contact makers, speakers, pressure proof fittings, where cables go through the hull, electronic fittings, as an example, wave guide fitting through the hull, flexible piping; mechanical items such as doors, hatches, exhaust valves, and all the mechanical operating.

Our approach is a straightforward engineering approach, based on experience over many years of designing submarines. When we had separated all the things out of our program to say exactly what do we need in order to make the THRESHER successful, we required 164 items, and of those 164, 59 of them have been successfully tested now.

Now, the shipbuilding program of the THRESHER is, like all the other programs in the last few years, one in which we have to design the ship at the same time we build it. The next chart will show how we are doing in our program. As I said before, each item has been very carefully scheduled to insure that it will be available on time. The dotted line shows the schedule, the number of tests we have to perform to meet that schedule. The broken dotted line is how well we have done. You can see that since we started, we have been either ahead of the schedule or right on it. The solid line are the number of tests that have been satisfactorily performed the first time. The difference between the 125 up here and the 59 that we have successfully passed, required, gives a margin of the backup that is available.

One of our fundamental concepts is that for every piece of equipment we design we must have a satisfactory backup for it.

On the next slide is a picture of some hardware that we have tested. This is the b(3) 10 US sea valve for the main circulating water system. It is a balanced sleeve type valve and has been thoroughly tested. It has been tested for high shock; it has been tested for hydrostatic pressure, and it has been tested for high impulse hydraulic shock. At rated flow and rated pressure, one man can operate this valve. The basic concept is that it is bolted from the outside so the sea pressure tends to seat it; therefore, the bolts are not necessary to hold the valve against sea pressure. This flange mounts right against the hull and the sea pressure tends to force it in. This particular valve is used in association with

Exh 224-87

another valve, which is outboard of it and hydraulically operated. This is the backup valve for the main circulating water system. This valve has been successfully tested to the criteria specified in detailed specifications. It will be shortly sent to Norfolk to be exposed to explosive charge to see, to determine its satisfaction to withstand explosive reactions.

In summary, I would like to say that our program is one in which we carefully schedule every piece of equipment that is going to be on the 593 that is thoroughly tested, to prove that it will be satisfactory and that it will be on time. The third one is that we have a backup for every piece of equipment to be put on the ship.

Now, Commander (b) (6) will talk to you again about the further shipbuilding --

RADM MORGAN: Just a second; I am afraid you may have given the wrong impression, at least I think it is wrong, maybe it is right. You indicated that first you have had no failures, of course, in any pressure tests?

CDR (b) (6) : Hydrostatic, no, sir.

RADM MORGAN: You further indicated, though, that on the shock tests your failures had been restricted to such things as limit switches. You have had other failures besides that which you haven't worked out?

CDR (b) (6) : We had one when we put a hydraulic impulse on a six inch ball valve, which will be a sea valve. It developed a crack in one of the flanges, which has since been redesigned, tested, and passed satisfactorily.

RADM MORGAN: I might add, gentlemen, that this shock test is something new since the War, but which undoubtedly will result in future generations not having some of the troubles that some of you had with your valves and fittings during the War.

PRESENTATION - "SHIPBUILDING STATUS" - by CDR (b) (6) , BUSHIPS:

Gentlemen, you have heard presentations on the various design items and component developments for the 593. Let's take a look at the over-all status of design and construction of the ship. Our second curve here is an ideal construction curve for the 593. The keel was laid on 28 May last year; scheduled completion is December '60. Our first curve represents the design program; as can be readily seen, the design leads the ship by about seven months. By

September of '60, all plans will have been issued. Notice this does not mean 100 percent design complete. The remainder of the design effort is for plan alterations, necessary shipboard test work, and such things that continue right up until the day the ship is delivered.

The third curve would be the first follow ship for the 593. There is a ten month lead time between the lead ship 593 and follow ship, which would be the SSN-594. Her keel laying date is presently scheduled for April 15, with a completion date of October '61.

To show how this lead time compares with past practice, we have chosen the 580 Class, a class of submarines nearing completion, which will deliver this year. The current design status of the 580 is 99 percent of the plans issued. This compares to 37 percent plans issued for the 593. On the keel date for the 580, 8 percent of the plans were issued, compared to 7 percent for the 593. At the first follow ship keel date for the 580, 30 percent of the plans were issued, whereas for the first follow ship for the 593 we will have 46 percent of the plans issued.

In summation, we would like to say that we have more than adequate lead time for design of the 593 and adequate lead time to support an entire shipbuilding program.

RADM KNOLL: As I said at the beginning, I will repeat again, the purpose of this is to acquaint you with the THRESHER and the number of new developments that are associated with THRESHER. The question that has been raised is are there too many new developments in one submarine. Are we proceeding too fast, and are we taking too much risk with regard to some of these developments.

Now, in approaching this and doing the analysis of all aspects of the problem, one of the things that we did look into immediately was the justification for the b(1) depth. We have not included that this morning but there is sufficient documentation by MOBSKA and OEG to justify going to the b(1) depth in submarines as soon as we can. We can provide the references for those documents to anybody who wants to become acquainted with them.

There were certain statements made that there are up to 370 new items in THRESHER. I think that that can be pretty well exploded. Further, it was stated that there are insufficient plans to build a follow ship at this time because of the number of new developments. We are particularly fortunate at this time in that we have Admiral Moore here from Portsmouth, who is building THRESHER. As you all

know, he was closely associated with the construction of NAUTILUS. He knows her growing pains and he knows that she probably had a lot more innovations in her than we have in THRESHER, so I will ask Admiral Moore to say a few words before we get into the discussion. Admiral Moore.

PRESENTATION - "THRESHER PROGRAM" - by RADM R. L. MOORE, JR., PORTSMOUTH NAVAL SHIPYARD:

Thank you very much, Admiral Knoll. I am very happy to have this opportunity to address this group. Several weeks ago Admiral Knoll and his group were up to Portsmouth to get first-hand information in connection with the building of the 593, on some of the things you gentlemen have been listening to this morning. At that time I think I gave them a dissertation up there that was a little bit full of fire and brimstone. I felt keenly about it at the time and still do. I don't intend to give you such a speech as that this morning, but I intend to give you a little bit of my thinking in connection with the 593 and how it ties in with other kinds of developments we have had before.

First off, I would like to state there is nothing spectacular about the developments we have going on in the 593. As you have heard, there are no major breakthroughs in the field of technology. I consider that the only thing that is required to build the 593 is the desire on the part of the people who want it. I would say if the customers want that vessel as badly as I would like to build it for them, we will have no troubles, we will not have red herrings drug across and not take up the time and effort of a great deal of people that have been going into this project in the last three or four years. I would like to get that off my chest; I feel it very sincerely.

Now, in so far as the philosophy of developing is concerned, I don't think I need to recount to any of you here that since the war we have made some quantum jumps in the art of submarining. I think that TANG was the first thing after the World War that got us into deeper depths and we capitalized on the experience of the Germans in the development of their Type 21 and Type 26, with a view to getting a true submersible with conventional power.

The growing pains we went through on going from 400 to 700 feet are well known to me, because at that time I was the Design Superintendent at Portsmouth and I was responsible for getting up that program in the same fashion that I am responsible for carrying through the b(1) development now. I see no more problems associated with the b(1) than with the 700. I think we have a considerably better lead in this case, I see no problems we are not going to surmount.

Exh 224-96

3091048-59

I don't suggest for a moment we don't have problems, because if we didn't have, none of us would be here today. If we didn't have troubles, I wouldn't be spending my time and effort at Portsmouth, and I think you can go down the line in that. Troubles are our business; everybody's business.

We expect a normal amount of them; we expect we can solve them, particularly when we are not advancing the horizon of technology any more than we are now. I might even suggest in point of fact that if we were as timid about the POLARIS development that we have going on, under way now, we would never have gotten it under way, because for every little problem that we have in the development of the 593, there must be ten major problems associated with the FBM, and the eyes of the entire nation are focused on that thing.

My only reason for advocating the 593 is I understand there is a requirement for b(1) and I understand also that noise is extremely important. I believe that, and I think every submariner in the business believes that. In point of fact, the reduction of noise was so important in World War II that right in the middle of our building programs, when the fleet needed submarines in the worst kind of way, the operating people raised so much Cain about the noise that when the Japs started getting on their necks, we had to get rid of the high speed gear type drive we had and we committed the entire submarine building program to a slow speed type motor, which fitted right in. That took a lot of doing, a lot of chance on the part of a lot of people, but the end results were so important that we committed ourselves to that and it came through nicely. Whereas maybe at the beginning of the war noise was not important, the importance of that noise does pick up as the enemy gets on top of you and starts dropping those little cans.

So even if we look at noise as from an academic point of view, when the pressure is on, I am sure that noise will no longer be academic.

I pointed out first the development of the TANG Class taking us to 700 feet. We were still, however, looking for the true submersible and nuclear power gave us that: there is no question about that. The ALBACORE came along and (b)(6) over here will tell you that with his hydrobatics, that is the fanciest Dan that ever came down the pike. There is as much difference between that and a conventional submarine as between a large transport type plane and a fighter plane. We finally have gotten to the point where we have married a true submarine with nuclear power, and we have the 585. That is a quantum jump, but certainly in the region of additional pressure, unless we push the 593 we are not going to make a further quantum jump. In so

Exh 224-91

far as noise reduction is concerned, I think all submarines we have built since the war, although we have made a lot of improvements, have been a major step backward, from a noise point of view. On fleet boats during the war we successively worked on motors, pumps, put in b(1) got them down so they fulfilled a criterion that had been set up for quietness of operation. After the war, however, we were so intent on building submarines, one class after another, that we could never get ourselves adjusted to any kind of development program from a noise point of view. These boats were pushed through to the optimum, without considering noise at all.

As some of you will recall, as we were developing NAUTILUS the early concept was to put a vessel to sea that had nuclear power. Were even told that we might leave the torpedo tubes off, that noise was not important; many things were not. The objective was to get that vessel to sea and to evaluate nuclear power. However, we put it out as a complete ship and the success of NAUTILUS is too well known for me to recount that to you.

However, when that vessel went to sea -- Captain (b) (6) is here and can bear out that she was one of the best noisemakers we had in the business. There is no question about it.

Shortly after she was delivered at Groton, she was so noisy we put her in a $600,000, one short overhaul, to bring down the noise, in fifteen selected pieces of equipment, wherever we were able to use well known techniques. That could have been worked out, if we had had more time, and made a quantum jump -- of 15 db quieting. She was still a noisemaker. The SEAWOLF is better, but still a noisemaker. When SKATE came around, a record was trying to be established on her by building in a 28 month period. In the area of sound we did very little. We always have the building program right ahead of us, we are pushed to meet the dates that CNO wants; you have precious little time left for developments.

In the case of the 585 Class, I think the Bureau finally said it was time some improvements were made both in the area of depth and noise, and pulled out the 593, which is the tail end of that class, with an objective of doing something in these areas. That, I think, gave rise to the birth of the 593 in its concept that you have listened to here this morning. I think you probably have heard enough here this morning to know that the 593 is on the track; I told you that the only thing necessary is this desire. You know the importance of that thing called "desire". We have had a Navy team that had that as a code name, which carried them to good feats. We have had other good teams, equally good, but not with that desire. And we get it, we get it at all levels.

Exh 224-92

UNCLASSIFIED

I think the major point here raised by Denny Knoll was not whether the concept of the 593 by itself was a sound one, but are we ready, because of these many developments, etc., to extend it to other vessels in the program. My answer to that is an unqualified "yes".

(b) (6) was up to see me last week on another matter. I had occasion to talk to him on the philosophy of the 593, where we took up how much money it took, the building time schedule, etc. He posed the following question to me. He said, "If you were committed right now to go on the line and build submarines as rapidly as you possibly could, couldn't you build the 578 much more rapidly than you could the 593 Class?" My answer was, "No; I think it is substantially a stand-off perhaps, the only difference being that the labor, as I see it now, for the 593 is from 15 to 20 percent greater than in the 578 because it is a bigger and more complicated vessel. But that is the only difference. The ship being larger than the 578, you could probably work it with more manpower; therefore, I should be able to build from a productive point of view on a par."

Then he said, "How about the delivery of components? You have a lot of developmental items under way."

I pointed out to him that as of this stage of life, I already have all my long lead time items for the 593 on order, and if I had to place orders for machinery for the 578 or 593, the only difference is I would make out a duplicate of the 578 in one case and the next of the 593. Since we are building the 593 in 30 months and with the present schedule, perforce any vessel that comes along should be able to match that, I am 37 to 40 percent along in design work now, keeping ahead of the game, so I think it is prima facie, if the 593 is a better class vessel and you are looking for better attack type submarines, then it stands to reason if these things on the chart are reasonable, and you want greater depth and less noise, then the 593 is the class we should commit ourselves to, if we put our desire to it.

I think, in a general way, that pretty much gives my slant in this matter. I am quite happy to talk about any phase of development. I would like to say, in connection with all the discussion you have heard on HY80 this morning, they said Portsmouth was doing real good in this area. I can report that Captain (b) (6) discussed this quite factually. We got into the cracking early. We picked it up; we have corrected those deficiencies. Since we have started exercising reasonable controls, we are not getting into any more difficulty than we have had with HTS before. We are getting about one crack in 100 feet, which I think is exceedingly good.

UNCLASSIFIED

Exh 224-93

Let me point out -- I want to make this quite clear -- that this business of cracking is perhaps more a function of thickness of the sheets rather than the welding, or the plate itself. If you were working with HTS of this thickness, with old techniques, you would probably come out with as many cracks as we get into on HY80 now.

Since they did discuss a little bit the controls that were necessary in connection with this HY80, I would like to point out that it is relatively simple. It only means you watch the welding sequences carefully, which we have done, so it means you watch the heat input very closely, which we have always done before. It means preheating it from 120 to 150 degrees, which is not prohibitive; we have done it many times in the past. And it means keeping the electrodes dry.

That is the sum and total of the controls we are talking about. I wanted to recount them because there is certainly nothing mysterious about them.

I think I have covered this point, that most of the difficulties are associated with the thicknesses themselves, rather than the weld or composition of the plate material itself.

I think that probably covers my reflections on this thing. I would be quite happy to answer any specific questions you have from the shipbuilding point of view.

RADM KNOLL: Are there any questions you would like to ask of Admiral Moore?

VOICE: How thick is that?

RADM MOORE: Eighty pount plate? About (b)(1) inches. I would like to mention one thing -- some of the experts can probably check me. If we were going to take the 593 and take it down b(1) with HTS steel, the boys made a quick rundown and told me the submarine would be 900 tons heavier, 75 feet longer, and 4 to 5 knots slower.

RADM MORGAN: That is not the question, Bob. The thing is the thickness of the material. If you can hold the same diameter, it would be b(1) and of course you couldn't hold the diameter because you would have to increase the diameter to get the buoyancy to carry it. It would be over b(1)

RADM MOORE: It is academic, when you can't handle that sort of plate. When you get up to 80 pound plate, you are getting up

Exh 224-94

UNCLASSIFIED

309 1048-59

real rough, particularly where you have a steel of 80 -- as a matter of fact, EB had to put in another thing to cope with the situation.

These techniques where you are having to preheat -- we have X-rayed pressure hulls in submarines, I want to make that clear. We are magnifluxing first and the final pass, to make sure we are not getting into cracks. That costs additional money, but in consideration of the tremendous advantages that go along with HY80, I think we can afford to pay the additional money that goes along with it.

In the amount of money, based on the Yard estimates, labor was cheaper on the 578 than on the 593, but our estimate of the cost -- shipyard costs was 20 million dollars versus 25 million dollars for the 593; that is reduced as a common denominator.

I think that gives you an idea of the money costs and time scales associated with these two vessels.

UNCLASSIFIED

Exh 224-95

BEGINNING OF DISCUSSIONS

RADM KNOLL: In our exploration of this problem, the one area that created some doubt was the area of HY80 steel, so our discussion initially should address itself to this area. I would like to have anybody here, particularly the people from the operating forces or with an interest in operations to address their questions to that initially.

VOICE: Before we get into detail, maybe there are two sides to this subject. Maybe we could have somebody that may be included towards the other side, that you may know here, to give us a very brief rundown of factors which might, from their point of view, make it more reasonable to do something another way.

RADM KNOLL: Are there any people here with other ideas?

RADM MORGAN: During our little coffee break, the remark was made to me that we hadn't brought out clearly that in regard to cracks in steel structures an extremely important factor is the toughness of the steel in resisting the spread of the crack. I thought we had, but let me say again that HY80 is the toughest structural steel we know of today, and therefore would have the maximum resistance to the spreading of a crack.

RADM KNOLL: Does COMSUBLANT have any comments?

CAPT (b) (6): One question that comes up is whether in this testing they have ever taken a large section of plate, say, two ten-foot sections, welded them together, and then actually depth charged or shocked them sufficiently to bend them out of shape, to see what happens. I know in the bend and roll tests, with small sections in the laboratory, they have been able to take a straight section, bend it 120 degrees, without failure of the weld, or without failure of the adjacent base metal. But I wondered if they had, perhaps at Portsmouth, where they have the plates available, made up test sections and taken them out and then depth charged them or put high explosives alongside, to see what rupturing effect there is.

During the war we had submarines that dimpled, but they didn't crack up like an egg and spill water in. Those that did have that happen--we didn't have them back to get test samples, but those that we did have back indicated they failed through the stretch point--and finally failed. SALMON was an example. I wondered if any tests have been made.

RADM MORGAN: Before that question is answered, Captain (b) (6) let me say one thing: The DRAGONET doesn't bear that out. You remember the rupture in the forward torpedo--that was a very brittle fracture.

09-8701638

CAPT (b) (6): That was a bad fracture.

RADM MORGAN: Let me tell you a little bit about steel. It has a property known as "transition temperature." This is a temperature at which a fracture changes from ductile to brittle. Various steels have various transition temperatures. In the case of high tensile steel, the transition temperature varies widely, according to the treatment the plates have been given. If they have been rolled below a certain temperature at the mill, their transition temperature will rise very greatly, so I would say that the plate you referred to was below our normal standard. But there were a good many others also below that normal standard.

In the case of HY80, one of the major factors in adopting it--because you will recall we adopted it for the 700 foot submarine--was the fact that its transition temperature is exceedingly low, on the order of 100 below zero or something of that sort. It has quite a distinct advantage there. I think I might say that you can't encounter a temperature at which you get a brittle fracture.

Relating to your question on the test, I am not checked out on that.

RADM MOORE: We are not doing that at Portsmouth. Tests are conducted at NRL. They are running many bulge tests. Tell them what we are doing on bulge. (b) , you know it, don't you?

CAPT (b) (6) : Yes, sir. I think I can speak to that point. In the explosion bulge testing, we have done two principal things to date. One is to test the basic strength of a butt welded joint in full scale, both with and without man-man cracks--by "man-made cracks," I mean actual cracks produced in the sample that is being tested. These samples are about so (indicating) square, set on a mandrel. Then a charge of explosive is set off to actually bulge that plate sample through a die, where we are sure that it is carried beyond the elastic limit. Then we observe the behavior of the sample, without any cracks, (without any man-made cracks), or without any visible cracks, then we examine the same sort of sample with a definite notch placed in the plate. The best statement of results would be compare, I believe, performance of this sort of test between what we call "HY80" and what we call "high tensile steels."

I can't quote you the precise figures, but I can quote qualitative figures: that at all temperatures in which a submarine will operate, it has been found not possible, when this explosion was set off, to produce any crack or any severe propagation of a man-made crack in the HY80 material, at the first blow. This would be a blow that would actually damage a submarine pressure hull.

Exh 224-99

RADM MORGAN: Let me tell you about the transition temperature. Notch sensitivity is a manifestation of it. That is how we test for it. You will recall that in World War II a number of merchant ships broke in two. At that time the phenomenon was not understood. This phenomenon became known later, substantially after the war. It has been learned that the main reason that those ships broke in two was because they had notch sensitive steel in them, or we might say steel with a high transition temperature. It is the same thing, and in every case that we have examined, they were brittle fractures. Brittle fracture, of course, absorbs no energy, and that is exactly what we are talking about.

RADM DASPIT: What is the transition temperature of high tensile steel?

RADM MORGAN: If we normalize the steel, which we do under modern procedures, we can get consistent results at a good low temperature, although nothing like as low as in HY80. The consistency of the results is the thing that is difficult to achieve.

RADM DASPIT: My point is since sea water never gets below 33 or something, that that area doesn't make any difference, as long as you are below that?

RADM MORGAN: That is exactly right, and we hope we are. This is a phenomena that we did not know at the time that those ships were built and the steel was manufactured. To answer your question, we have found transition temperature in high tensile steel as high as room temperature, but fortunately not often.

RADM MOORE: I think some of the people here may not know that the hangar decks on the GROWLER, the 577, and the 574, GRAYBACK, are made of HY80 and the ALBACORE itself is HY80 and has been in operation for five or six years.

RADM KNOLL: I think, in amplification of Captain (b) (6) s statement, in talking to some metallurgists, the one question they raised was whether there had been adequate testing of HY80 applied to a pressure vessel and the explosive testing, and that was the one area that there may be some desirability of further tests, to test it as a plate, and then test it as a shell part of a pressure vessel might be desirable. I wonder whether NOL or NRL have any plans to do that?

RADM MORGAN: We can go into that and see if it is feasible, try to work something out. I can give you assurances that the tests we have are clearly indicative of what results we can expect. Going back to high tensile steel, I have seen some of that that wouldn't bend ten degrees before it snapped. You mentioned 120, Captain (b) (6),

Exh 234-98

CAPT (b) (6): Yes, sir.

