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The court, after inquiring into all the facts and circumstances connected with the incident which occasioned the inquiry, and having considered the evidence, finds as follows:

FINDINGS OF FACT

1. That the U.S.S. Thresher (SS(N)593) was built at Portsmouth Naval Shipyard, Portsmouth, New Hampshire, the first of a new class of nuclear powered attack submarines, capable of diving to a depth of *B1* feet, and with significant advances in sonar equipment, ability to resist shock, and to operate with reduced noise radiation. U
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2. That THRESHER, under the command of Lieutenant Commander *B-6* U.S. Navy, *B-6* departed Portsmouth Naval Shipyard, on the morning of 9 April 1963, to conduct scheduled sea trials following a post shake-down availability which extended from 16 July 1962 to 11 April 1963.

3. That THRESHER was a unit of Submarine Development Group TWO, and was operating under the orders of Commander Submarine Force, U.S. Atlantic Fleet (Administration) Portsmouth, for the sea trials.

4. That the following persons, in the status indicated, were on board THRESHER when she departed Portsmouth, New Hampshire, and were on board when she was lost:

HARVEY, John W.	LCDR	USN	USS THRESHER
GARNER, Pat M.	LCDR	USN	USS THRESHER
DI NOLA, Michael J.	LCDR	USN	USS THRESHER
LYMAN, John S., Jr.	LCDR	USN	USS THRESHER
SMARZ, John (n), Jr.	LT	USN	USS THRESHER
PARSONS, Guy C., Jr.	LTJG	USN	USS THRESHER
HENRY, James J., Jr.	LTJG	USN	USS THRESHER
BABCOCK, Ronald C.	LTJG	USN	USS THRESHER
WILEY, John J.	LTJG	USN	USS THRESHER
MALINSKI, Frank J.	LTJG	USN	USS THRESHER
COLLIER, Merrill F.	LT	USN	USS THRESHER
GRAFTON, John G.	LTJG	USN	USS THRESHER
KRAG, Robert L.	LCDR	USN	STAFF, DEPUTY COMMANDER SUBMARINE FORCE, U.S. ATLANTIC FLEET
ARSENAULT, Tilmon J.	ENCA(SS)-P2	USN	USS THRESHER
BAIN, Ronald E.	EN2(SS)-P2	USN	USS THRESHER
BELL, John E.	MM1-P2	USN	USS THRESHER
BOBBITT, Edgar S.	EM2(SS)-P2	USN	USS THRESHER
BOSTER, Gerald C.	EM3(SS)-P1	USN	USS THRESHER
BRACEY, George (n)	SD3(SS)	USN	USS THRESHER
BRANN, Richard P.	EN2(SS)-P2	USN	USS THRESHER
CARKOSKI, Richard J.	EN2(SS)	USN	USS THRESHER
CAYEY, Steven G.	TM2(SS)	USN	USS THRESHER
CHRISTIANSEN, Edward (n)	SN(SS)	USN	USS THRESHER
CLAUSSEN, Larry W.	EM2(SS)-P2	USN	USS THRESHER
CLEMENTS, Thomas E.	ETR3(SS)	USN	USS THRESHER