RADM DASPIT: I have some things brought back from Mare Island, which weren't specifically mentioned here, and I would like to have them confirmed, that in welding steel butt welds properly made you have been successful all the time--that, I take it, is where you join sections together--that the trouble has occurred in fillet welds, where you weld frames to the structure. Furthermore, that cracks do not propagate beyond the heat effect of the main plate; in other words, they don't go all the way through, like they have done in the past in some steels. This was from Mare Island, and the experience in other yards may not be the same.

RADM MORGAN: Yes, I believe that the experience is uniform; that the cracks, where they do develop, do not propagate into the base plate. Coming back to this earlier comment, on the specific testing of welded structures rather than just flat plates, these explosion bulge tests at the Naval Research Laboratory--which, incidentally, have been going on for, I believe, 13 years were a fundamental research tool in identifying this whole transition temperature character of steel.

CAPT (b) (6) : Tests have been made there not only with the flat plates, with seams in the middle of the sample but they have tested structure, a flat plate with T's on it, simulating the T's which would be stiffeners in the submarine hull. They set up a mandrel with a hole in that, the same width as the stiffener, so the edges of the stiffeners, i.e., welds, were right at the radius of this mandrel. That structure is then "blown" from the stiffener side, not the outside, but from the inside, and these welds therefore come right at the radius or curvature of the mandrel, which is the worst possible way of attacking that type of welding.

RADM KNOLL: Are there further questions on this?

QUESTION: Admiral, has there ever been a question about the use of the HY80 compared to the high tensile? Hasn't it all been in just the welding?

CAPT (b) (6): No; I think there has been a question of actual use of the metals. There has been some application where they wouldn't use HY80 because of its chance for embrittlement and failure. One thing that may sound a little naive here--but I think is in this too--is the basic thought of whose judgment can one trust. This is a real fundamental thing in this man's Navy.

We have all been brought up--or at least I was brought up so if my boss said to do something, I would do it. I might question it,

Exh 224-99

but I went ahead and did it, and in the end it worked out that I got back all right.

To me, this business of testing of steels--Lukens Steel makes it, US Steel--can you trust their metallurgists? They are the guys that make it. It seems to me they should be the authorities on it. Then how does the word of authority get to us? Through those in the technical business of bringing us this information.

I am sure that Admiral Warder wouldn't be as naive as I am, to bring this out on the table, but he supports this theory, that we trust those in the business, all the way up the line, in the supply corps, in the engineering corps, the medical corps--you have to trust your experts. We can't all be experts in everything. And I am sure that Admiral Warder's position is he wants better ships, he wants these deeper-diving quiet submarines. The only thing he doesn't want is a bunch of cripples tied up to a pier, and the decision is whether the designers can build submarines that will basically sail the sea, that if something goes into them, as Admiral Moore pointed out, which is a new development, and it fails, do we tie this submarine up like an X-1, or do we put her down b(1) and can we continue to operate--and I think so, and operate safely. That is Admiral Warder's position, and I think this group has given me the assurance. I will give it back to the Admiral.

Now I have some questions, not in the field of metallurgy, but in other fields. As far as I am concerned, that finishes SUBLANT on the HY80.

RADM KNOLL: Admiral Farrell, have you anything? Anyone else, on this subject?

RADM FARRELL: I can only endorse everything that Captain (b) (6) said, SUBPAC agrees with SUBLANT.

CAPT (b) (6): I think perhaps I have followed the development of the cracks in the HY80 steel over the past few months, as closely as anyone. We feel, in SUBRONFOURTEEN, that the problem will be licked. We have been concerned about it--as we should be--but we have not questioned the approach on it, and felt that the submarines and POLARIS missile submarines will come out on schedule, despite the difficulties that they have been having.

RADM KNOLL: I would like to ask one question in regard to Babcock and Wilcox being in on the project. I was reassured when I heard their advice was being sought, because of their long history, and association with pressure vessels, like boilers, and to what degree they have made any further contributions, or will they make some?

RADM MORGAN: Let me give you a broader picture first: We are approaching this in every activity that can really contribute to our problem, not that we are trying to solve the problem we have been confronted with--because we feel we have the solution, if people do the work the way it is supposed to be done. But we want to make it easier, faster, less costly, and want to make it easier for the shipbuilder to do it.

We have various projects, NRL, DTMB, UER at Norfolk. Now, to get to B&W, that contract itself is comparatively new. Captain (b) (6) can tell you about that.

CAPT (b) (6): That contract is just getting started. We have two of their top metallurgists as members of this touring committee, going around now on this rather quick visit, to each of the shipyards. Then either or both of these B&W people will go back to each of the yards and spend about a week getting the details of their actual procedures and practices, and will come up with an initial report there where I think we will come up with some comparative knowledge of practices among yards, which will give us some immediately usable information, and they will also further define areas where we need to go back into the laboratory and develop more specific information, particularly to give us developments in semi-automatic or automatic welding processes, where we can increase our production rates.

Without getting into a dissertation here on welding, I think it would be pertinent at this time to point out that there is still considerable of an art to it, as well as a science, and I do not believe that you will find any two shipyards or steel fabricating organizations where one's processes will exactly duplicate the other fellow's. It is a sum total of facilities, crane facilities enter into it, fabricating facilities, previous habits, and the sum total of the package in every case, as far as we are concerned, has to add up to crack free welds.

But I don't expect when we get through--we haven't in HTS or anything else been able to weld by rule; we have to weld by principles and a combination of principles which are practiced by each individual corporation. What we are trying to do is get a better definition, and spread information on principles and practices, so each productive organization then can apply those in his particular situation and give us the best job at the most economical price.

RADM KNOLL: Are there any further views in regard to HY80 steel that should be recorded here?

RADM TRIEBEL: I have to go now, may I make an observation before leaving?

RADM KNOLL: Certainly.

RADM TRIEBEL: Without knowing the answers to all this, certainly one thing that strikes me here is I can remember many times in the past when those of us that go to sea have been pushing for progress. I can remember times when it didn't look like we were getting it. But certainly it looks to me now that we have got somebody pushing us to go to sea. If we keep this up, I am sure you will all come out with the right answers.

RADM KNOLL: Thank you.

RADM DASPIT: I am sure that Captain(b) (6) didn't mean his remarks to be taken the way they may be taken, but to point out the way it is; that is, we depend on the advice from the technical people. If they say it is OK, we accept it. Everything brought out here was brought out last spring. I know that frequently people on top of the technical side don't get the whole picture, particularly at the start. We went through everything brought up here today--I did--and came up with almost the same results we came up with here today. Any time the operators have doubts, I think it is our job to look into them and reassure them. Any time they have doubts, if they come to me, I will see that it is done. This is why we are doing it now. I did not blindly accept the technical advice. We went into this ourselves.

RADM MORGAN: I can make a speech now, unless Admiral Honsinger wants to say something.

RADM HONSINGER: Yes; I do. I am impressed with the fact that, without exception, everything that has gone on has been reviewed with the front office of BUSHIPS; with review and re-review. We are constantly doing this. Every time something comes to our attention that looks a little black, or looks like we should question it, we try to get the experts down from our own shop, as well as from the shipyards or industry, as appropriate. I know we give information from ti e to time to the Ship Characteristics Board, and others here, as and when we can; however, I personally appreciate the opportunity to hear this review at one sitting, as I haven't heard it at one sitting before.

RADM MORGAN: My speech was a little different. I certainly appreciate, from the technical fellow's side, Captain(b) (6) s viewpoint, but I wholly and heartily concur with Admiral Daspit. We respect and are enthusiastic when the operating people go into technical matters that are of interest to them and question us and ask us to come up and tell them what we are doing. I think you are entitled to that. I certainly do not support any position in which we want you blindly to take our viewpoint.

UNCLASSIFIED

RADM HONSINGER: No; quite the contrary. We certainly welcome and encourage it.

RADM KNOLL: That is the one area, perhaps where we have failed the operating forces, as we found out there are areas of doubt, we should keep you advised of what we have found out, so you have confidence in us and are working as a team to solve these things. As a result of this meeting, we will circulate to the operating forces and everyone here what we have discussed here.

We hope, as there is any further progress in HY80 areas or any other areas, we can from time to time promulgate the type of information that will reassure you, that we are not blind to what is taking place. I think we have exhausted the subject of HY80.

I think the second area where I have heard repeated expressions of doubt is in the b(1) area. I think perhaps COMSUBLANT probably has some concern.

RADM DASPIT: I am concerned that some people may leave and there are two slides I would like to explore more, because they are dangerous; that is, the two slides showing the reduction of passive noise that affects your own listening and your own noise. Could we get those back on before people leave? Perhaps Captain (b) (6) can say something while we are waiting.

b(1) (b) (6)

CDR (b) (6) : I am sorry, sir; I didn't hear the question.

UNCLASSIFIED

Exh 224-103

b(1)

RADM HONSINGER: Beware of the difficulties. It is a lot better if you plan this ahead of time than put it in an alteration.

CDR (b) (6) : That is right. One thing in mounting any equipment is you must have room.

RADM MORGAN: I think maybe the impression has been given here that the major portion of our improvement is in the b(1) But there are other remarkable advances in the quieting of the machinery. I can give you a minute sketch of that. The practice until comparatively recently was rather coarse gears, with a moderate helix angle. b(1)

In the case of the 585, for example, a set of these was ordered and the coarse gears kept as backups. In the 588, we were able to do a little more. b(1)

Exh 224-104

RADM MOORE: Another good example is b(3) 10 USC 130 has to run all the time, and in the 585 class, it is quite a noisemaker. We have a contract with Westinghouse. and using known techniques, b(1) It is that much less of a noisemaker, because people manufacturing it have been given the criteria and the desire to do something about it, not just b(1) . This is where the major jump has been made in all the machinery.

CDR (b) (6) : Yes, sir; I agree.

RADM MORGAN: We have a curve here.

CDR (b) (6) : I think that is one of the important facets of our problem, that we have brought the manufacturer into this problem and given them goals to shoot for.

RADM MORGAN: Explain that curve.

CDR (b) (6) : This is a set of curves to show the noise signature of the 593 under different conditions. This is decibels or the noise intensity. This is frequency of the noises put out into the water. This curve across here is the curve that we would expect if we didn't do anything to the 593. In effect, we made a repeat of the 588 class. This is the curve down here.

This curve is the 593 specifications, the way it is set up in the ship characteristics. It is a curve which we expect to meet. Our signatures will be below this curve. In every one of our components, we purchase, we have put in stringent noise requirements and said these pieces of equipment should be designed and manufactured to be as quiet as possible. If we put this equipment in the ship b(1) everything else, we will be on this curve, right here. That is with b(1) This noise reduction we get from here to here is due to the specifications of each of the components to be quieter. Now, if we put--this also has b(1) As Commander (b) (6) showed you, b(1) has a large effect on the noise. If we took the b(1) we would come along this curve.

RADM MOORE: Explain those spokes to them, Harry.

CDR (b) (6) : Well, in our specifications we said to make these pieces of equipment as quiet as you possibly can make them. However, we all know there are certain limitations to the amount you can do. We further said that if you have to make noise, make it in this frequency range, from here to here, from here to here, and below here.

Exh 224-105

The reason we selected these ranges was those are the frequencies that less affect the sonar, both in the passive and active sonar. Therefore, we have said, first of all, make them as quiet as you can, and the noise you can't get rid of concentrate it in certain frequencies, so it will not affect the sonar.

QUESTION: How has reducing the noise of some of the components, such as the pumps, etc., affected the efficiency of the pumps?

CDR (b) (6) : I would like to answer that by telling the story about our development on the pumps. When we first started this program we called the pump manufacturers in, gave them our pitch in making quiet pumps. Some people said, yes, they would try it; other people said they can't do it, etc. They were universally of the opinion that you could make some sound reduction, but this would be at the expense of efficiency. One of the pump manufacturers made a pump, put it on test, and he achieved a reduction of 20 db on the pump. When he finished his first, much to his surprise, instead of decreasing it increased five per cent. This pump manufacturer now is hot for noise reduction because he thinks he can beat all the competitors by giving a more efficient pump.

RADM DASPIT: One thing I would like to point out in this curve is that we have reduced the noise in the slots in order to listen better, but when we put noise in a different frequency, the noise in that is higher than if we had a random selection of outputs, so if you did it, you would lower that curve a little, but even the peaks are a lot lower than any ship we have today. However, you are paying a price for it.

RADM MORGAN: Get that other chart.

VOICE: I think the point, Admiral, was to keep noise out of certain bands, rather than to put it in other bands.

RADM DASPIT: Right. Could we get that listening slide out?

CDR (b) (6) : Very briefly, these colored curves are actual noise levels as measured on the NAUTILUS. SKATE is about the same. SEAWOLF is about the same at 4 knots, so these are actual curves of the noise level versus frequency. This curve that Commander (b) (6) showed you is superimposed on here for the 593, which is what we hope to achieve. The difference between this curve and this is the difference we hope to achieve on the 593.

VOICE: That is the 4 knot curve?

Exh 224-106

3091048-59

CDR (b) (6) : Yes; and we are designing in the 593 this special condition for listening. This is as he pointed out to suit the sonar particularly down here is the LOFAR. b(1)

This area goes down here to accommodate PUFFS, which operates in the 2,000 to 5,000 cycle range. I thought this might give you a clearer aspect of where we are and where we hope to go.

RADM DASPIT: This is the chart I am really concerned about, because this talks about the detectability ranges of ships at full power. It shows at full that the 593 is going to be detected at (b)(1) miles by your shore stations. My question is, is this cavitating or not? As you go deep, you do not cavitate. As I understand the 593 at deep submergence will not cavitate at all?

CDR (b) (6) : This is correct, sir.

RADM DASPIT: Is this cavitating or not?

CDR (b) (6) : It makes little difference, with this type of detection, whether it is or not. The blade rate we observed on the NAUTILUS, SKATE and SEAWOLF can be observed whether or not we have cavitation.

CAPT (b) (6) : This just leaves you one line working with LOFAR.

CDR (b) (6) : Or more. We got about (b)(1) blade frequencies in the--

RADM MORGAN: Doesn't the turbine blade frequency come into this?

CDR (b) (6) : Yes, sir; I was addressing it to the propeller. For the SOSUS work, if you had the rotating speed of the turbine and your propeller, etc.--

RADM DASPIT: I have heard some statements that blade rates and things don't show up too well, unless you are cavitating. Then they sort of modulate that and make them more detectable; is that incorrect?

CDR (b) (6) : No, sir; not completely, because a modulated cavitation beat can be heard with a cavitation as a carrier by the submarine sonar. They don't actually hear the blade rate itself. On NAUTILUS at this speed it is probably (b)(1) cycles. The cavitation, however, if present, can be modulated by this beat at (b)(1) cycles. This can be heard. The cavitation is a carrier, but the sonar cannot hear this range. This is the reason for the difficulty.

Exh 224-107

RADM KNOLL: These are based on estimates, not real observations?

CDR (b) (6) : This is correct, sir, based on NRC curves which I showed you. They are only for comparative purposes.

RADM DASPIT: We have just had SKATE run tests. We have not gotten the report on them. We will test other ships. People are going to take these figures away. What are these predicting passive detection ranges, a snorkeling submarine?

CDR (b) (6) : Yes, sir; at ten knots.

CAPT (b) (6) : What sound gear, hypothetical?

CDR (b) (6) : Hypothetical, so it is comparative.

CAPT (b) (6) : In other words, you do not have the S93 sound gear?

CDR (b) (6) : No, sir.

CAPT (b) (6) : Which would give it far better.

CDR (b) (6) : No, sir; we are predicting with a BQS-2. This would go out further, perhaps (b)(1) miles. This is only as a basis for comparison, same sonar as the one the NRC curves have used, which has real characteristics, but is in that sense a fictitious sonar.

RADM DASPIT: Those were the points I wanted to make, Admiral Knoll.

CAPT (b) (6) : Admiral, since we have expanded the discussion, I would appreciate it if I could say a few words.

RADM KNOLL: Please do.

CAPT (b) (6) : I appreciate the chance of saying a few words. I don't have any slides or prepared spiel, and I may sound a slightly different note, but I appreciate this opportunity of saying a few words. The reason I do is because I am worried. I am genuinely worried. I am worried about our submarine construction program.

I took NAUTILUS to sea four years ago. It had problems. Our air revitalization didn't work; we had a terrible problem in our hull vibration. The hydraulic system gave us problems, but all in all that ship was a spectacular success.

I have operated that ship, I have reviewed very thoroughly the operations of all our other nuclear submarines, and as an operator, I

UNCLASSIFIED

309104S-59

would like to say that those ships have a real potential as anti-submarine weapons. The NAUTILUS went to sea four years ago. Today we have four nuclear powered submarines operating. I said I am worried. I am worried about the Russians. If they operate a nuclear submarine as spectacularly successful as the NAUTILUS was four years later, they will have more than four. There has been a lot of presentation here today. Several people have gotten up and stated their qualifications. I would like to state mine: I have had over fourteen years at sea riding submarines. I have been seven years in command of submarines. I have been on them long. I have had since the war two of the post-war Guppies, a fast attack boat, and the NAUTILUS. I was an executive officer on the first guided missile boat.

I am an operator. I am the guy on the scene when we have troubles with pancake diesels; I am back there seeing my people sweat and toil to make them run. I happen to be one of the operators that raised the point that he was worried.

The question today seems to be the THRESHER. I don't believe that is the fundamental question. The fundamental problem is that we have four nuclear submarines. The fundamental question is "Where are the ships, and why don't we have more?" Let's go back in time a little to when we got the concept of the 593. Admittedly the NAUTILUS was noisy. I believe as an operator that the exact implications of that in some quarters are slightly misunderstood. I have made many approaches on diesel submarines with that ship. I have seen results of some 350 approaches. Noisy or not--that noise is bad--that ship can go out today--so can SKATE and SEAWOLF--and kill diesel submarines. I think it would be important if we had more such ships, the best we can build.

So back in '56, in the '57 shipbuilding program, we had one developmental ship, the 593, for the purpose of noise. Well, because we are for development, we stuck a lot of things in there. Eventually there are many items--some I consider of marginal importance--but I am for them. I am for that depth and noise reduction. I think those two things are vital for an operator. I think we need them in our ships. But, admittedly, it is a development.

That ship was authorized in '56. We will get it at the end of '60. The follow ship, using the follow plans, will come along ten months later. That is a long, long time, since the NAUTILUS went to sea.

Now, I said I don't think we have the right fundamental question. The question is not the THRESHER. I think those things are wonderful. The presentation today make them sound encouraging as can be but the problem is that in subsequent shipbuilding programs we have 12 follow

UNCLASSIFIED

Exh 224-109

ships, four POLARIS and 8 attack boats, which are now predicated on the 593 design improvements that really aren't yet solved, because that ship hasn't been built and tested. If you want to try something, b(1) Put that on the NAUTILUS, take it to 30 degrees, and just feel the strain. How are you going to test that (b)(1) Is that going to be at sea? You will not do it over in the test shops where you are (b)(1) it. However, I don't want to talk about individual items, but the philosophy. We have compounded development with production. We have a large number of design developments in this thing and if any one of them fails, we just hold up our ships. That is all; it costs a little more money, and holds them up.

Personally, I think that is important, because I think that ships we have today can do a job. I believe there is no question about the THRESHER at all, but I believe we should very seriously look at the follow ships that are going to be predicated on that design, with a time basis, whether it is important in time that we get them.

RADM KNOLL: Do you have any comments?

RADM MOORE: Specifically that is why I gave the information I did in connection with the time scale in the 593 and the cost associated with it, and why I stressed so much the fact that this is no FBM program. This is not a POLARIS job. This is a straightforward thing, on engineering developments and if you call it compounding a felony because we are trying to b(1) and reduce the noise at the same time, compound the felony; so be it.

The specific question in connection with the rate of building vessels ties in mostly with funds appropriated and the number of submarines each year. You can't build submarines when they are not appropriated for and when you have restrictions on money, which is obligated. About a year ago, DOD put out restrictions, not only to Navy Yards, but all private concerns, restricting the expenditure of funds. I could spent 36 million dollars on new construction at Portsmouth, no more, no less. When DOD hands down decrees like that, you have to say the rate of building submarines isn't fast enough, but DOD, the President, and everybody else doesn't go along with it.

RADM MORGAN: I would like to make a remark: The NAUTILUS was very successful. In some ways it is a yardstick as to what to do. It was designed for 700 feet. There was no 700 feet submarine in existence at that time, they were on the drawing boards, being built. The keel of the NAUTILUS was laid in '52 and we didn't have a single completed TANG at that time. We didn't worry about it; we met the problems and solved them.

309108-59

RADM HONSINGER: There is a philosophy of building that Captain (b) (6) has brought out, which it seems to me does bother people in the Navy. Do we spend money today to build the newest thing we have, or to build a sure thing? Ships cost a great deal and to build, take three to four years, or five or six from the germ of the idea until the whistle blows and the ship goes to sea. During that period of time there is much development. If we don't build each one of these expensive ships--and we have a limited number--with the latest designs that are feasible and practicable to use, we will end up with a Navy that will be so far out of date that it won't be any good when D-Day starts.

We see it every day. We canceled REGULUS the other day, just as the first REGULUS submarine was completing. The Newport News paper said, "What in the heck is the matter with the Bureau of Ships and the Bureau of Aeronautics? Why don't they get together and talk? Why build a ship for a missile that is no longer any good?"