UNCLASSIFIED

UNCLASSIFIED

CUMMINGS, Francis M.	SOS2(SS)	USN	USS THRESHER
CARMODY, Patrick W.	SK2	USN	USS THRESHER
DABRUZZI, Samuel J.	ETN2(SS)	USN	USS THRESHER
DAY, Donald C.	EN3(SS)	USN	USS THRESHER
DENNY, Roy O., Jr.	EM1(SS)-P2	USN	USS THRESHER
DIBELLA, Peter J.	SN	USN	USS THRESHER
DUNDAS, Don R.	ETN2(SS)	USN	USS THRESHER
DYER, Troy E.	ET1(SS)-P1	USN	USS THRESHER
DAVISON, Clyde E., III	ETR3-P1	USN	USS THRESHER
FORNI, Ellwood H.	SOCA(SS)-P1	USN	USS THRESHER
FOTI, Raymond P.	ET1(SS)	USN	USS THRESHER
FREEMAN, Larry W.	FTM2(SS)	USN	USS THRESHER
FUSCO, Gregory J.	EM2(SS)-P2	USN	USS THRESHER
GALLANT, Andrew J., Jr.	HMC(SS)	USN	USS THRESHER
GARCIA, Napoleon T.	SD1(SS)	USN	USS THRESHER
GARNER, John E.	YNSN(SS)	USN	USS THRESHER
GAYNOR, Robert W.	EN2(SS)	USN	USS THRESHER
GOSNELL, Robert H.	SA(SS)	USNR	USS THRESHER
GRAHAM, William E.	SOC(SS)-P1	USN	USS THRESHER
GUNTER, Aaron J.	QM1(SS)	USN	USS THRESHER
HALL, Richard C.	ETR2(SS)-P2	USN	USS THRESHER
HAYES, Norman T.	EM1-P2	USN	USS THRESHER
HEISER, Laird G.	MM1-P2	USN	USS THRESHER
HELSTIUS, Marvin T.	MM2	USN	USS THRESHER
HEWITT, Leonard H.	EMCA(SS)	USN	USS THRESHER
HOAGUE, Joseph H.	TM2(SS)	USN	USS THRESHER
HODGE, James P.	EM2	USN	USS THRESHER
HUDSON, John F.	EN2(SS)	USN	USS THRESHER
INGLIS, John P.	FN	USNR	USS THRESHER
JOHNSON, Brawner G.	FTG1(SS)-P2	USN	USS THRESHER
JOHNSON, Edward A.	ENCA(SS)	USN	USS THRESHER
JOHNSON, Richard L.	RMSA	USN	USS THRESHER
JOHNSON, Robert E.	TMC(SS)-P1	USN	USS THRESHER
JOHNSON, Thomas B.	ET1(SS)-P2	USN	USS THRESHER
JONES, Richard W.	EM2(SS)	USN	USS THRESHER
KALUZA, Edmund J., Jr.	SOS2(SS)-P1	USN	USS THRESHER
KANTZ, Thomas C.	ETR2(SS)	USN	USS THRESHER
KEARNEY, Robert D.	MM3	USN	USS THRESHER
KEILER, Ronald D.	IC2(SS)-P2	USN	USS THRESHER
KIESECKER, George J.	MM2(SS)-P2	USN	USS THRESHER
KLIER, Billy M.	EN1(SS)-P2	USN	USS THRESHER
KRONER, George R.	CS3	USN	USS THRESHER
LANOUILLE, Norman G.	QM1(SS)	USN	USS THRESHER
LAVOIE, Wayne W.	YN1(SS)	USN	USS THRESHER
MABRY, Templeman N., Jr.	EN2(SS)-P2	USN	USS THRESHER
MANN, Richard H., Jr.	IC2(SS)	USN	USS THRESHER
MARULLO, Julius F., Jr.	QM1(SS)	USN	USS THRESHER
MC CLELLAND, Douglas R.	EM2(SS)	USN	USS THRESHER
MC CORD, Donald J.	MM1(SS)-P2	USN	USS THRESHER
MC DONOUGH, Karl P.	TM3(SS)	USN	USS THRESHER
MIDDLETON, Sidney L.	MM1(SS)-P2	USN	USS THRESHER
MUISE, Ronald A.	CS2	USN	USS THRESHER
MUSSELWHITE, James A.	ETN2(SS)-P2	USN	USS THRESHER