I think we in the room understand this. If the crystal ball were clearer, we would know what to do and end up better three or four years later.

But in order to predict technical progress, which we are making, at a staggering rate, yet not enough, to do all the ships we need, we do the best we can to put everything on as we go along and make each ship the best we can.

The aviators, when they build five hundred of one design can get a half-dozen airplanes for test. We can't do that with submarines or ships. We don't buy them by the hundreds.

RADM KNOLL: Within the terms of reference of the Ship Characteristics Board--which does not make a decision on how many ships to build, or how much money goes to submarines, have we answered the problem, from the standpoint of the Ship Characteristics Board, that you raised?

CAPT (b) (6) : In the case of the THRESHER, I think so.

RADM KNOLL: Are we proceeding too fast?

CAPT (b) (6) : No; but the concept of that ship was an experimental ship, to make improvements.

RADM HONSINGER: No.

CAPT (b) (6) : Yes, there were six ships in the '57 building program, and the last one was set aside to do something about this

Exh 224-111

noise problem. That hasn't been done yet. Yet all future ships, just because they are a subsequent number, come under that same program. I understand what you say, Admiral, and I feel ridiculous, being against progress, because I am for deep depth and against noise, but I want some of these ships in my time.

RADM HONSINGER: The 593 is not experimental, because we have had some experience--we have had a couple, however, the DD 828 is one--

CAPT (b) (6) : If we had done this on that we would have been runied.

RADM HONSINGER: The 828 was an experimental ship. We expected that it would break down as it did. It was way out in the blue. The next experimental ship I can recall was the ALBACORE, and our current ASW ships; that for research. Except for those, I don't recall any other experimental ships. We certainly picked out the 593 as the last of the lot and decided to make her different from the first ones, but that doesn't make her experimental.

RADM MORGAN: That was to give her a year's more time to work out these problems, which we didn't have in these other ships. We didn't have it in the TANG.

CAPT (b) (6) : Surely, but when did the 593 start? We laid it down last May, it was authorized in the middle of '56. I am just an operator. There are a lot of people here in this room who have a better picture of the world situation than I do. I just know that with development goes delay, and I know that if our production schedule of ships is tied up in a multitude of developments, that there has to be a delay. I have seen too many developments. I have gone through those ships where the development comes to life. There are people that know the importance of having those ships better than I. If it is important for what we are getting to delay our finest thing, I am for it. If there is no threat of war, fine. I am sorry, but I question that.

RADM MORGAN: Let me answer that. I hesitate to bring this out, but I was, as most of you know, in charge of design and construction of submarines throughout entire World War II.

CAPT (b) (6) : Those were good ships.

RADM MORGAN: I found at the end of the war there was not a single feature of those ships that was the same as at the beginning of the war--not a single feature. The lines of the ships were the only things

Exh 224-112

UNCLASSIFIED

we kept. We changed the hull, the steel, nearly every mechanism in them. We changed from 9 to 10 cylinders in the Fairbanks diesel engines. We changed the motors, as was brought out here today, but not by delaying the production, but phasing it, by planning and doing it properly. In time of war, you certainly could not justify, particularly when the effectiveness of our submarines was so great, delaying the ships. But we went along--at one time, I sat down and reviewed those ships from stem to stern and couldn't find a feature we hadn't changed. Yet we didn't have delays. You don't have to have delays to get development.

CAPT (b) (6) : Well, I think it is a real good system, when a guy is worried and has been into something intimately, like I have--I think it is fine that we are having a meeting like this. I think I know all of these people, and I really am worried. That is why I spoke my piece. I am not worried about THRESHER. I was only worried about the production ships. If I am wrong, and a thorough review shows it, fine. Personally, I am not convinced.

RADM DASPIT: I would like to state a few things: I would like to emphasize the delays which are caused by manpower ceilings and financial ceilings. We are having ships being built right now delayed. BARBEL is one; HALIBUT is one. These will exist if you build SKATES or THRESHERS. It is out of our control. I agree that nuclear boats we have now are wonderful for handling the Russian diesel submarines. It is the approved policy of CNO to build nothing to handle diesel submarines. Every new thing we build is aimed at the Russian nuclear submarines. This is one of the things back of dropping RAT, because RAT didn't have the growth potential. We are building these ships to last for 20 years, not to fight the Russian diesel submarine fleet, because if they get nuclears, they will probably put a lot more money in them than we will.

CAPT (b) (6) : That is why I said you have a better picture.

CAPT (b) (6) : The four submarines we have now, SSGN's, that were changed over to the 593 class, were slipped from the '58 program into the '59 program, and construction hasn't started on any yet, except at Mare Island. They are about ready to lay the keel on the first one. This was caused by financial considerations--by things we can't control.

CAPT (b) (6) : In fact, those are the ones we raised the question about, not about THRESHER.

CAPT (b) (6) : Those ships lost a year on legislation--not on legislation, but by edict.

UNCLASSIFIED

Exh 224-113

RADM KNOLL: What you have said, Captain (b) (6) , is your area of concern is not within the purview of the Ship Characteristics Board at all; it is challenging the administrative and budgetary controls put upon us by people outside the control of the Navy, people here in Washington. We are as concerned with those, surely, but up until this time we haven't been able to do too much about it.

CAPT (b) (6) : Yes, sir, but it must be within your purview as to what the follow ships will be.

RADM DASPIT: What people have been telling you doesn't make any difference, that they can build THRESHERS as fast as they can SKATES--whether or not they will--but it can be done.

CAPT (b) (6) : With no unsolved problems, they probably can, except for a little difference in manpower.

RADM MOORE: We had enough problems on the 700 one, and we put that together. How many times did we change the control in the engine room? I don't remember your challenging that any. We made many others. A lot of money was spent in the NAUTILUS per se; you can't figure out the number of dollars that come in it. That is precisely the type of thing you are talking about, Denys. They are all developmental--more so. The things we are talking about here are horse and buggy; there is nothing so fascinating about developing a valve to withstand more pressure.

CAPT (b) (6) : I agree that you will solve the problems, but it will take time.

RADM MOORE: I can't agree with you. You saw the charts. You know I am not ready to put in things under design. But I already have 45 or 50 per cent of the things. I will be ahead. Even if I had them all designed and in hand now, I couldn't put them in. I am way ahead of schedule. I am talking about valves, etc.

CAPT (b) (6) : The long lead time items were predicated on--

RADM MOORE: It was conceived as the 593 and many items were long lead time items.

CAPT (b) (6) : But some of those haven't been let yet.

CAPT (b) (6) : I think one of the fundamental points Captain (b) (6) makes is maybe he thinks we should stick to 700 feet. I think the need has been proved for the b(1) but if we build follows for these others, we have to go back to the 700 feet, or change their designs radically.

CAPT (b) (6) : No, sir; I am for deep depth and a lot of things. But the point I made is we have a multitude of things.

RADM MORGAN: What are they?

CAPT (b) (6) : The 700 feet and various things, b(1) reduction gears, b(1)

RADM MORGAN: That is part of the b(1) If you are talking about those, b(1) that we have down there. The development you have touched on is that of the b(1) . If we don't get them on time we won't delay the ship, but will turn it out on time b(1) Then we will keep working on the development. If two or three years later we get the b(1) we can put them in and have a substantial improvement.

The other thing you mentioned b(1) There is no great difference in principle in going from 400 feet to 700 and from 700 to b(1)

CAPT (b) (6) : I would like to say from the other side of the fence that I surely appreciate my chance to have a say and I thank you for the way it was accepted, too.

RADM MORGAN: The day we don't encourage you people to come forward with you say, we are in bad shape.

RADM KNOLL: Has anybody any more on this?

CAPT (b) (6): Shall we progress to the next subject? I think we have some other items. I have a couple that I would like to ask. One is the principle that is being used in sealing cables. That suitcase idea of taking instruments up looks practical to me. I am not so lazy I mind carrying a suitcase with me.

CAPT (b) (6) : You might decide to leave it there.

CAPT (b) (6): I might even do that.

VOICE: With three minutes dive time, I don't think you will have any trouble.

CAPT (b) (6) In the nuclear submarine, diving is such an event that you go to GQ and everybody stands around, because you only do it once a month. That is a heck of a note. But I want to ask about the principle that is being used on sealing cables where they go through the hull.

RADM MOORE: I would suggest in that area, since this is a very broad field, I would be happy if you would come up and take the time and we can show you the entire development.

RADM KNOLL: We encourage the operators to do that, because what we have seen is very impressive. If the Ship Characteristics Board goes into the field, we find out more in ten minutes than in a much longer time back here.

RADM MORGAN: Well, can't we answer his question anyway?

RADM MOORE: There are different principles being used.

RADM MORGAN: Then you can't answer it simply?

RADM MOORE: No.

CAPT (b) (6) : During the presentation they said there are 164 items under development. I presume they all apply to pressurization involved with the b(1) problem. Is that the total number of new developments?

RADM MORGAN: No; the sonar bow.

CAPT (b) (6) ; The fire control, etc. How many items are there of a new development character.

RADM MORGAN: Those are all I know.

RADM KNOLL: It depends on what you classify as "items." If we isolate items--we had 14. If you go to end pieces of hardware, you can get a fantastic number, and it is impressive, but it doesn't address itself to the real problem.

CAPT (b) (6) : I wonder if that is exactly so.

RADM MORGAN: The sonar bow is an assembly of pieces put together to work together.

CAPT (b) (6) : The sonar equipment you are putting in is a completely developed item?

RADM MORGAN: No; you didn't hear what I said. I said it is an assembly of developed items that when put together work together. I don't think it has been done before.

CAPT (b) (6) : How about the angled tube; everything has been developed?

Exh 224-116

RADM MORGAN: There is no problem on the torpedo tubes. As a matter of fact, I wanted this brought out. They didn't do it, but we are designing the torpedo tubes for a collapse depth of (b)(1) feet.

CAPT (b)(6): Admiral, I am not trying to question whether or not they have--

RADM KNOLL: How many specific items? Do you want specific items, hardware?

CAPT (b)(6): Yes, sir.

RADM MORGAN: Do you want to know how many five inch valves--

CAPT (b)(6): That is not the point. You have certain items, ship control, fire control, ordnance. We ought to have some idea of how many new major components are going into the ship, how many are new items, under development for this class.

VOICE: The fire control system is now under development.

CAPT (b)(6) What is that?

VOICE: The 113. It is the first of that type. It is, however, a take-off on other things.

CAPT (b)(6): I don't want to dwell on any item, but I want to get the items. The 164 are associated with pressurization?

RADM MORGAN: The torpedo tube is part of that.

RADM HONSINGER: I imagine there hasn't been a ship built in this century without literally hundreds of items new and developed.

RADM MOORE: And anyone I have seen is--as a matter of fact, the 80 is almost as developmental as anything we have.

RADM MORGAN: I think you have to distinguish between ordinary engineering application and development in the sense of being experimental.

RADM HONSINGER: The 700 to b(1) is engineering; it is a calculation.

CAPT (b)(6): Admiral, I am not questioning-- I have been very much impressed with the presentation. I see no particular problem in going to b(1)

Exh 224-117

RADM DASPIT: This point comes up from time to time and will keep coming up. Can't we give him relative items, as compared to the first 700 feet?

RADM MORGAN: What is an item? Say, b(1)

RADM DASPIT: That is. Just give them the figures on the two boats. It sounds like a lot but if you go back to the first 700 foot boat, you probably would have the same number. Later, I would like to see those other slides.

RADM KNOLL: We had ten items of new areas that required changes of hardware.

RADM MOORE: The TANG Class was a great deal more developmental than this because it was a complete change in concept, we went over from a basic DC distribution to a basic AC. Fire control equipments were different.

CAPT (b) (6) : But that ship didn't turn out very well.

RADM MOORE: I heard you brag about the WAHOO many times.

CAPT (b) (6) : Surely; I was in charge of her.

CAPT (b) (6) : If they had development items in the TANG and they are now being called out in the 593, that is fine; we won't talk about them. But if they are calling out items in the 593 which are developmental items--

RADM KNOLL: What do you define as a "developmental item?"

CAPT (b) (6) : They have yet to be produced for the first time.

RADM HONSINGER: The suitcase of instruments on the bridge is developmental. Certainly we can make a list of things.

VOICE: I was trying to get around to the point that Captain (b) (6) made, that after the ship is built, he doesn't want the ship to have to put alongside the dock. It is not only the problem that you can't go to b(1) that is not the only problem. But you might put her alongside the dock because the sonar won't work, or for umpteen other reasons.

RADM KNOLL: There is no one item in the THRESHER now to prevent it from getting underway. You might limit it to 700 feet or something, but there is no item that we have been able to locate, in the couple of weeks we have been exploring this whole area. I think that has been

confirmed by everybody I know that has been associated with this. If I am mistaken, I would like to hear what item it is.

CAPT (b) (6): There are numerous items--nuclear ships, God bless BUSHIPS for building them. I am proud of BUSHIPS' success, and proud of NAUTILUS' successful feat in going under the ice. But in our submarines we have problems, for instance, with resin. This irritates us, and we fix it. I suspect the same thing will happen in the next model of submarine, just like in the next model of automobile.

RADM HONSINGER: This is part of our living in the Navy in peacetime.

RADM TRIEBEL: May I say something before I leave?

RADM KNOLL: Certainly.

RADM TRIEBEL: Once upon a time I was an operator. Also I have lived with technical people. Now I am afraid I have spent too much time with the Joint Chiefs of Staff; I am ready to compromise.

We have operators that more or less fall into two classes, old operators, like division commanders, who want to see the boats on the line, ready to go--and they have charts of them, etc. They are sort of against progress. Then you have young operators, wild-eyed boys--once I was one of those and gave them heck. They have ideas, they know, they read technical journals. They know that some of these things should be changed, and can be.

Now, the technical people, their worst thing is that they are experts. They have tested this ten times or twenty. They know this idea is no good. Finally they are signed out, it is good, but they want to work on it, but don't give it the priority they should, so it comes along three or four or five or six years later. So we use the young operators to push the experts, and use the experts to do the things, and use the old operators who can put the boats on the line. So thank God we have them all.

RADM KNOLL: What area have we failed to cover, b(1)

CAPT (b) (6): One of the things that worries Captain (b) (6) is delays. I might say that producing and running a boat is no proof you want to duplicate it. (1)

As far as I know, they still haven't found out where the leak came from. They patched (b)(1) they thought was leaking, and they still don't know what happened.

On that chart, the turbines and gears are 80 per cent completed. They are going to undergo a complete test on the beach. If they fail that test, what are you going to do?

RADM MORGAN: The turbines and gears, or b(1)

RADM DASPIT: Turbines and gears. A lot of people ask about that--or at least one man--

RADM HONSINGER: This happens year after year in our program.

RADM MORGAN: We are engineers. Those gears have a lower loading than almost any we have recently built.

RADM DASPIT: How long would it take to get new ones, however?

RADM HONSINGER: Twelve or fifteen months, if you had to fall out and fall in again and you couldn't steal them from some other place.

RADM MORGAN: But you have two kinds of things--unit loading and the K factor, which is a measure of the unit pressure, which causes gears to fail. The K factors and the unit loadings are lower than other gears, because you have so many teeth.

RADM HONSINGER: If it fails, the whole thing won't--it will fail in a tooth or something. We are having failure in the CVAN-65 gear. First one gear, and now a pinion has failed, because of a faulty forging. But that won't hold up the end product one iota.

RADM DASPIT: I have a specific question: Suppose that gear does fail. On the next 593 class, could you go back to the other gear and get it in time, not to hold up the ship? This is their point, that it might hold up future ships.

CAPT (b) (6) : It is a new development.

RADM MOORE: The same gear is going into the 588.

CAPT (b) (6) : It is fine tooth.

RADM MORGAN: You can go back one step further, the 585.

CAPT (b) (6) : No, sir.

CDR (b) (6) : There is a slight difference between the 585 and the 588.

Exh 224-120

RADM MORGAN: That is right, the 588 are longer and larger in diameter, reducing the loads.

RADM HONSINGER: The answer to your question is that once the die is cast, if the whole thing is no good, we will lose time.

RADM DASPIT: On this ship. Would we necessarily lose time on the follow ships?

RADM HONSINGER: I think we would, but we are doing this, and have been for the last hundred years. A step up in engineering of gears is not new. This is a new gear, but the gear design and manufacture is not so new that we are way out on the end of a limb.

RADM MORGAN: We tested over 40 sets of these gears b(3) 10 USC 130 at EES. We have the K factors and loading, engineering data.

RADM DASPIT: I am trying to bring out the questions that no one else has brought out.

CAPT (b) (6) : With that fine tooth gear, there is a realignment problem. We b(3) 10 USC 130 with a gear design nowhere near that fine. You can't argue about a technical gear sitting here, but it is development, and the very concept of development you have.

RADM MORGAN: We have had the thing up to full power already, in the test.

RADM DASPIT: This gear, for the 588?

RADM MORGAN: Yes. I think we have the third set on the test. They have been up to full power.

RADM DASPIT: That answers that question.

VOICE: If this gear doesn't work out in the 593 and subsequent submarines, can you put the gear you built for the 585 in this submarine?

RADM MORGAN: You can put it in; it is a smaller gear.

CAPT (b) (6) : I am probably out of line saying it, but the whole idea or b(1)

I would recommend an alternate development where we use direct drive, or electric drive.

Exh 224-121

RADM MORGAN: We haven't gone into what we are doing in the way of alternate developments.

CAPT (b) (6) : All these future ships are committed to this development.

RADM MORGAN: No.

CAPT (b) (6): As of now. There is nothing that says it can't be changed.

RADM HONSINGER: We have considered electric drive and several varities of propulsion.

CAPT (b) (6) : Aren't four out of the nine POLARIS and eight boats to follow the 593 presently contemplated as this design?

RADM MORGAN: Yes; but you said all future ones.

CAPT (b) (6) : I meant now authorized.

RADM MORGAN: We have other developments going ahead. Sometimes it is better not to bring them out, because if they look tasty, then you want them immediately. You might not give us a chance to test them before you want us to put them in the ships.

RADM DASPIT: May I explore this gear with Captain (b) (6) , who represents one of the people who question this, in view of the fact that this gear has been tested at full power, would you call it a development item?

CAPT (b) (6) : Yes, but say it has high potential, and say it looks like a great prospect of success; yes. My point is I am trying to get a figure of how many different pieces of equipment that will go to make up the total system of a ship are of a development nature. If we look at each one and say they all have a high potential of success, we have nothing to worry about.

RADM DASPIT: Would you list the reactor?

RADM MOORE: Getting back to the FBM, I would say if Red Raborn had to have every development that he needs in his system, he would never get it, and getting back to the POLARIS system, we might as well say--we will have submarines before that system is here. You are saying, "Let's knock off the FBM," because you are worried.

VOICE: I am not saying that.

VOICE: I hear the words.

CAPT (b) (6) : I would like to get a comparison of the 578 and 585. I am sure you must have some idea of new development items.

CAPT (b) (6) : Are you talking about the sonar bow, fire control, b(1)

CAPTAIN (b) (6) : All of those. It may be that in the 593, compared to the 578 or 585, you in fact have less number. I don't know.

RADM KNOLL: Have you analyzed this with regard to aircraft and missiles too? Why are we just attacking one ship in a building program? You would find out this ship is conservative, in terms of new items.

CAPT (b) (6) : This is what I would like to bring out. If this is so, I would like to bring that out.

CAPT (b) (6) : On this gear problem, if we address ourselves to the gear, the gear will ride in the 588. b(1)

RADM MORGAN: Yes.

CAPT (b) (6) : The (b)(1) is the 593, for which we have a fix, if we need it.

RADM MORGAN: I haven't the details.

RADM KNOLL: Is there a definition now of what you in 91 consider a definition, across the board, of Navy hardware, that we can use, to answer your question? Has it been applied to POLARIS, REGULUS, and has it been applied to other than a submarine? Let us see a definition and we will try to meet it, within the criteria.

RADM MORGAN: Let's take the FORRESTAL; four elevators are all different. Let me talk about gears for a moment. I didn't know it but I have just been told that by mistake they ran it up to 125 per cent full power, and they couldn't break it; they broke the machine.

VOICE: I think the answer is there isn't any more development than in any other ship.

RADM DASPIT: Any lead ship.

Exh 224-123

CAPT (b) (6) : I would like to clarify my position: I wasn't a party to this yesterday, or the day before. But a rumor I heard was the 593 is loaded down with new development items, that on many of these there seems to be a question about their validity. If this isn't so, that is exactly what I am here to learn. I am not saying you have 150 development items, of which 50 have very little potential. It may be that your 593 class has less number of new development items than the previous class you have built. If that is so, I don't understand why we have been having any excitement about the problem.

RADM MORGAN: You have an appropriation known as Research and Development; there is not anything on here that would go into that category.

CAPT (b) (6) : You have an appropriation labeled "Research and Development Test and Evaluation."

RADM MORGAN: None of this would go in that category.

CAPT (b) (6) : That is where, as you well know, Admiral, there is a great deal of controversy.

CAPT (b) (6) : I would like to say, from the Warfare Desk that this ship is designed as a weapons system. The sonar dome is designed as a part of that, and BUORD's equipment is designed as a part of that. This ship is supposed to run between 100 and b(1) feet. From an operator's standpoint--this is one of the old operators that he was talking about--this is what we want. If we can't get it, that is too bad; we will fight. We want more than that, we want to go deeper, but we are willing to take this now.

RADM MORGAN: That brings up one thing: Why do you suppose we went to b(1) CNO wrote us a letter and said they wanted to go b(1) one year, b(1) the next year, and b(1) the next year. We would now be really stewing around--just as much when you change from one to another. We wrote over and asked "which one do you want? It is as easy to give b(1) What do you need? You pay for it in size and cost." They got in OEG reports and wrote back and said, "make it b(1) "

RADM KNOLL: I think, to answer 91's problem, we have learned a lot in the building of submarines and everything else, in prototypes, and NAUTILUS and SKATE, to build THRESHER. If someone will give me a definition as to what is a new development item, I will show by comparison the number of development items in NAUTILUS as compared to THRESHER. I think all concerned will be impressed that THRSHER is conservative. At the same time, I'd like to look at missiles or aircraft, find out how many new development items are there, keeping the same definition.

This is a lot of work, but we are prepared to do it, to answer your problem. In the physical examination of the THRESHER within the last three weeks, I was impressed that there is a conservative number of new developmental items in THRESHER.

RADM DASPIT: I think it would be nice to have this on a DLG, because they are follow items.

RADM KNOLL: We need a definition as to what is considered new development items before we can answer the question because there hasn't been any criterion as to what is a new development item.

RADM MORGAN: I think over 2,000; we have to draw 2,000 new plans.

RADM KNOLL: That is the other extreme.

CAPT (b) (6) : As an operator, I would say a development item was a new item that you had to develop that imperiled the ship.

RADM KNOLL: That is like saying when is research not research.

CAPT (b) (6) : When your air compressors for that boat don't work then that is a development item.

RADM MORGAN: I think that is a good definition. If they don't work, we will put the 700 foot ones in, and we haven't lost anything.

CAPT (b) (6) : Time and money.

RADM MORGAN: How?

CAPT (b) (6) : If you do all this other development and put the air compressor on, it costs you.

RADM KNOLL: Gentlemen, it is naring 12:30. Is it the feeling of the Board that we adjourn for lunch and reconvene, or is it the feeling that with another few minutes we can adjourn for the day? I am open to suggestions either way.

RADM MORGAN: We have really gotten down to argument. Shouldn't we stop?

RADM KNOLL: Is there anything we need to discuss?

RADM MORGAN: Condensers were mentioned.

CAPT (b) (6) : Condensers are just an item; you don't have a condenser developed for b(1) You don't have it in hand, do you?

CAPT (b) : You don't have one for 700 feet.

RADM MORGAN: I would like to know something about this.

CAPT (b) (6) : On the one on the NAUTILUS.

(b)(1)

RADM MORGAN: The NAUTILUS condenser was designed for b(1) feet, as you probably know. We were talking a little while ago about the hazards involved in going from 700 to b(1) feet. Actually the NAUTILUS in all its main power plant went further. We had 400 foot submarines. The machinery of that was designed for b(1) not 700, because between the first cast-up, before appropriated--but the machinery was in development, we were talking about b(1) The submarine people were giving us that push that Admiral Triebel said we needed. We checked the tubes with our factor of safety, and we said to take the next thickest tube. In the case of this condenser, it was multiplied by 13 sevenths, and the next tube taken. That wasn't our initial intent, in that direction, but it cost us a couple of tons of copper alloy.

CAPT (b) (6) : If you made a list, that would be one item on the list.

RADM MORGAN: Let's take a valve.

CAPT (b) (6) : What is going there is not that same NAUTILUS condenser; it is a new one.

RADM MORGAN: What about valves, bolts, flanges? The developmental item is to increase the pressure depth.

CAPT (b) (6) : That is right.

RADM HONSINGER: Thousands and thousands of items have to be redesigned and re-engineered; that is not development.

CAPT (b) (6) : In a hundred items that have to do with increased depth, if five aren't solved--which I have no doubt they will be--then you don't go deep.

RADM MORGAN: Until we solve them; then we fix them and are in business.

CAPT (b) (6) : That was my point--not that they wouldn't be solved. If BUSHIPS turns its mind to make the ship go deeper, I have faith that everything will work, but it will take time.

UNCLASSIFIED

RADM HONSINGER: On the first day out, all the things may not work.

RADM DASPIT: There is nothing to keep you from going to 700 feet. You don't have to tie it up at the dock.

CAPT (b) (6) I: It sure hasn't gone to sea--

CAPT (b) .: I think we are beating this thing to death.

RADM KNOLL: I want to express my appreciation to everyone who came here. We want to maintain the reputation of a free exchange of ideas and free exchange of discussion. We are not trying to keep anybody from discussing this, as long as they would like. Other people have things to do and I hope to hear no charges that this was a whitewash or this kind of exercise. This was intended to bring facts to light with the people who are most interested. This will be documented and circulated to all the people who are attending here, and many others. If, in the course of further investigation, analysis, or exploratory affairs, we find a need for another meeting, it will be convened forthwith. There is only one reason we stay here, to end up with the best ships we can build, with the advice of the operating people and technical people, everybody in the Navy

So we will adjourn. If there is any rumor or anything that starts in the future, let us hear about it and we will try to do something about it.

Is there anything else? Captain (b) ., have you anything?

CAPT (b) .: No, sir, except to express SUBLANT's appreciation. I think this has been a healthy thing.

RADM KNOLL: Have you anything further?

CAPT (b) (6) I: No, sir; I would like to express my appreciation for getting a chance to speak so frankly.

(The meeting was adjourned at 1240 hours.)

UNCLASSIFIED

Exh 224-127

[Exhibit 225]

UNCLASSIFIED

DEPARTMENT OF THE NAVY
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.

DRAFT OF PRESENTATION ON

EFFECTS OF SHOCK ON

MACHINERY AND EQUIPMENT IN USS THRESHER (SSN 593) (U)

STRUCTURAL MECHANICS LABORATORY
SHIP PROTECTION DIVISION
TECHNICAL NOTE
SML 740-24

Technical notes are not formal Model Basin Reports.
Their distribution is restricted.

March 1963

S-F 013 1002
Task 1799

EXCLUDED FROM AUTOMATIC REGRADING
DOD DIR 5200.10 DOES NOT APPLY

EXHIBIT # 225

Encl (1) to DTMB ltr
Ser 0279 of 25 Mar 1963
630329-0157

PRNC-TMB-666a

UNCLASSIFIED

UNCLASSIFIED

INTRODUCTION

BACKGROUND

The incorporation of sufficient shock strength and reliability in vital equipment is a prerequisite to the safe and effective operation of ships and to the full exploitation of the potential capabilities of weapon systems. A program of shock trials is being conducted on operating submarines to improve the shock strength and reliability of equipment necessary for the operation and mission of the fleet. Underwater explosion shock tests have been conducted on five submarines: USS TROUT (SS 566), USS SKATE (SSN 578), USS BONEFISH (SS 582), USS SKIPJACK (SSN 585), and USS THRESHER (SSN 593). This presentation summarizes the major results of the most recent and most severe tests, those on USS THRESHER, the first of a new class of attack submarines.

OBJECTIVES

The tests on THRESHER had both immediate and long range goals. The immediate goals were: (1) evaluate the shock hardening measures based on the results of previous tests that were applied to equipment in THRESHER, (2) evaluate the shock performance of the novel noise reduction features incorporated in the ship, and (3) disclose and correct specific equipment weaknesses that were uncovered during the test.

UNCLASSIFIED

630329-0157 PRNC-GEN-175 (Rev. 12-55)

In order to provide a basis for improvements in THRESHER equipment during the post test shipyard availability, a report[1*] was immediately prepared and issued. A more comprehensive test report[2] has also been completed.

A primary long range goal was to secure quantitative data on which to base the development of more rational techniques for the design of efficient shock resistant equipment and more realistic shock specifications.

The shock tests on THRESHER disclosed many deficiencies which were caused by poor workmanship, installation errors, inadequate inspections, deviation from plans, inadequate maintenance and the use of unsuitable materials. These shortcomings seriouslylimited the combat capability and safety of the ship.

The purpose of this presentation is to show how a modern submarine can be made more effective and safer under enemy attack. Examples of the actual occurrence of damage will be shown with high speed motion pictures and illustrated by numerous slides. Means are presented by which potential failures may be avoided.

* References are given on page 26.

TEST SET-UP

TEST METHOD

The THRESHER tests were conducted with the ship underway and submerged at periscope depth. A water depth of about 275 ft was chosen to provide sufficient depth for the test and to permit salvage in an emergency. The charge containing (b)(1) lb HBX-1 was suspended, as shown in Figure 1, from a pontoon which is tethered to the ATF which rigged it. A "range line" was attached between the pontoon and the closer of two flag buoys. The flag buoys were joined by a light line. Tension was maintained on the array by a work boat as shown. For the test, THRESHER submerged and ran a course which took her between the flags on a course perpendicular to the range line. When the submarine was in test position, the count down was given and the charge was fired from the ATF on command from the submarine. The actual range and orientation of the ship relative to the charge was precisely determined after the test from recordings of the time of detonation of the charge and its arrival at the hull.

ATTACK CONDITIONS

The measured ranges for the THRESHER test are tabulated in Figure 2. The tests were made progressively more severe by decreasing the distance from the ship to the charge from (b)(1) ft. A (b)(1) lb charge was necessary to obtain the desired test severity

and at the same time maintain a large test standoff. With the (b)(1) lb charge of HBX-1, the range for the most severe test, (b)(1) ft, is the smallest which will provide an essentially uniform shock loading (± 10%) over the length of the submarine. In addition, the standoff was needed to simplify ship handling.

The equivalent ranges from a depth charge and from a (b)(1) kiloton nuclear explosion to produce the same maximum test severity in terms of bulkhead velocities are also given in Figure 2. The most severe test on THRESHER corresponds roughly to the detonation of a (b)(1) lb depth charge at a distance of (b)(1) ft, or of a (b)(1) kiloton weapon at a distance of about (b)(1) ft.

NOVEL STRUCTURAL ARRANGEMENTS

A primary reason for shock testing THRESHER was to evaluate new types of equipment, new designs, and the b(1)

These are described below.

ENGINE ROOM ARRANGEMENT

Figure 3 is a schematic cross section of the engine room showing the propulsion turbine platform b(1)

b(1)

"COCOON" ARRANGEMENT

To isolate the control and living spaces from the ship's sonar radiation, the entire midship compartment in THRESHER is b(1)

as a unit (the cocoon) from the pressure hull; see Figure 4. These (b)(1) also were expected to protect equipment and personnel from shock. High-speed motion-pictures were taken of one of the b(1)

supporting the cocoon structure.

Selected documentary scenes are also contained in the movie showing the conduct of the test as seen on the surface, and the reaction of personnel aboard the submarine during the test.

PRESENTATION OF MOVIE

(The movie[3] on the THRESHER tests should be presented at this point. Running time is about 6 min.)

SHOCK TEST INSTRUMENTATION

To provide a basis for understanding the shock environment and the response of equipment, THRESHER was extensively instrumented with 139 gages consisting of velocity meters, accelerometers and strain gages as well as 24 monitoring circuits and 7 high speed cameras. The distribution of instruments throughout THRESHER is shown in Figure 5. In addition the instrumentation served as a necessary control for the test. A signal

was telemetered from the charge at the instant of detonation to THRESHER and recorded with data from pickups on THRESHER. With these data, the location of THRESHER relative to the charge was determined by triangulation.

TEST RESULTS AND DISCUSSION

An important instrumental result was the measurement of the effectiveness and limitation of the b(1)

and the "cocoon".

The shock velocities on either side of the b(1)

are shown as a function of time in Figure 6. The lower curve shows the abrupt motion produced in the turbine foundation b(1) The upper curve shows the b(1)

During the most severe test, the peak athwartship velocity was reduced by a factor of b(1) and the peak acceleration, measured by the slope of the velocity-time curve, was reduced by a factor of b(1)

SHOCK LEVELS AT VARIOUS LOCATIONS

The levels of shock severity produced at various locations on THRESHER are compared in Figure 7. The graph shows that the peak shock velocity on the turbine foundation was b(1) that measured on the hull. The peak velocity seen by the b(1) propulsion turbine was b(1) that on the foundations.

A comparison was made of THRESHER data with similar measurements on SKIPJACK. The comparison shows the large reduction in shock motion applied to b(1) turbines in THRESHER equipment compared to that applied to the b(1) turbines in SKIPJACK. It is noteworthy that some misalignment between the propulsion turbines and reduction gear occurred in SKIPJACK.

A comparison of the two bars on the right hand side of Figure 7 gives a measure of the effectiveness of the b(1) They show that the peak horizontal velocity of the "cocoon" was reduced to b(1) that of the b(1) , b(1)

DAMAGE TO EQUIPMENT

After each shot, a careful evaluation was made of the instrumental data obtained to determine the severity of attack and the response of equipment to the shock motion. Concurrently, a careful and comprehensive inspection of all ship's equipment was made. The primary purpose of the inspection was to document equipment shock damage. For each item of damage a special report form was filled out. This form was designed to permit rapid handling and analysis of detailed damage data. A LARC computer at the David Taylor Model Basin is used for this purpose.

An average of 100 casualty reports were submitted by the crew after each shot. While the damage to the majority of items reported was minor, the cumulative effect was to produce confusion and seriously hamper the safe and effective operation of the ship.

In spite of an effective and highly successful shock hardening and policing effort prior to the tests, significant casualties occurred in every shot. In the following the most significant casualties are described for each shot.

SIGNIFICANT DAMAGE IN SHOT 1

The more important casualties which occurred during Shot 1, the least severe shot, and the resulting operational effects are given in Figure 8. For this shot the charge range was about (b)(1) times greater than that necessary to cause hull collapse.

Failure of Silver-Brazed Pipe Joint

The ship was surfaced when flooding of the forward room was reported. In addition, the main hydraulic system lost pressure. These effects were due to the same casualty, a silver-brazed joint in the hydraulic line which failed.

The actual break between the nipple and the pipe in the hydraulic line is shown in Figure 9. This was one of about 29 similar casualties to silver-brazed joints which occurred throughout the ship during the test. It was particularly significant in this case, not only because it caused an erroneous report of flooding and loss of use of the main hydraulic system, but in addition, the hydraulic fluid which sprayed out seriously damaged sonar cables which will have to be replaced.

b(1)

b(3) AEA

Reduced Accuracy of SINS

The accuracy of the SINS was greatly reduced by a shift in the drift rate of the gyros. The ship had no way to compensate for the shift in drift rate. The suspension of the SINS equipment after Shot 1 is shown in Figure 11. The SINS equipment is mounted rigidly to the overhead through frangible pins. The pins are designed so that under a specified shock loading the pins will fail and protect the equipment by dropping the SINS equipment onto rubber mountings. The pins sheared during the test. This however, did not prevent a change in the drift rate

for the gyrocompasses that greatly reduced the accuracy of the SINS equipment.

Main Shaft Vibration Reducer Sensing Element Misaligned

Finally, on the first shot, the radiated noise level increased when the ship vibration reducer malfunctioned. This malfunction was due to the shift of a sensing device due to the loosening of bolts, as shown in Figure 12.

SIGNIFICANT DAMAGE IN SHOT 2

The more important casualties which occurred during Shot 2 are given in Figure 13.

Loss of Normal Control of Planes and Rudders

The ship lost normal control of planes and rudders when feedback syncros shifted due to inadequate support and a switch malfunctioned causing failure of hydraulic pumps.

Increased Self Noise

The self-noise of the ship increased when deck lockers opened, hinges on these deck lockers were broken. Typical deck locker hinges are shown in Figure 14. The broken hinges shown here have been temporarily repaired. In addition, the latches for these lockers proved to be unsatisfactory during the test. Open lockers disturbed the fair surface of the ship and thus increased self-noise. Self-noise further increased when the fairing over the ECM antenna was lost in a later test.

Weapon Fire Control System Capability Reduced

The weapon fire control system Mark 113 capability was seriously reduced. It was found that debris had settled on the perforated program tape of the memory unit. It is striking that it took the ship and the equipment technical representative 20 hours to uncover this casualty.

Damage to Gages

Safe and efficient operation of the ship was compromised when the many indicators and gages were disabled or made erroneous in their readings. Figure 15 shows various types of casualties in the (b)(1) . Some gages came completely adrift, some gages gave wrong indications due to changes in linkage adjustments, and some gages were completely inoperable.

b(1)

Where new gages, designed as a result of previous experience, were installed there were no casualties. All of the casualties were to the existing ship's gages.

SIGNIFICANT DAMAGE IN SHOT 3

The more important equipment casualties which occurred during Shot 3 are tabulated in Figure 17.

Radar Mast Damage

The ship's speed was limited when the radar mast raised to the fully extended position and jumped its track. This casualty was due to the actuation of the raising mechanism by shock and the failure of the shoe of the radar mast to stay in its track. The mast was retracted by rigging a chain fall. If the ship had been operating at higher speed, the mast would have bent. The shoe on the radar mast out of its track is shown in Figure 18.

Loss of b(3) 10 US Power

The SINS and gyro repeaters were disabled when one b(3) 10 USC bus grounded and power to these units had to be secured. A bolt in one of the connection boxes cut through insulation grounding one bus. The SINS equipment had to be cut off from the line.

Not true! ground in one phase does not require system or equipment be de-energized

660

Torpedo Firing Valves Malfunctioned

The ship was unable to impulse fire any torpedo tubes when both firing valves stuck in the open position. The valves had to be disassembled to repair.

Torpedo Tube Breech Door Disabled

The ship was unable to open one torpedo tube breech door when door latch release pins sheared and were dislodged. The breech door of one of the torpedo tubes after the hinge pins were expelled is shown in Figure 19. The high-speed motion-pictures showed these pins working loose and falling from their seats.

Loss of Depth Control

Prior to Shot 4 the ship lost depth control. This casualty occurred when an "O" ring blew out of the stern plane hydraulic control line. As a result the planes went to the full-dive position. The ship had just gone from high-speed operation down to a speed of about 6 knots. If the ship had been operating at high speed when casualty occurred, the results might have been very serious. The casualty points up the need for a safe arrangement. For example, if the tolerances around the "O" ring were small the rate of release of hydraulic fluid after failures of the ring might have been tolerable.

SIGNIFICANT DAMAGE IN SHOT 4

The more important equipment casualties which occurred during Shot 4 are given in Figure 20.

Loss of All b(3) 10 US Power

The gyrocompasses, SINS, and most of the sonar equipment was disabled, when all b(3) 10 USC power was lost in the ship. This loss was due to the opening of a silver-soldered electrical connection.

Loss of Ship's 60 cps Power

60% of the ship's electric power was lost. Under normal conditions this would have caused b(1) The

FRRC-GEN-175 (Rev. 12-55)

loss of electric power resulted from b(1)

Loss of IFF capability

The interrogation and identification capability of the ship was disabled when the identification friend or foe system was disabled by an electrical plug connection that fell out. In earlier tests there were many malfunctions due to poor or improperly fastened connectors. In THRESHER the problem was minimized by actually tieing connectors in place. The casualty demonstrates the need for connectors which can be and are locked in place.

Failure of Torpedo Handling Skids and Tracks

The torpedo delivery capability was permanently reduced as a result of numerous casualties to torpedo handling and firing equipment. These casualties were in general beyond the capability of the ship's force to restore.

A broken aluminum torpedo skid casting is shown in Figure 21. Because of the failure the skid and torpedo were not secured in the ship. In floating shock platform tests on similar skids, conducted prior to these tests, similar failures occurred.

A broken torpedo portable track which was necessary for transferring torpedoes across the torpedo room is shown in Figure 22. Again cast aluminum is demonstrated to be unsuitable for use in submarines.

SIGNIFICANT DAMAGE IN SHOT 5

The more important equipment casualties which occurred during Shot 5 are given in Figure 23.

Loss of All b(3) 10 U Power

The gyrocompasses, SINS, and most sonar equipment were disabled when b(3) 10 USC 130 MG sets tripped off the line and all b(3) 10 USC power was lost.

Temporary Loss of Propulsion

Propulsion had to be secured when a silver-brazed joint in the lube oil line to the main shaft failed.

Flooding from Sea

Flooding from the sea occurred when another silver-brazed joint in a non-isolatable 1/4 inch line open to the sea failed. A damage control plug was driven into the open pipe as shown in Figure 24. However, this damage control measure would not have been possible if the ship had been at or near operating depth. Note that this silver-brazed joint was carrying the weight of a rather heavy valve. The weight of the valve should have been supported from the ships structure rather than from the silver-brazed joint.

Loss of Torpedo Fire Control Capability

Torpedo fire control capability was lost when a short circuit in the fire control switchboard occurred. The ship's force required 5 hours to restore this capability.

Valve Linkages Disabled

b(1)

This type of casualty also occurred during the last shot.

Damage to Electronic Equipment

The ship was unable to transmit on long range ship-to-shore frequencies, when both the WRT and the TBL transmitters were disabled. The type of failure that occurred in one transmitter is shown in Figure 26. There were in addition to the normal (b)(1) supporting sub-assemblies. With this redundant system (b)(1) some of the internal components moved through large relative displacements. For example, the meter in the front panel of this transmitter was

driven completely out of the panel by the impact from a (b)(1) chassis. One of the redundant (b)(1) that led to this casualty is shown in Figure 27.

SIGNIFICANT DAMAGE IN SHOT 6

The more important equipment casualties which occurred during the most severe test are given in Figure 28. Shot 6 was detonated at a range about (b)(1) greater than necessary to cause hull collapse. The following operation effects occurred.