B-6

UNCLASSIFIED

UNCLASSIFIED

NAULT, Donald E.	CS1(SS)	USN	USS THRESHER
NOONIS, Walter J.	RMC(SS)	USN	USS THRESHER
NORRIS, John D.	ET1(SS)-P2	USN	USS THRESHER
OETTING, Chesley C.	EM2-P2	USN	USS THRESHER
PENNINGTON, Roscoe C.	EMCA(SS)-P2	USN	USS THRESHER
PETERS, James G.	EMCS-P2	USN	USS THRESHER
PHILLIPPI, James F.	SOS2(SS)	USN	USS THRESHER
PHILPUT, Dan A.	EN2(SS)-P2	USN	USS THRESHER
PODWELL, Richard (n)	MM2-P2	USN	USS THRESHER
REGAN, John S.	MM1(SS)-P2	USN	USS THRESHER
RITCHIE, James P.	RM2	USN	USS THRESHER
ROBISON, Pervis (n), Jr.	SN	USN	USS THRESHER
ROUNTREE, Glenn A.	QM2(SS)	USN	USS THRESHER
RUSHETSKI, Anthony A.	ETN2	USN	USS THRESHER
SCHIEWE, James M.	EM1(SS)-P2	USN	USS THRESHER
SHAFFER, Benjamin N.	EMCM(SS)-P2	USN	USS THRESHER
SHAFFER, John D.	EMCS(SS)-P2	USN	USS THRESHER
SHIMKO, Joseph T.	MM1-P2	USN	USS THRESHER
SHOTWELL, Burnett M.	ETRSN	USN	USS THRESHER
SINNETT, Alan D.	FTG2(SS)	USN	USS THRESHER
SMITH, William H., Jr.	BT1-P2	USN	USS THRESHER
SOLOMON, Ronald H.	EM1-P2	USN	USS THRESHER
STEINEL, Robert E.	SO1(SS)-P1	USN	USS THRESHER
SNIDER, James L.	MM1	USN	USS THRESHER
VAN PELT, Rodger E.	IC1(SS)-P2	USN	USS THRESHER
WASEL, David A.	RMSN	USN	USS THRESHER
WALSKI, Joseph A.	RM1(SS)-P1	USN	USS THRESHER
WIGGINS, Charles L.	FTG1-P2	USN	USS THRESHER
WISE, Donald E.	MMCA(SS)-P2	USN	USS THRESHER
WOLFE, Ronald E.	QMSN(SS)	USN	USS THRESHER
ZWEIFEL, Jay H.	EM2-P1	USN	USS THRESHER
ALLEA, Philip H.	LCDR	USN	PORTSMOUTH NAVAL SHIPYARD
BILLINGS, John H.	LCDR	USN	PORTSMOUTH NAVAL SHIPYARD
BIEDERMAN, Robert D.	LT	USN	PORTSMOUTH NAVAL SHIPYARD
PRESCOTT, Robert D.			Civilian Employee, Design Division, Portsmouth Naval Shipyard
CHARRON, Robert E.			Civilian Employee, Design Division, Portsmouth Naval Shipyard
GUERETTE, Paul A.			Civilian Employee, Design Division, Portsmouth Naval Shipyard
FISHER, Richard K.			Civilian Employee, Design Division, Portsmouth Naval Shipyard
WHITTEN, Laurence E.			Civilian Employee, Combat Systems Division, Portsmouth Naval Shipyard
BEAL, Daniel W., Jr.			Civilian Employee, Combat Systems Division, Portsmouth Naval Shipyard

B-6

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DES JARDINS, Richard R.	Civilian Employee, Combat Systems Division, Portsmouth Naval Shipyard
CRITCHLEY, Kenneth J.	Civilian Employee, Production Department, Portsmouth Naval Shipyard
CURRIER, Paul C.	Civilian Employee, Production Department, Portsmouth Naval Shipyard
ABRAMS, Fred P.	Civilian Employee, Production Department, Portsmouth Naval Shipyard
PALMER, Franklin J.	Civilian Employee, Production Department, Portsmouth Naval Shipyard
DINEEN, George J.	Civilian Employee, Production Department, Portsmouth Naval Shipyard
MOREAU, Henry C.	Civilian Employee, Production Department, Portsmouth Naval Shipyard
CORCORAN, Kenneth R.	Contractor's Representative, Sperry Corporation
JAQUAY, Maurice F.	Contractor's Representative, Raytheon Corporation
KEUSTER, Donald W.	Contractor's Representative, Sperry Corporation
STADTMULLER, Donald T.	Contractor's Representative, Sperry Corporation

5. That the persons listed as being on board were military members of the naval service on active duty, civilian employees of the Portsmouth Naval Shipyard or civilian employees of activities under Government contract, as indicated.
6. That all persons on board THRESHER were on board for the purpose of executing official duties.
7. That U.S.S. Skylark (ASR20), under command of Lieutenant Commander ^{by} U.S. Navy, was designated to act as escort to THRESHER during sea trials, pursuant to orders of Commander Submarine Flotilla TWO. Commanding Officer, THRESHER, was Officer in Tactical Command.
8. That THRESHER's movement orders were CONFIDENTIAL; SKYLARK's were unclassified. Sea trial agenda, issued by Commanding Officer, THRESHER, were unclassified and were not held by SKYLARK.
9. That THRESHER effected a rendezvous with SKYLARK at about 0949R on 9 April 1963 in the vicinity of Latitude 42-56 North, Longitude 70-26 West.