Failure of Threaded Joint

The ship was surfaced when a b(1) airline failed and the air bank bled down. The nipple which fractured is shown in Figure 29.

Stern Plane Indicators Disabled

Ship control was lost when both the normal and the emergency stern plane indicators were disabled. In addition a silver-brazed joint in the stern plane ram vent line also failed, disabling normal operation of the planes.

Loss of Electric Power

b(1)

Torpedo Firing Capability Lost

Torpedo firing capability was lost when numerous casualties to torpedo fire control and handling equipment occurred. After 15 minutes two tubes were available but with greatly reduced reload capability.

Failure of Flared Pipe Fittings

One of the failures of a flared pipe fitting is shown in Figure 30. The pipe was pulled loose. This casualty was the result of the weight of valves supported by the fittings.

Effect of Ballast Tank Damage

The radiated and selfnoise increased on this shot when the ballast tank plating became deformed as shown in Figure 31. The pencil shows a deformation of about 1-1/4 inches which occurred near the ballast tank top. b(1)

POTENTIALLY SERIOUS CASUALTIES

Each casualty which has been shown had an immediate effect on the operational capability or safety of the ship. In addition there were casualties which may have been serious under further shock.

Fractured Foundation

b(1)

Leak at PUFF's Hull Cavity

During the first deep dive after the last shot a slight salt water leak around the No. 2 PUFF's hydrophone cavity was detected. As a result the operating depth of the submarine was limited to 100 ft. Shipyard inspection revealed that the leak was due to a poor weld and a change from plans in the attachment of the hydrophone cavity to the pressure hull. As shown in Figure 33, the plans called for a double filet weld. This was changed during fabication to a single fillet weld. In addition, the first bead was poor and thus the weld leaked.

Bolts Made of Wrong Material

After the test it was found that bolts of the wrong material had been used to support all three hydraulic accumulators in the engine room.

The bolts were severely deformed in the test as seen in Figure 34. The material specified was a high strength alloy steel. The material used was actually mild steel.

PRE TEST SHOCK HARDENING

Significant failures occurred in THRESHER at all test levels. However, much of the equipment operated without malfunction or damage. This was due in part to the increasing awareness of the need for protection from shock and the pretest shock hardening. Many of the weaknesses that were disclosed by earlier shock tests on other submarines were corrected to at least the higher shock test levels on THRESHER. In the same way by correcting the weaknesses disclosed, THRESHER and other submarines will be made more shock resistant.

A summary of the most significant items shock hardened before the tests is shown in Figure 35.

Electrical

As a result of many malfunctions in previous tests, the type ACB main line circuit breakers in THRESHER were modified and some were tested on a standard Navy HI shock test machine. There were no malfunctions on THRESHER of this type of circuit-breaker by shock actuation of the breaker.

Mechanical

b(1)

The main propulsion clutch malfunctioned on SKATE and SKIPJACK. A modification to prevent the casualty was made in THRESHER. The modified clutch operated successfully.

The shock strength of various machinery and equipment foundations were checked by calculations, where necessary modifications were made. The tests demonstrated that the modifications were generally necessary.

Of the sample of 100 silver-brazed joints inspected by the ultrasonic technique and repaired where faulty joints were detected, there were no casualties. On the other hand there were 29 failures among the uninspected joints.

Electronic

The comparatively small number of failures in electronic equipment was due in part to the removal of redundant shock mounts from equipments

In addition, missing hold down bolts and component clamps were installed, connecting plugs were fastened in place, sufficient slack in connecting cables was supplied and mechanical short circuits of shock-mounted equipment were removed.

Control

There were no casualties among the sample groups of 50 shock-proof type gages installed prior to the tests.

Miscellaneous

Many casualties were avoided by a directed policing effort in which loose or improperly fastened items were better stowed by the ship company. However, despite an intense effort some faults escaped detection. For example, the lubricating oil purifier was found out of alignment with its pump after Shot 6. It was found that the bolts supporting the motor from the purifier had been omitted some time prior to the test, as shown in Figure 36.

Greater Shock Resistance of THRESHER

With these and other improvements THRESHER was able to make repairs and remain maneuverable after more severe shocks than those applied to the previous ships tested. A measure of the greater shock strength of THRESHER is shown in Figure 37. It shows the maximum shock load applied to each of the three nuclear and two diesel submarines tested in this program.

The maximum shock severity applied has been progressively increased from a shock factor of b(1) to a shock factor of b(1) Improvements made in equipment strength and reliability have permitted each successive nuclear submarine to be tested to a greater shock load. Even at the higher shock loads on THRESHER, primary power capability was less effected than on SKATE or SKIPJACK. b(1)

It should be noted however that on all ships tested, b(1)

PROBLEM AREAS

The main problem areas revealed by the tests are listed in Figure 38. They are:

1. Torpedo Handling Equipment.

   To quote the CO of THRESHER "Simply too flimsy."

2. Planes-Rudder Controls.

   These are not sufficiently reliable. Casualties resulted from failures of indicating and control elements, in piping, hydraulic systems and "O" ring seals.

3. Pipe Joints.

   Silver-brazed fittings, "O" rings, threaded joints, and flared joints all gave trouble, particularly when used to support fittings and valves.

b(1)

5. Electric Power Systems.

   Casualties to the electric power system seriously reduced the available 60 and b(3) 10 USC power.

6. MK 113 Underwater Fire Control System

   Deficiencies seriously reduced the offensive capability of the ship.

7. Indicators and Alarm Circuits

   Safe and orderly operation of the ship was compromised by inoperative and erroneous indicators.

8. Radar Mast

9. Deck Hatches, Lockers and Tank Plating.

   Deck access covers should be strengthened. b(1)

CONCLUSIONS

The tests showed, Figure 39, that THRESHER is more shock resistant than any submarine previously tested.

a. THRESHER was able to maneuver after tests of greater shock severity than those which disabled previous nuclear submarines.

b. Pretest shock hardening techniques greatly reduced the number and significance of equipment casualties.

c. The b(1)

, reduced the shock loads transmitted to equipment, and minimized damage at the THRESHER test levels.

In general the improvement in reliability was due primarily to:

a. Greater attention to shock requirements.

b. b(1)

c. Effective pretest shock hardening.

d. Careful policing by ships force.

The combat capability of a modern submarine is still limited by the shock sensitivity of vital equipment.

b(1)

The tests point up the necessity for continuous attention to shock requirements in the installation, maintenance, and operation as well as in the design, fabrication, and testing of equipment.

Almost all deficiencies were the result of the following:

a. Poor workmanship

b. Installation errors

c. Inadequate inspection

d. Deviation from plans

e. The use of brittle materials

f. Inadequate mechanical design

g. Inadequate maintenance

h. The use of shock sensitive components for which shock-hardened items now available.

REFERENCES

1. (b) (6) and (b) (6), "Shock-Noise Tests on USS THRESHER (SSN 593) Preliminary Report of Shock Tests," David Taylor Model Basin Report C-1445 (July 1962) CONFIDENTIAL - RESTRICTED DATA.
2. (b) (6) and (b) (6), "Shock-Noise Tests on USS THRESHER (SSN 593) Final Report of Shock-Tests," David Taylor Model Basin Report C-1565 (to be published) CONFIDENTIAL - RESTRICTED DATA.
3. DTMB Movie M 2063 "USS THRESHER (SSN 593) Shock Tests," CONFIDENTIAL.

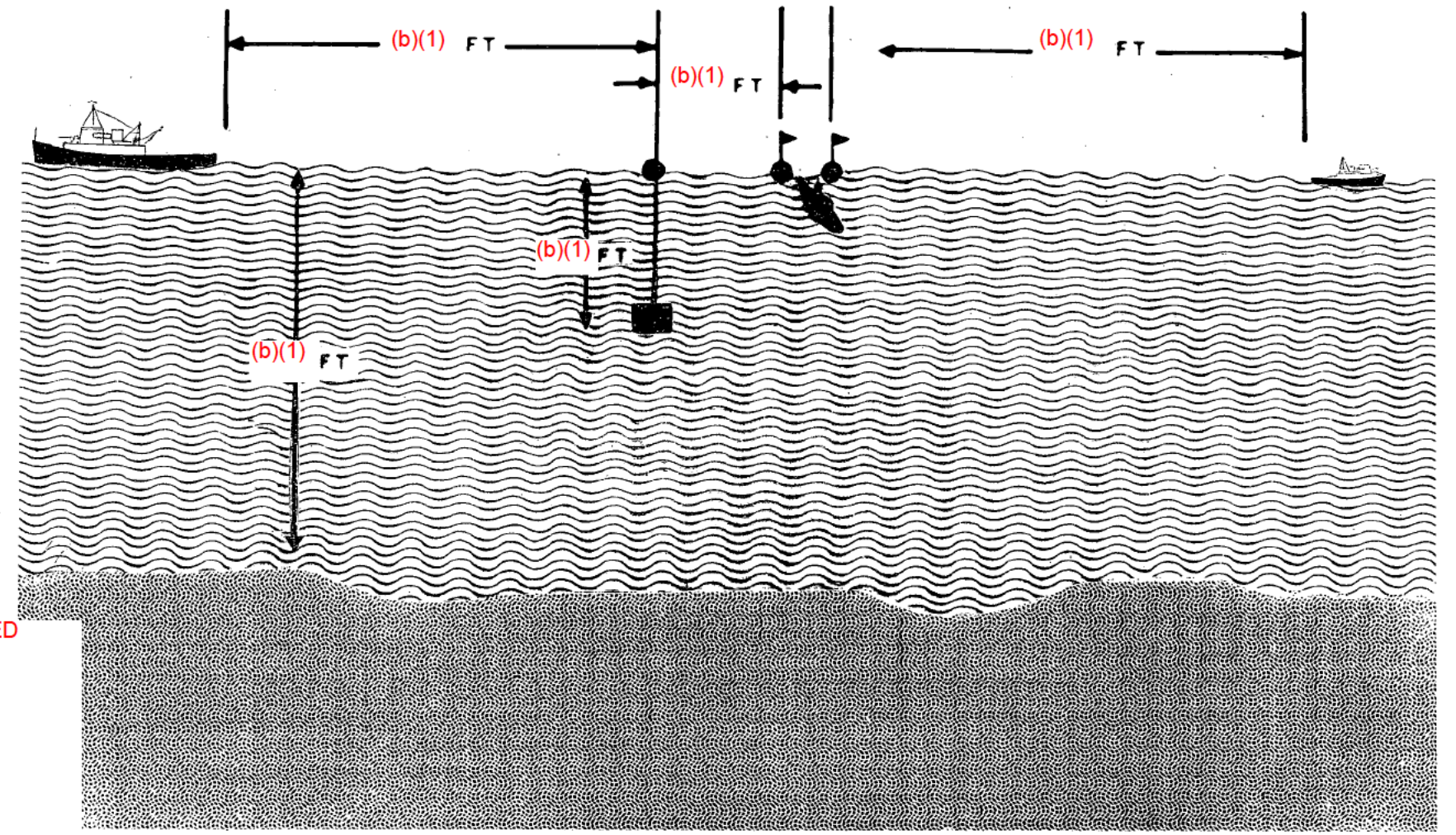
(b) (6)

Prepared by_____
Head, Submarine Shock Section, Shock Branch

(b) (6)

Head, Shock Branch

UNCLASSIFIED



UNCLASSIFIED

FIGURE 1 METHOD FOR CONDUCTING SHOCK TESTS ON OPERATING SUBMARINES

UNCLASSIFIED

ATTACK CONDITIONS

SHOT NO.	TEST STANDOFF FEET	EQUIVALENT STANDOFF FEET
1	(b)(1)	
2		
3		
4		
5		
6		

UNCLASSIFIED

FIGURE 2 ATTACK CONDITIONS

UNCLASSIFIED

b(3) 10 USC 130

UNCLASSIFIED

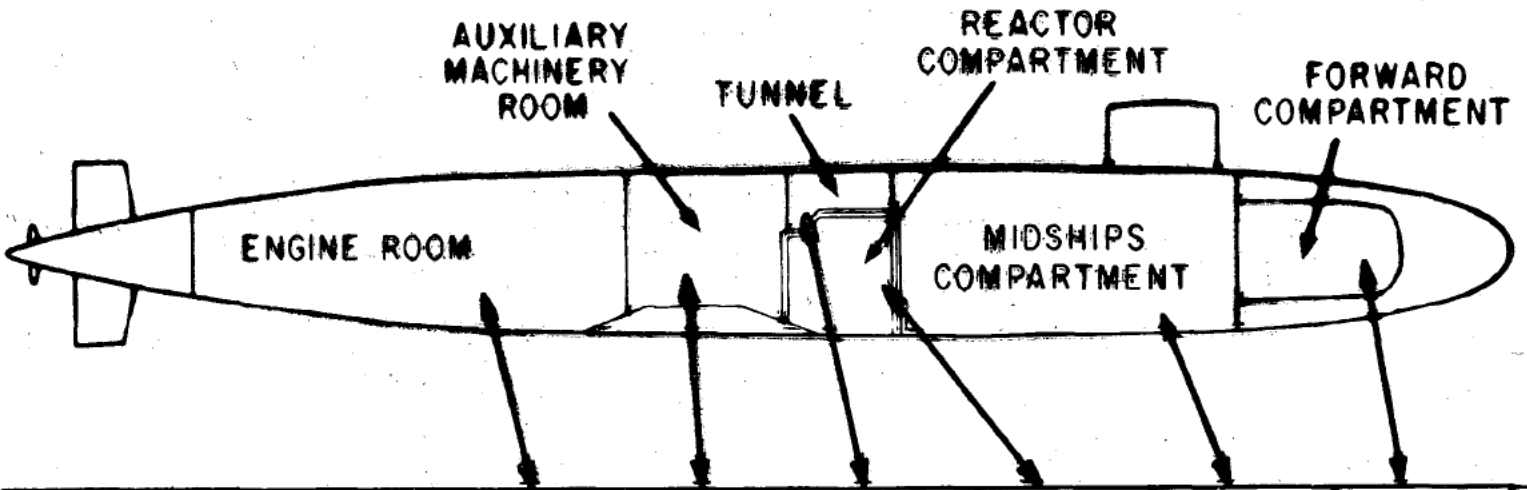
FIGURE 3 SCHEMATIC CROSS SECTION OF ENGINE ROOM

(b)(1)

FIGURE 4 SCHEMATIC CROSS SECTION SHOWING b(1) IN THE MIDSHIP'S COMPARTMENT

UNCLASSIFIED

SHOCK TEST INSTRUMENTATION



							TOTAL
VELOCITY METERS	17	10		3	16	5	51
ACCELEROMETERS	23	6	2	36	5		72
STRAIN GAGES	5			11			16
VOLTAGE MONITORING	5	6		13			24
HIGH-SPEED MOTION PICTURE CAMERAS	4				3		7

UNCLASSIFIED

FIGURE 5 SHOCK TEST INSTRUMENTATION

b(1)

UNCLASSIFIED

UNCLASSIFIED

b(1)

UNCLASSIFIED

SHOT 1

OPERATIONAL EFFECT	CASUALTY
1 SHIP SURFACED WHEN FLOODING OF FORWARD ROOM WAS REPORTED	SILVER BRAZED JOINT IN HYDRAULIC LINE FAILED
2. MAIN HYDRAULIC SYSTEM LOST PRESSURE.	
5. SINS ACCURACY REDUCED.	◆ DRIFT RATE OF GYROS SHIFTED. SHIP UNABLE TO CORRECT
6. RADIATED NOISE LEVEL INCREASED.	◆ SHAFT VIBRATION REDUCER MALFUNCTIONED.

◆ REPETITIVE CASUALTIES

FIGURE 8 SIGNIFICANT DAMAGE SHOT 1

UNCLASSIFIED

UNCLASSIFIED

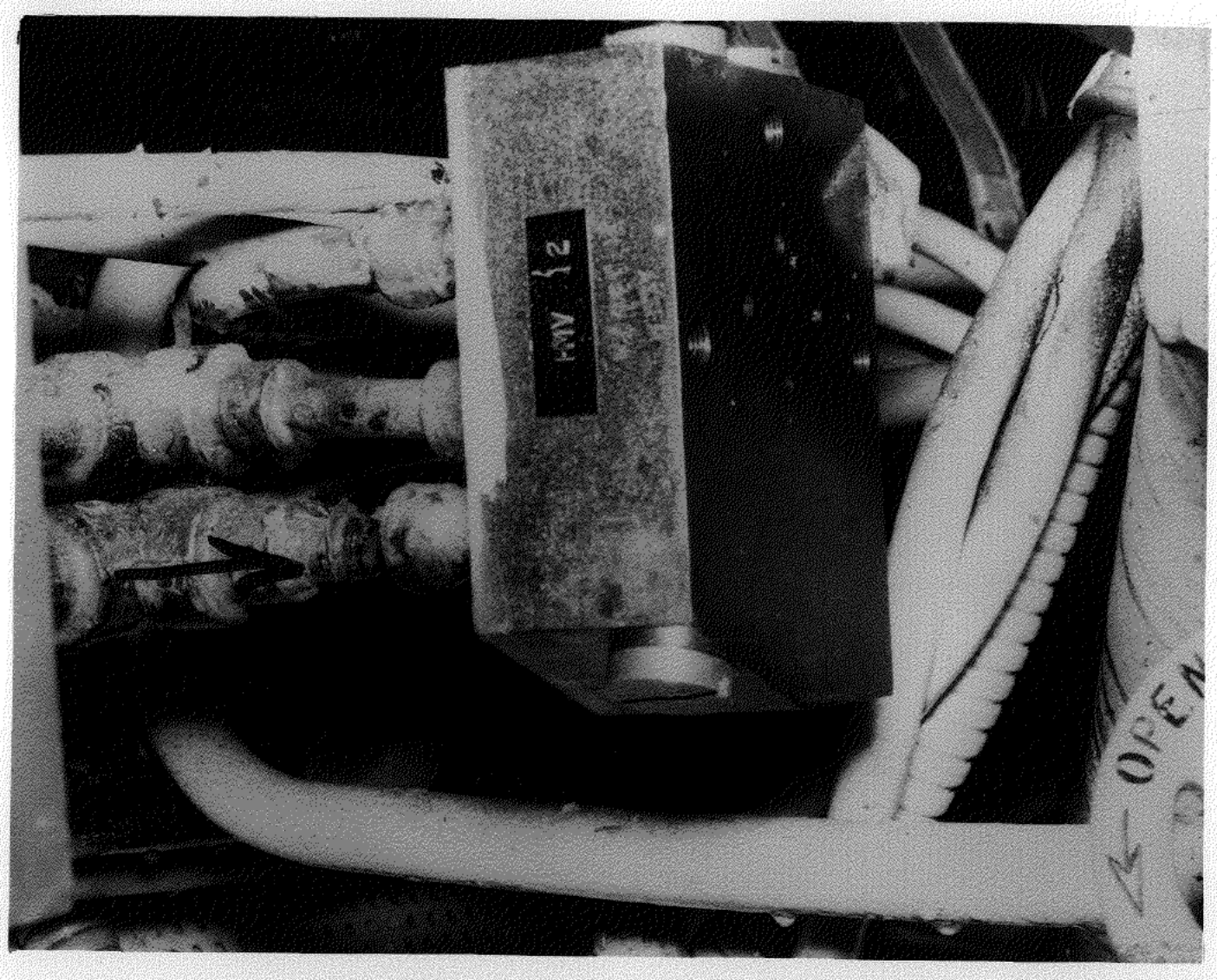


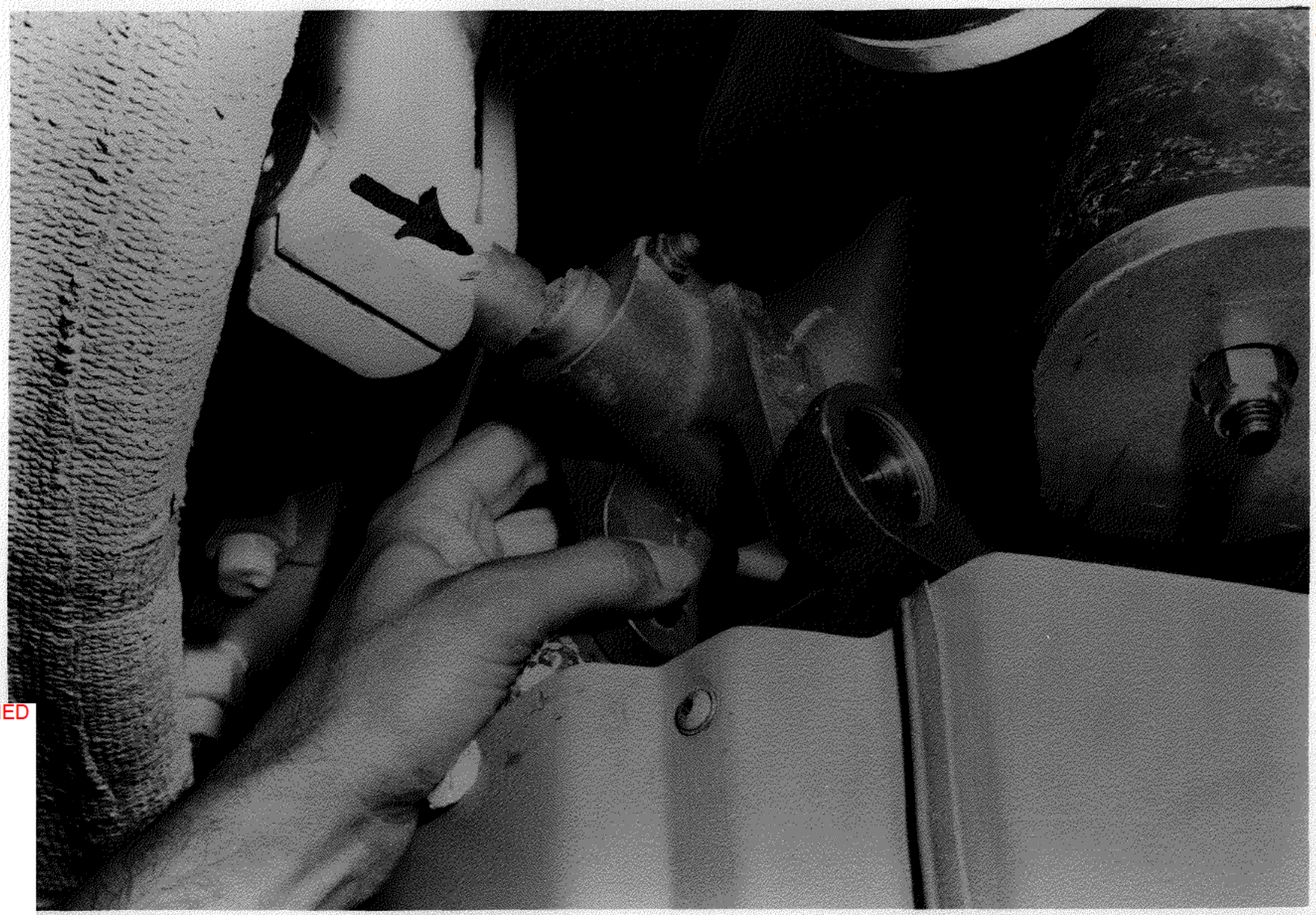
FIGURE 9 FAILURE OF SILVER-BRAZED PIPE JOINT

PSD 307910

UNCLASSIFIED

b(3) 10 USC 130

UNCLASSIFIED



UNCLAS
SIFIED

FIGURE 11 FRACTURED FRANGIBLE PIN IN SINS SUSPENSION

PSD 307901

UNCLASSIFIED

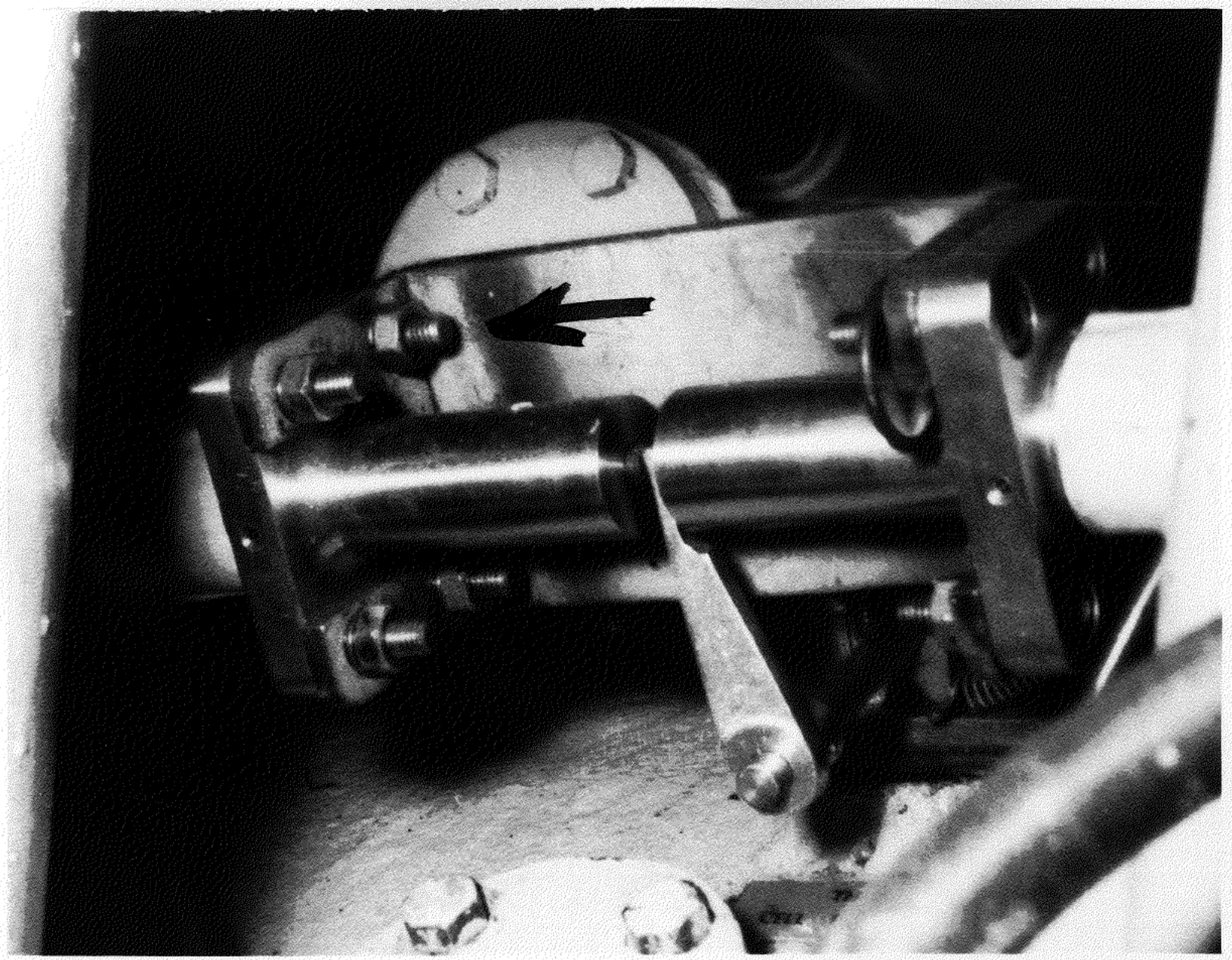


FIGURE 12 MAIN SHAFT VIBRATION REDUCER SENSING ELEMENT MISALIGNED

PSD 308408

UNCLASSIFIED

UNCLASSIFIED

SHOT 2

OPERATIONAL EFFECT

1. LOST NORMAL CONTROL OF PLANES AND RUDDER
2. SELF NOISE INCREASED
3. MK 113 WEAPON FIRE CONTROL CAPABILITY SERIOUSLY REDUCED
4. SAFE AND EFFICIENT OPERATION OF SHIP COMPROMISED

CASUALTY

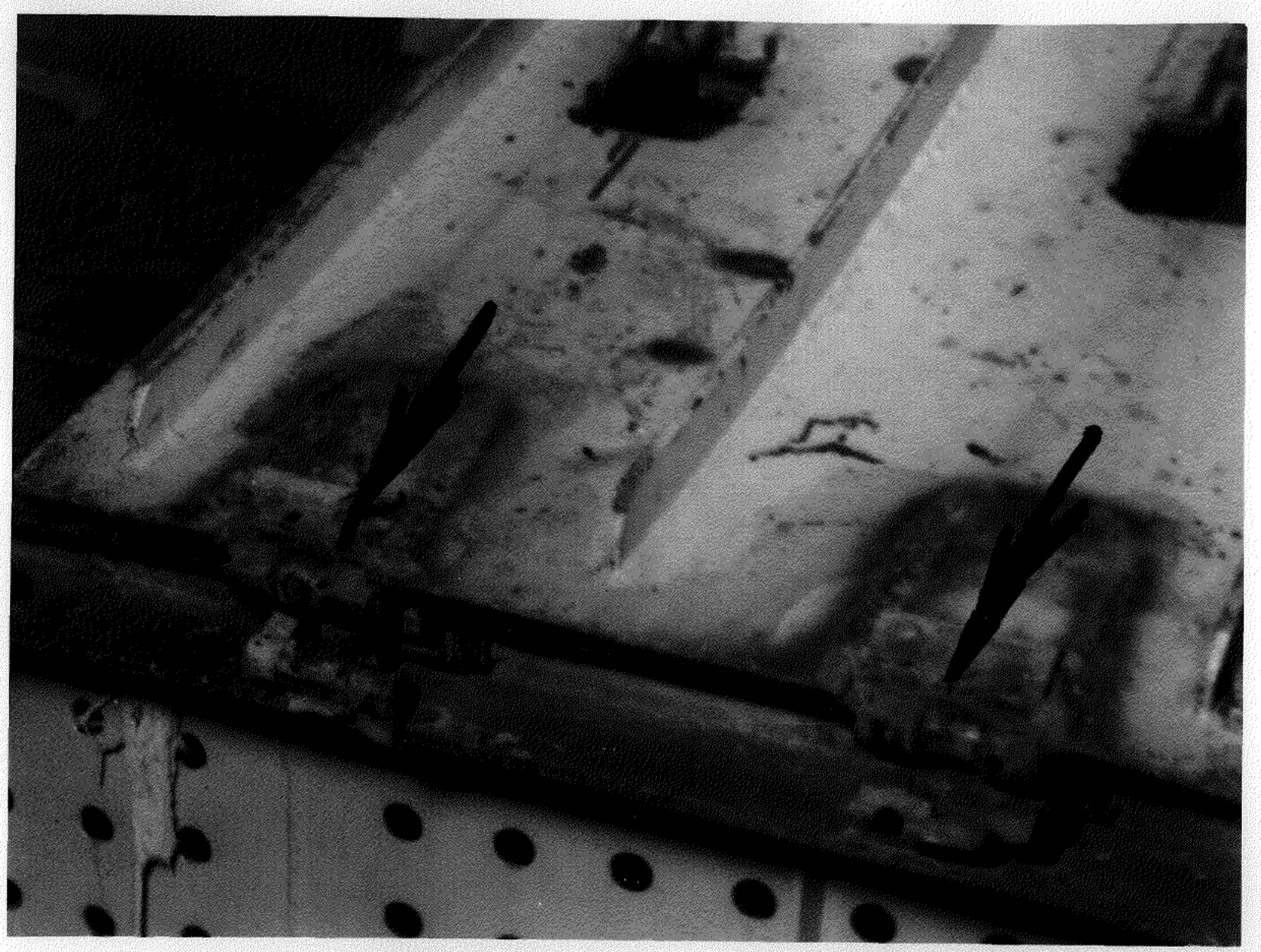
- FEEDBACK SYNCHROS SHIFTED. SWITCH MALFUNCTION CAUSED LOSS OF HYDRAULIC PUMPS.
- DECK LOCKERS OPENED. HINGES BROKEN.

  DEBRIS SETTLED ON PERFORATED PROGAM TAPE OF MEMORY UNIT. SHIP AND TECHNICAL REPRESENTATIVES UNCOVERED CASUALTIES IN 20 HOURS.
- MANY INDICATORS DISABLED, INACCURATE OR ERRONEOUS.

UNCLASSIFIED

FIGURE 13 SIGNIFICANT DAMAGE SHOT 2

UNCLASSIFIED



PSD 308405

FIGURE 14 BROKEN HINGES ON DECK LOCKERS

UNCLASSIFIED

b(1)

b(1)

UNCLASSIFIED

SHOT 3

OPERATIONAL EFFECT

1. SHIP SPEED LIMITED.

2. SINS AND GYRO REPEATERS DISABLED

3. UNABLE TO IMPULSE FIRE ANY TORPEDO TUBES.

4. UNABLE TO OPEN ONE TORPEDO TUBE BREECH DOOR.

UNCLASSIFIED

TH CONTROL LOST PRIOR TO SHOT 4.

CASUALTY

- RADAR MAST RAISED TO THE FULLY EXTENDED POSITION AND JUMPED TRACK.

ONE 400 CYCLE BUS GROUNDED (BOLT CUT INSULATION.)

BOTH FIRING VALVES STUCK IN OPEN POSITION

- DOOR LATCH RELEASE PINS SHEARED

"O" RING BLEW OUT OF STERN PLANE HYDRAULIC CONTROL LINE. PLANES WENT TO FULL DIVE POSITION

FIGURE 17 SIGNIFICANT DAMAGE SHOT 3

UNCLASSIFIED

FIGURE 18 RADAR MAST DISPLACED FROM TRACK

PSD 307928

UNCLASSIFIED

UNCLASSIFIED

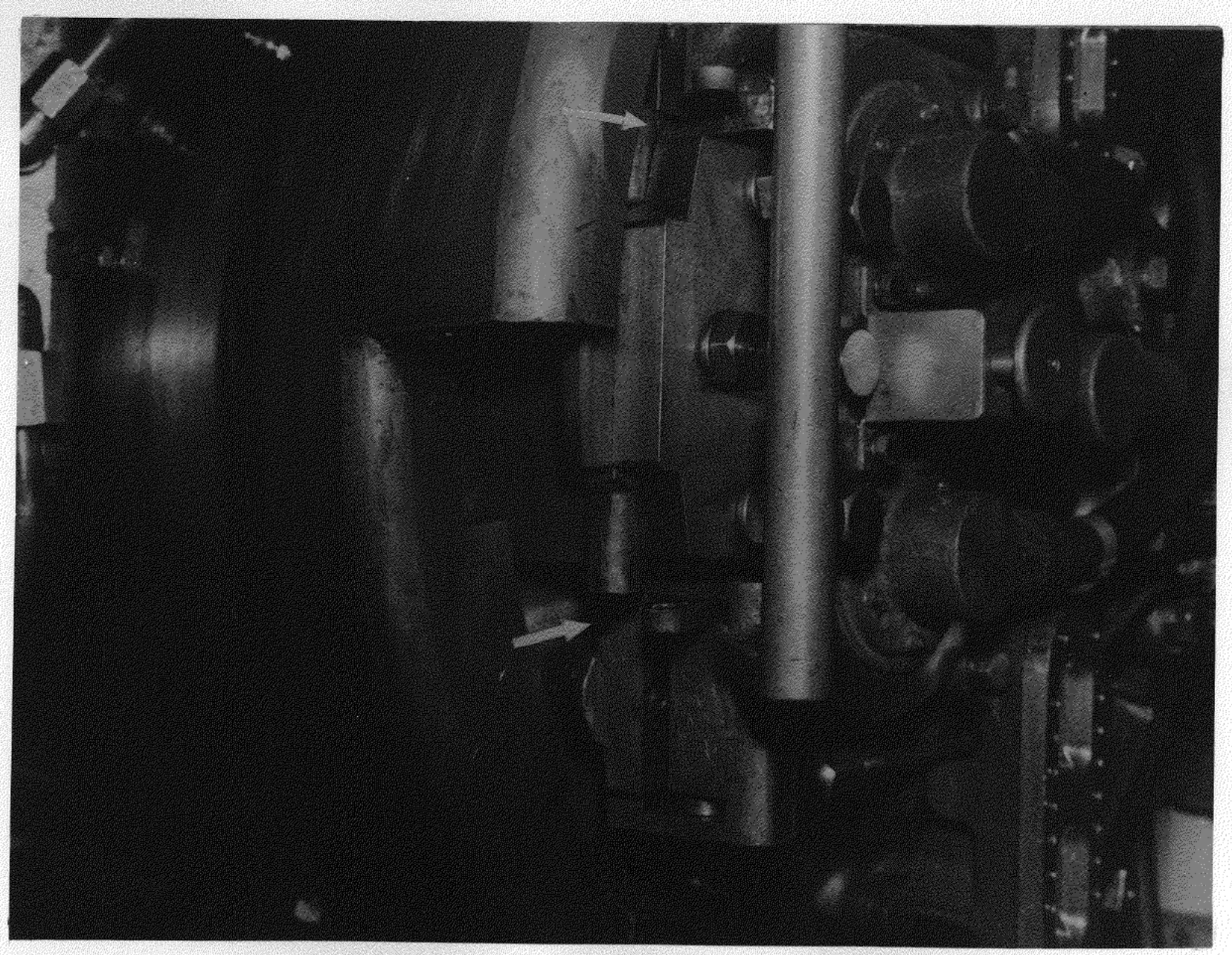


FIGURE 19 BROKEN PINS IN TORPEDO TUBE BREECH DOOR

PSD 307973

UNCLASSIFIED

UNCLASSIFIED

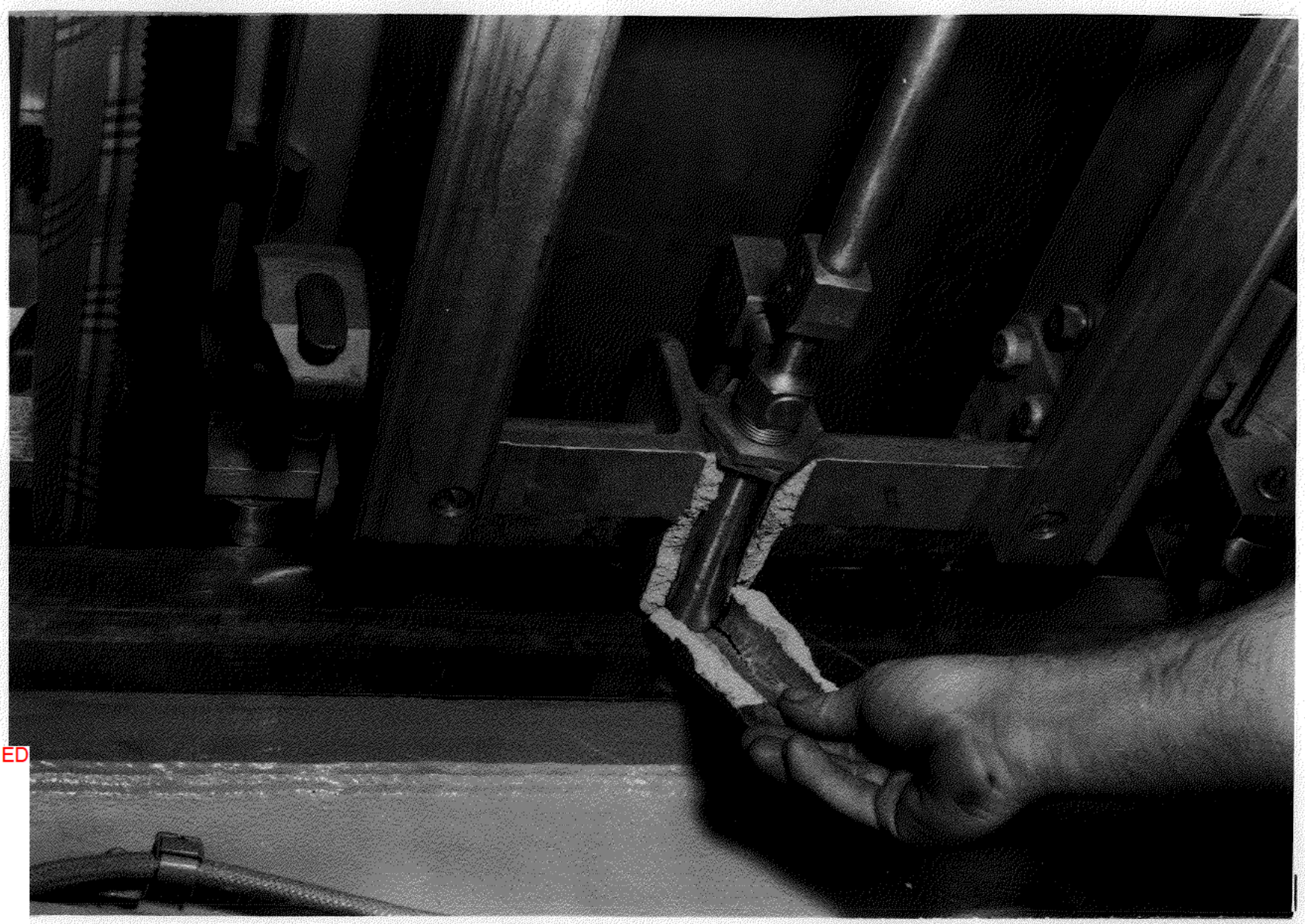
SHOT 4

OPERATIONAL EFFECT	CASUALTY
1. GYROCOMPASSES, SINS AND MOST SONAR EQUIPMENT DISABLED.	SILVER-SOLDERED ELECTRICA CONNECTION OPENED. 400 CPS POWER LOST.
3. INTERROGATION AND IDENTIFICATION CAPABILITY LOST.	IFF SYSTEM DISABLED BY LOOSE PLUG.
1. TORPEDO DELIVERY CAPABILITY PERMANENTLY REDUCED.	NUMEROUS CASUALTIES TO TORPEDO HANDLING AND FIRING EQUIPMENT BEYOND CAPABILITY OF SHIP'S FORCE TO RESTORE.