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10. That on completion of a scheduled shallow dive, the two ships proceeded independently during the night to a second rendezvous in the vicinity of Latitude 41-46 North, Longitude 65-03 West. During the transit, THRESHER proceeded surfaced and submerged and conducted various test evolutions, including full power propulsion.
11. That at 0745R, 10 April 1963, SKYLARK was in the vicinity of Latitude 41-46 North, Longitude 65-03 West, and THRESHER reported to her that SKYLARK bore 147° True, 3400 yards from THRESHER.
12. That UQC (underwater telephone) provided the means of voice communication between the ships when THRESHER was submerged. SKYLARK was fitted with QHB-A type sonar equipment, having a maximum range scale of 3750 yards, but did not have sonar contact on THRESHER at any time on 10 April 1963. U
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13. That SKYLARK carried a rescue chamber with a maximum depth capability of 850 feet.
14. That the sea was calm, with a slight swell, at 0900R on 10 April. Wind was from 015° True at seven knots. Depth of water in this area is about 8500 feet. Visibility was about ten miles. No other ships are known to have been in the vicinity.
15. That at 0747R, THRESHER reported by underwater telephone that she was starting a deep dive. Depth for this dive had been set at 600 feet. SKYLARK then maintained her approximate position. THRESHER reported course changes and depth changes, but SKYLARK did not plot THRESHER's position. U
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16. That the deep dive appeared to SKYLARK personnel to proceed satisfactorily until about 0913R, when THRESHER reported to SKYLARK to the effect, "Experiencing minor difficulties. Have positive up angle. Am attempting to blow. Will keep you informed."
17. That at about 0916R, SKYLARK heard a garbled transmission which was believed to contain the words "... test depth". An additional garbled transmission was received about 0917R, reported as containing the words "... nine hundred North". U
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18. That Commander Oceanographic Systems Atlantic obtained information that ⁵ and that a high energy, low frequency noise disturbance of the type which could have been made by an implosion emanated from THRESHER at 0918.1R. There were also indications of two disturbances, one extending from 0909.8R to 0911.3R, the other from 0913.5R to 0914R, which could have been made by the blowing of the ballast tanks. U
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19. THRESHER was lost at sea with all on board at about 0918R on 10 April 1963, in the vicinity of Latitude 41-45 North, Longitude 65-00 West.
20. Bureau of Naval Personnel message 121935Z of April 1963 reported that determination had been made on 11 April 1963 under the Missing Persons Act (Title 50 Appendix, U.S. Code Annotated, section 1005), that all persons on board the U.S.S. THRESHER on 10 April 1963, died on 10 April 1963. UNCLASSIFIED

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21. That there was no evidence of sabotage or enemy action in connection with the loss of THRESHER.

22. That upon receipt of the communication from THRESHER at 0913R, "Experiencing minor difficulty..." etc., SKYLARK initiated the following actions:

- a. Advised THRESHER that the area was clear.
- b. Advised THRESHER of SKYLARK's course and requested range and bearing from THRESHER.
- c. Asked THRESHER at about 0915R, "Are you in control?" and repeated this query.
- d. Established LORAN position (logged at 0921R as 41-45N 64-59W).
- e. Attempted to establish communication by underwater telephone, sonar and radio.
- f. At 1040R commenced dropping series of hand grenades indicating to THRESHER that she should surface.

23. That at about 1045R, SKYLARK began preparation of a message reporting the loss of contact with THRESHER.

- a. At about 0940R, when the Operations Officer had asked the Commanding Officer if he should send such a message, the reply was to the effect that, "It is too early."
- b. At about 1045R, the Commanding Officer, SKYLARK directed the Operations Officer to initiate the message.
- c. Although SKYLARK had conducted radio communication checks with NBL (Radio New London) earlier on the morning of 10 April, difficulty was reported at the time of transmission of the message. SKYLARK shifted to an alternate frequency.
- d. NBL receipted for the message at 1245R.

24. That SKYLARK's message, 101604Z, stated, "UNABLE TO COMMUNICATE WITH THRESHER SINCE 0917R. HAVE BEEN CALLING BY UQC VOICE AND CW QHB CW EVERY MINUTE EXPLOSIVE SIGNALS EVERY 10 MINS WITH NO SUCCESS. LAST TRANSMISSION RECD WAS GARBLED. INDICATED THRESHER WAS APPROACHING TEST DEPTH. MY PRESENT POSITION 41-43N 64-57W CONDUCTING EXPANDING SEARCH."

25. SKYLARK message 101604Z did not convey to operational commanders the full extent of the information available.

- a. Although inclusion of additional information such as the 0913R UQC transmission "Experiencing minor difficulty..." etc., was suggested by the Operations Officer, the Commanding Officer decided not to include such information.

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- b. SKYLARK did not include such additional information in any subsequent reports.