UNCLASSIFIED

FIGURE 20 SIGNIFICANT DAMAGE SHOT 4

UNCLASSIFIED



UNCLASSIFIED

PSD 307940 FIGURE 21 CAST ALUMINUM TORPEDO SKID FAILURE

UNCLASSIFIED

PSD 307931

FIGURE 22 CAST ALUMINUM TORPEDO PORTABLE TRACK FAILURE

UNCLASSIFIED

UNCLASSIFIED

SHOT 5

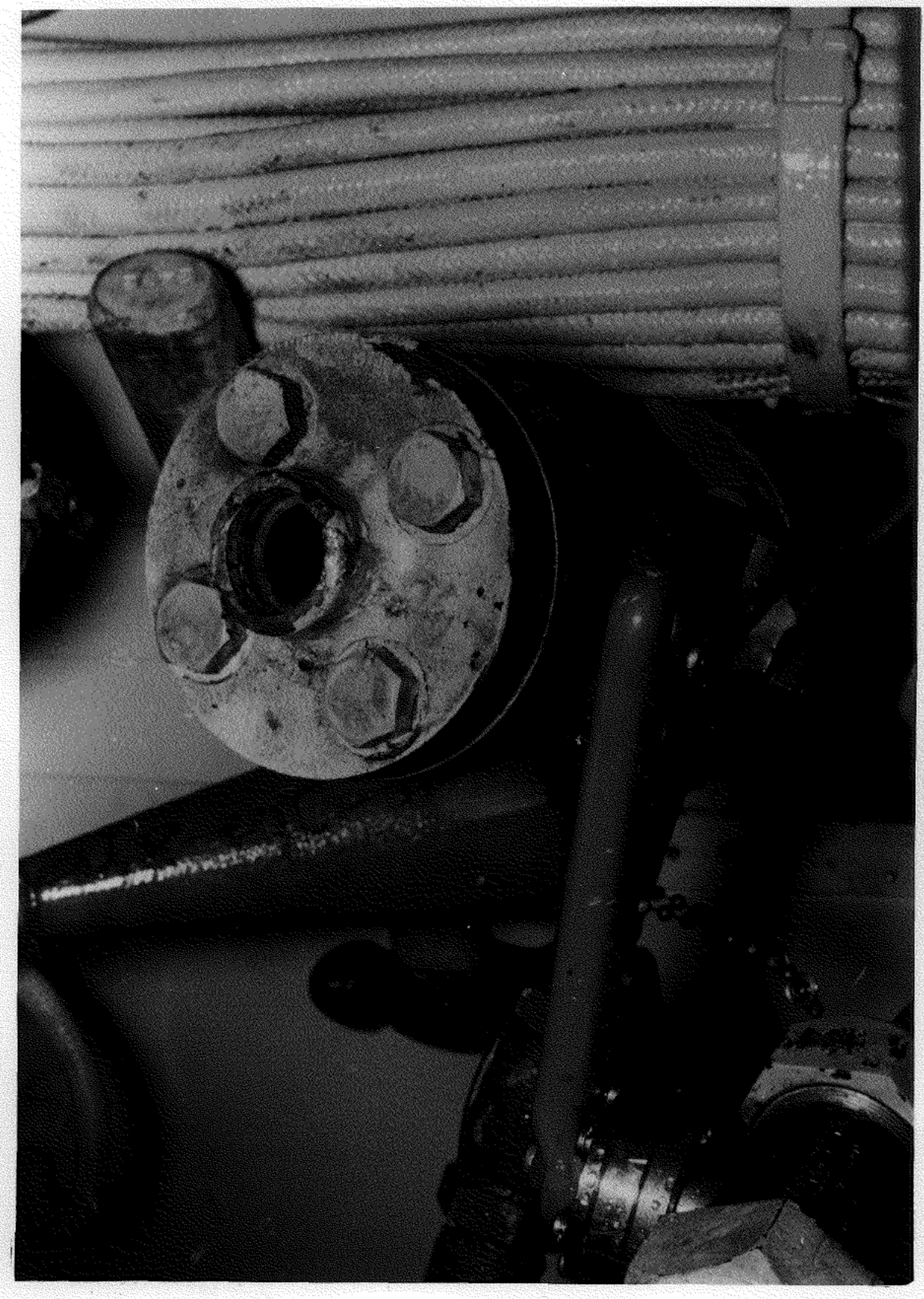
OPERATIONAL EFFECT	CASUALTY
1. GYROCOMPASSES, SINS AND MOST SONAR EQUIPMENT DISABLED	BOTH 400 CYCLE MG SETS TRIPPED
2. PROPULSION SECURED	SILVER-BRAZED JOINT IN LUBE OIL LINE TO MAIN SHAFT FAILED.
3. FLOODING FROM SEA.	SILVER-BRAZED JOINT IN A NONISOLABLE ¾ INCH LINE OPEN TO THE SEA FAILED.
4. TORPEDO FIRING CAPABILITY LOST.	SHORT CIRCUIT IN FIRE CONTROL SWITCHBOARD (5 HOURS TO RESTORE)
6. UNABLE TO TRANSMIT ON SHIP-TO-SHORE FREQUENCIES.	BOTH THE WRT AND TBL TRANSMITTERS DISABLED BY MANY COMPONENT FAILURES.

b(1)

UNCLASSIFIED

FIGURE 23 SIGNIFICANT DAMAGE SHOT 5

UNCLASSIFIED

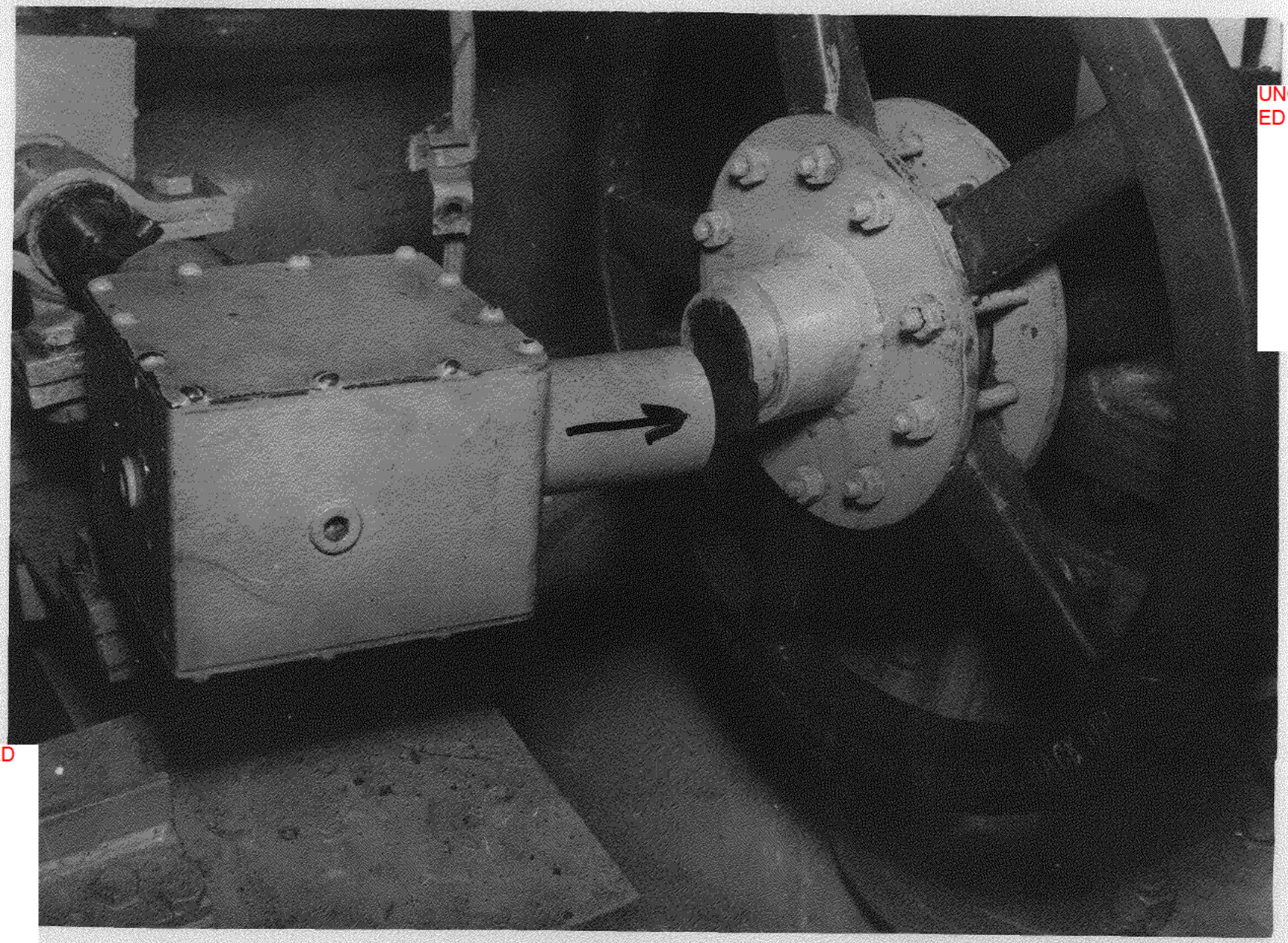


PSD 307962

FIGURE 24 SILVER BRAZED PIPE JOINT FAILURE WHICH PERMITTED FLOODING FROM SEA

UNCLASSIFIED

UNCLASSIFIED



UNCLASSIFIED

FIGURE 25 DISENGAGED HYDRAULIC VALVE OPERATOR

PSD 307979

UNCLASSIFIED

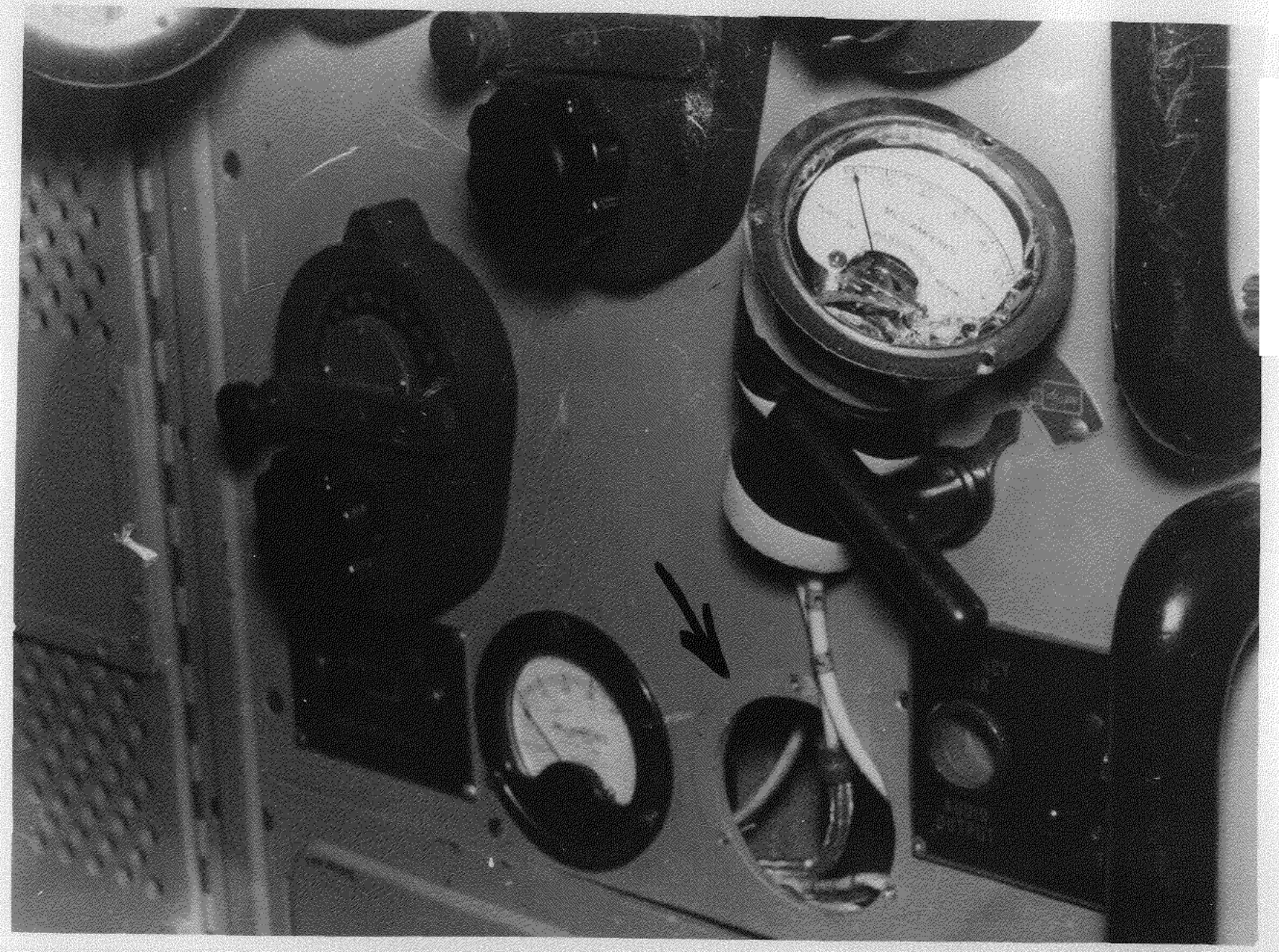


FIGURE 26 METER DRIVEN FROM TRANSMITTER CONSOLE

PSD 308008

UNCLASSIFIED

UNCLASSIFIED

(b)(1)

PSD 307984

b(1)

FIGURE 27 REDUNDANT

UNCLASSIFIED

UNCLASSIFIED

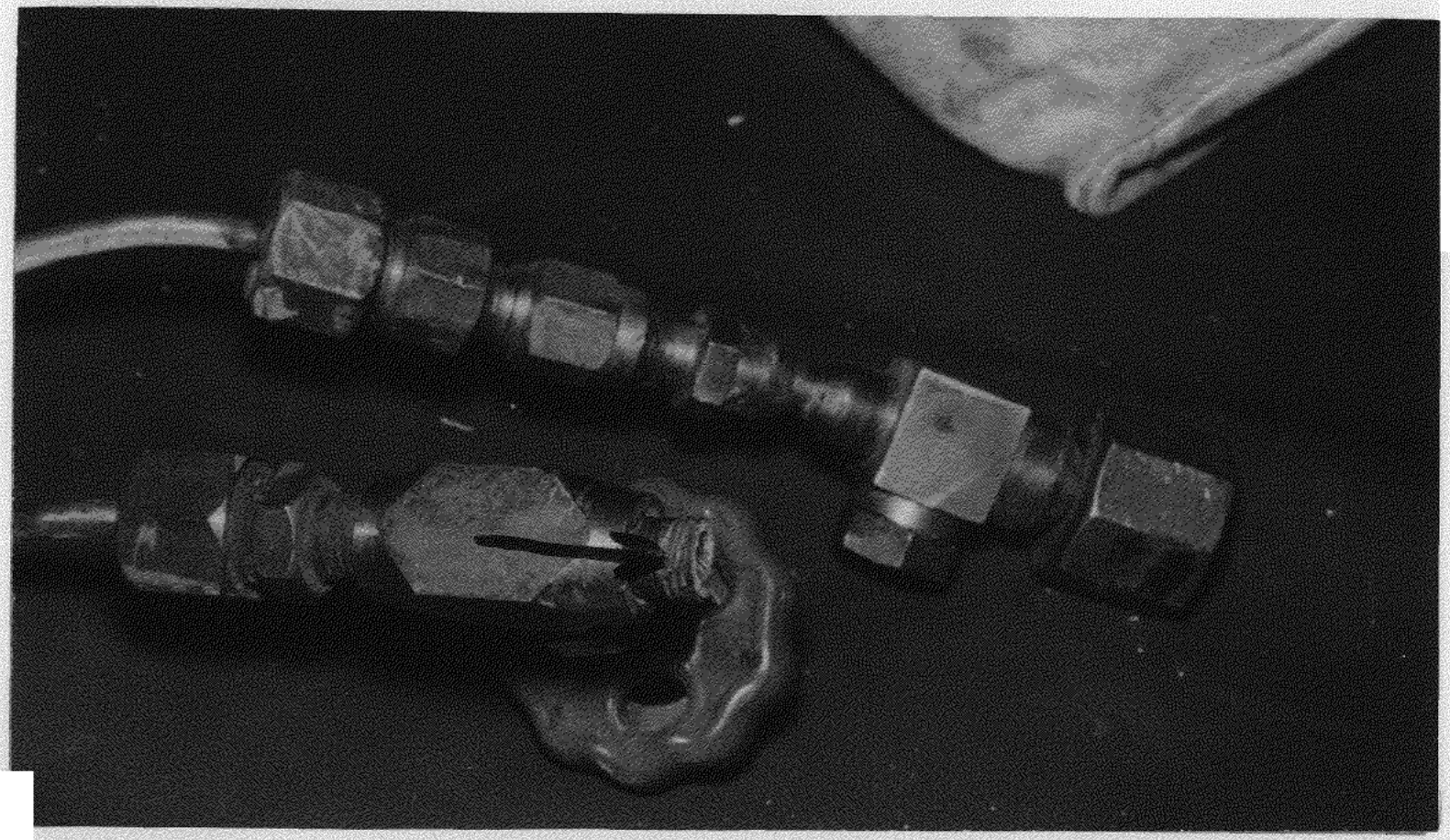
SHOT 6

OPERATIONAL EFFECT	CASUALTY
1. SHIP SURFACED	(b)(1) AIR LINE FAILED AIR BANK BLED DOWN
2. DEPTH CONTROL LOST	NORMAL AND EMERGENCY STERN PLANE INDICATORS DISABLED. SILVER-BRAZED JOINT IN STERN PLANE RAM VENT LINE FAILED
3. SHIP SPEED LIMITED. POWER REDUCED	b(1)
b(1) 4.	
5. BACK UP PROPULSION CAPABILITY LOST	SECONDARY PROPULSION MOTOR WOULD NEITHER TRAIN NOR RUN
6. TORPEDO FIRING CAPABILITY LOST	NUMEROUS CASUALTIES TO TORPEDO FIRE CONTROL, HANDLING EQUIPMENT AND TUBES. AFTER 15 MINUTES TWO TUBES AVAILABLE BUT WITH GREATLY REDUCED RELOAD CAPABILITY.
7. SELF AND RADIATED NOISE INCREASED	BALLAST TANK PLATING DEFORMED

FIGURE 28 SIGNIFICANT DAMAGE SHOT 6

UNCLASSIFIED

UNCLASSIFIED

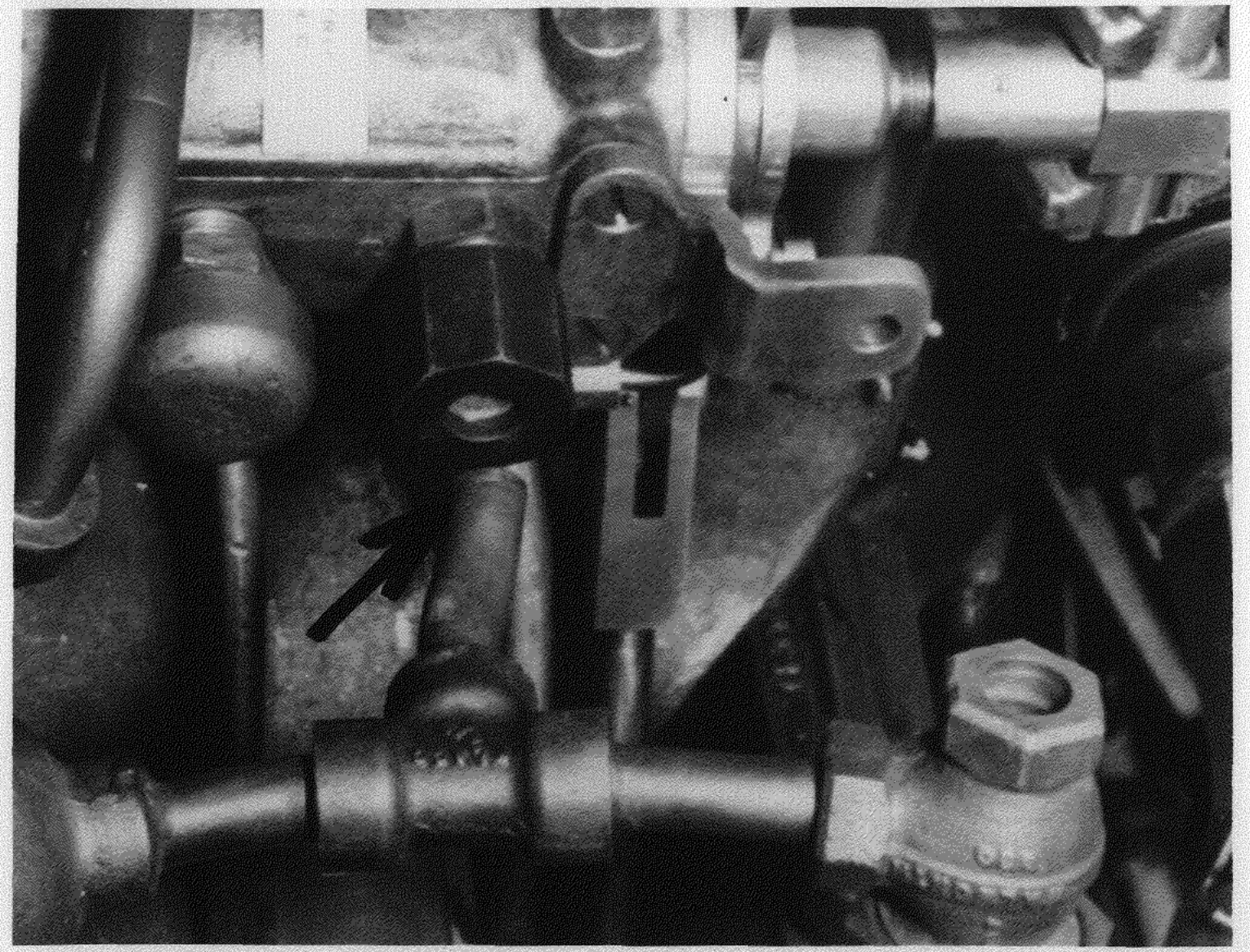


PSD 307986

FIGURE 29 THREADED PIPE FITTING FAILURE

UNCLASSIFIED

UNCLASSIFIED



PSD 308003

FIGURE 30 FLARED PIPE FITTING FAILURE

UNCLASSIFIED

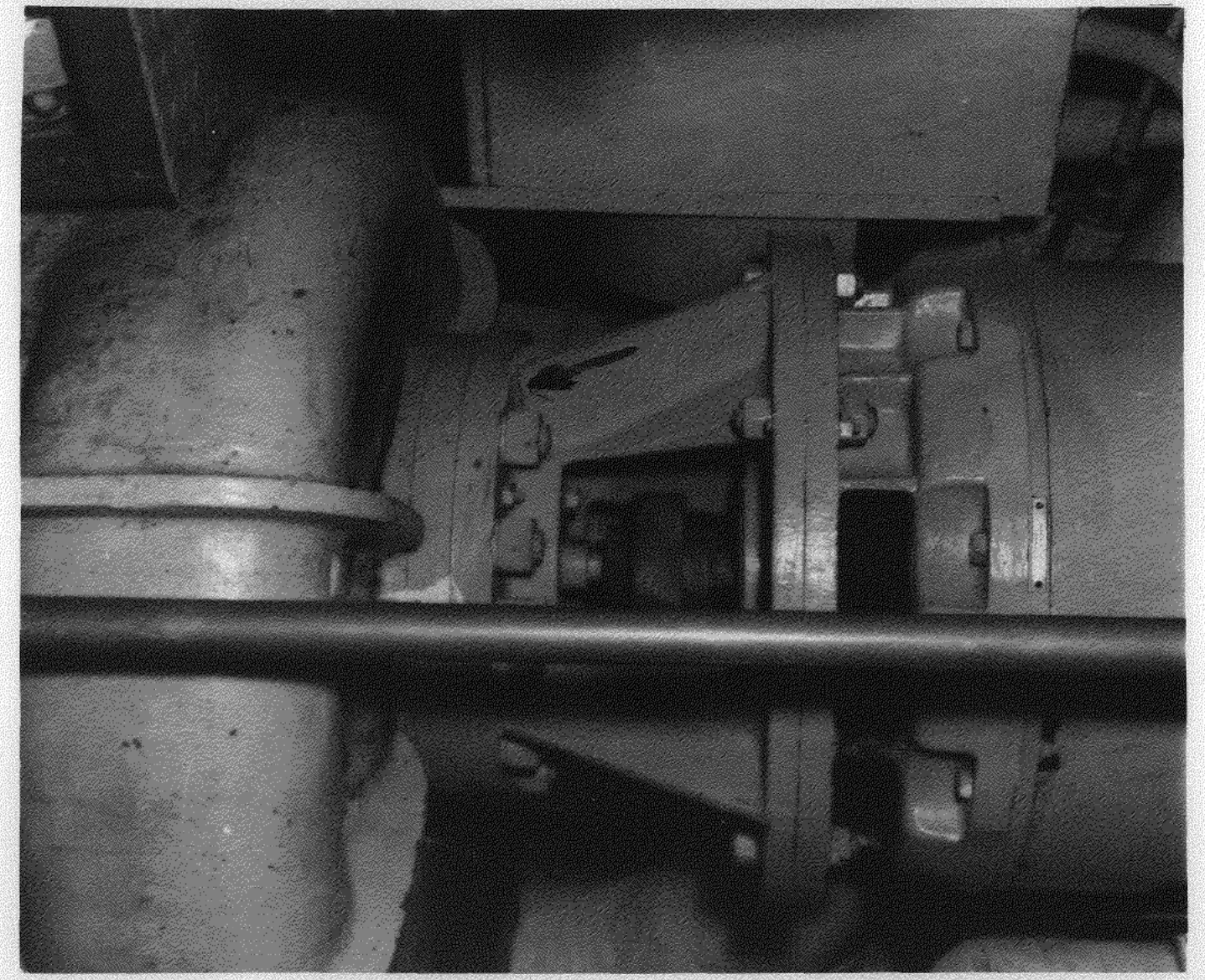
UNCLASSIFIED

PSD 308398

FIGURE 31 BALLAST TANK DIMPLING

UNCLASSIFIED

UNCLASSIFIED



PSD 308406

FIGURE 32 FRACTURED FOUNDATION

UNCLASSIFIED

UNCLASSIFIED

NO.2 PUFFS HYDROPHONE

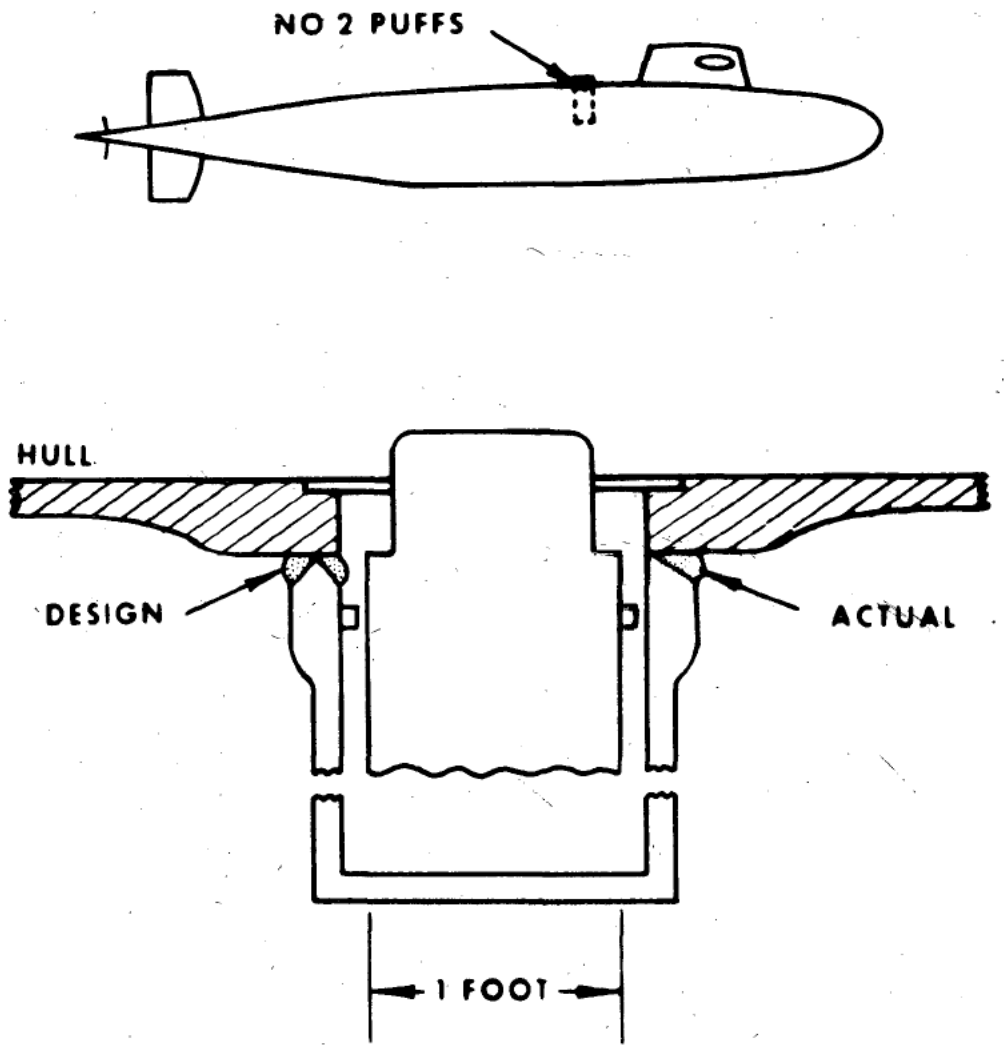
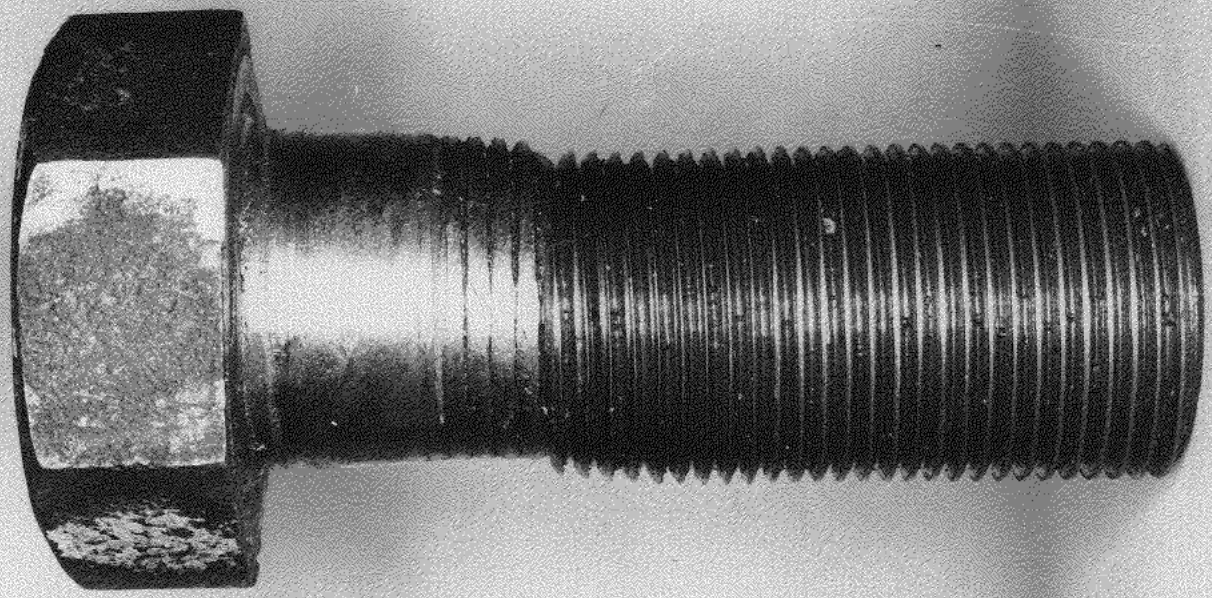


FIGURE 33 LEAKS AT PUFFS HULL CAVITY

UNCLASSIFIED

UNCLASSIFIED



UNCLASSIFIED

FIGURE 34 BOLT MADE OF WRONG MATERIAL

PSD 308457

UNCLASSIFIED

PRE—TEST SHOCK—HARDENED ITEMS

ELECTRICAL

TYPE ACB CIRCUIT BREAKERS

TURBOGENERATOR OVERSPEED TRIPS

MECHANICAL

MAIN PROPULSION CLUTCH

FOUNDATIONS

AIR AND WATER FLASKS

b(3) 10 USC 130

HEAT EXCHANGER

SILVER BRAZED JOINTS

ELECTRONIC

SONAR

COMMUNICATIONS

CONTROL

GAGES

MISCELLANEOUS

FIGURE 35 PRE-TEST SHOCK HARDENING

UNCLASSIFIED

UNCLASSIFIED

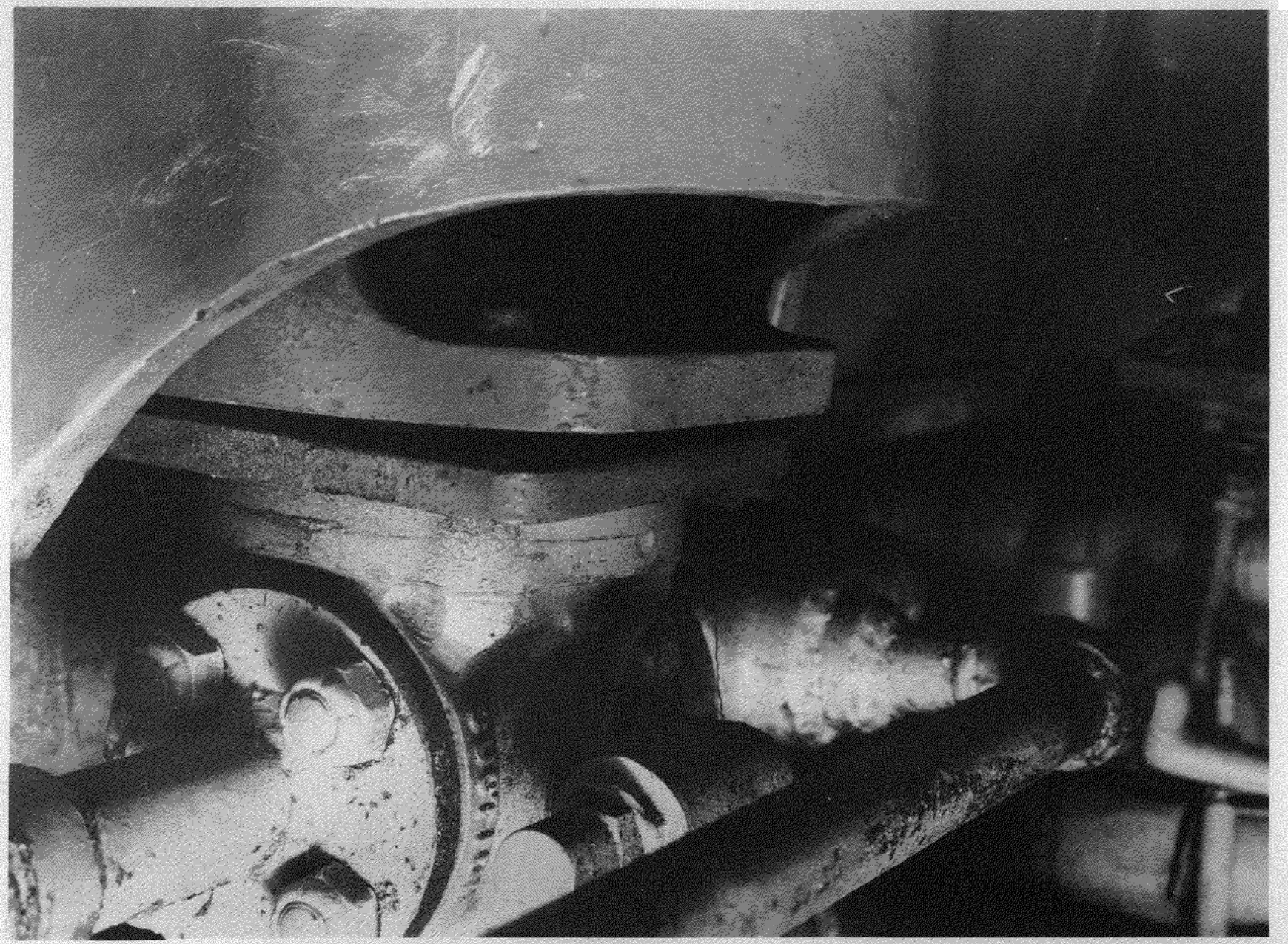


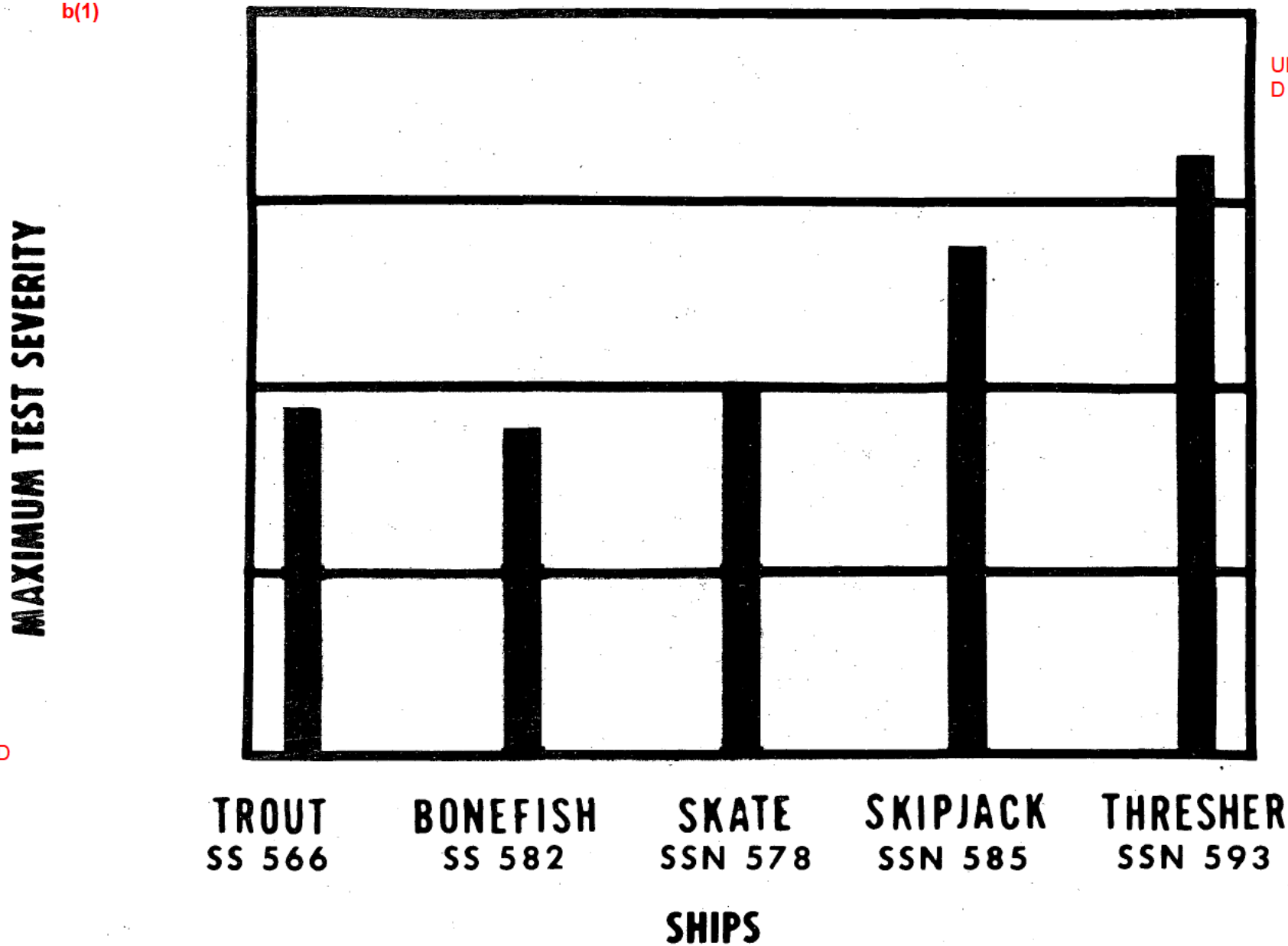
FIGURE 36 UNFASTENED LUBE OIL PURIFIER MOTOR

PSD 307935A

UNCLASSIFIED

b(1)

UNCLASSIFIED



UNCLASSIFIED

FIGURE 37 IMPROVED THRESHER

UNCLASSIFIED

PROBLEM AREAS

- 1— TORPEDO-HANDLING EQUIPMENT
- 2— PLANES AND RUDDER CONTROL
- 3— PIPE JOINTS
- b(1)
- 5— ELECTRIC POWER SYSTEMS
- 6— MK 113 UNDERWATER FIRE CONTROL SYSTEM
- 7— INDICATORS AND ALARM CIRCUITS
- 8— RADAR MAST
- 9— DECK HATCHES AND LOCKERS

UNCLASSIFIED

FIGURE 38 PROBLEM AREAS

UNCLASSIFIED

SHOCK CONCLUSIONS

1. THRESHER IS MORE SHOCK RESISTANT THAN ANY SUBMARINE PREVIOUSLY TESTED

   A. GREATER ATTENTION TO SHOCK REQUIREMENTS

   B b(1)

   C. EFFECTIVE PRETEST SHOCK HARDENING

   D. CAREFUL POLICING BY SHIP'S FORCE

UNCLASSIFIED

FIGURE 39a CONCLUSION 1

UNCLASSIFIED

SHOCK CONCLUSIONS

2. THE COMBAT CAPABILITY OF A MODERN SUBMARINE IS STILL LIMITED BY THE SHOCK SENSITIVITY OF VITAL EQUIPMENT

EQUIPMENT IS CONSIDERABLY MORE SUSCEPTIBLE TO SHOCK DAMAGE THAN IS THE HULL OR PERSONNEL

UNCLASSIFIED

FIGURE 39b CONCLUSION 2

UNCLASSIFIED

SHOCK CONCLUSIONS

3. THE TESTS POINT UP THE NECESSITY FOR CONTINUOUS ATTENTION TO SHOCK REQUIREMENTS IN INSTALLATION AND MAINTENANCE AS WELL AS IN THE DESIGN, FABRICATION AND TESTING OF EQUIPMENT.

ALMOST ALL DEFICIENCIES WERE THE RESULT OF;

A. POOR WORKMANSHIP
B. INSTALLATION ERRORS
C. INADEQUATE INSPECTION
D. DEVIATION FROM PLANS
E. USE OF BRITTLE MATERIALS
F. INADEQUATE MECHANICAL DESIGN
G. INADEQUATE MAINTENANCE
H. USE OF SHOCK SENSITIVE COMPONENTS FOR WHICH SHOCK HARDENED ITEMS ARE AVAILABLE

UNCLASSIFIED

FIGURE 39c CONCLUSION 3

SSIFIED

683328-157

UNCLASSIFIED