26. That on 10 April 1963, Commander Submarine Force, U. S. Atlantic Fleet (Vice Admiral ^{B1} USN) was in Annapolis, Maryland, in a duty status, delivering a submarine presentation. His administrative headquarters remained in Norfolk, Virginia. Vice Admiral ^{B1} returned to Norfolk at about 1420R. At 1435R he was advised of THRESHER's status.

27. That on 10 April 1963, Deputy Commander Submarine Force, U. S. Atlantic Fleet (Rear Admiral ^{B1} USN) was en route to New London, Connecticut from Key West, Florida. He had been conducting an inspection of units at Key West. He arrived at Trumbull Airport, Groton, Connecticut, at about 1830R. He proceeded by helicopter to Newport, Rhode Island and embarked in the U.S.S. Blandy to proceed to the scene of the search.

28. That on 12 April 1963, the Court of Inquiry requested that SKYLARK witnesses and records be made available as soon as possible to acquaint the court with the details of the last transmission from THRESHER and the best knowledge of her last known movements.

- a. Deputy Commander Submarine Force, U. S. Atlantic Fleet, was relieved as search force commander (CTG 89.7) by Commander Submarine Development Group TWO at about 1630R on 12 April. Lieutenant (jg) ^{B1} USN, Navigator of SKYLARK, two enlisted men, and necessary SKYLARK logs were transferred to BLANDY for return to Newport to permit appearance before the Court of Inquiry.
- b. Shortly after the transfer to BLANDY, Rear Admiral ^{B1} interviewed Lieutenant (jg) ^{B1} and examined the UQC (underwater telephone) log. Upon seeing the UQC log, Rear Admiral ^{B1} became knowledgeable for the first time of the last communications from THRESHER. This information had not previously been communicated to him or to anyone outside SKYLARK.
- c. Rear Admiral ^{B1} advised Commander Submarine Force, U. S. Atlantic Fleet by message of the substance of the last UQC transmissions.
- d. This information from SKYLARK was made known to the Court of Inquiry in testimony on 13 April 1963.

29. That shortly after 0917R, when efforts to communicate with THRESHER had been unsuccessful, SKYLARK commenced an expanding search pattern. The QHB-A sonar was the principal means of underwater detection available to SKYLARK.

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30. That SKYLARK was joined in the search area by patrol aircraft and by the U.S.S. Recovery (ARS-43) during the afternoon.

31. That at about 1730R, RECOVERY sighted an oil slick about seven miles to the Southeast of SKYLARK's 0917R position.

32. That samples were collected and articles of debris were recovered. These items and debris subsequently recovered were examined by laboratory personnel of the Portsmouth Naval Shipyard and were determined to be materials which could have come from THRESHER.

33. That radiation measurements were taken in the search area by surface ships and submerged submarines. Water samples and the recovered debris were examined by laboratory personnel. No radioactivity beyond normal background level was found to exist in the search area or in any of the material examined.

34. That additional ships and aircraft were employed in the search effort. Command of the search force passed from Commanding Officer, SKYLARK, to Commander Submarine Development Group TWO at about 0530R on 11 April 1963, and was subsequently exercised, for varying and consecutive periods, by Deputy Commander Submarine Force, U. S. Atlantic Fleet, Commander Submarine Development Group TWO and Commander Submarine Squadron EIGHT.

35. That while operating as a unit of the search force, the U.S.S. Seawolf (SSN575) recorded possible electronic emissions and underwater noises. None of the signals which SEAWOLF received equated with anything that could have been originated by human beings.

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36. That Naval units and personnel were assisted by civilian scientists and research ships. The search for THRESHER is continuing.

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37. That THRESHER was designed by the Bureau of Ships, assisted by Portsmouth Naval Shipyard in contract design phase (1957-1958); working plans were developed by Portsmouth Naval Shipyard (1958-1959).

38. That Portsmouth Naval Shipyard built THRESHER, starting in 1958. Initial sea trials were held on 30 April 1961 to 2 May 1961, but were aborted at 31 feet by instrumentation deficiencies. Severe water hammer was experienced, resulting in an extensive program of hydraulic shock and impulse tests on trim and drain and auxiliary sea water systems. Special operating procedures were prescribed for the trim and drain system. The next sea trial, fully instrumented, commenced on 22 May 1961, was fully successful, and the hull stresses measured confirmed stresses predicted by earlier model tests.

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39. That there were several design reviews of THRESHER Class during the building period. The Chief of Naval Operations review in March, 1959, was one such review.

40. That THRESHER was commissioned and delivered on 3 August 1961; the condition of the ship was defined by the certificates of condition furnished by the Commander, Portsmouth Naval Shipyard and the report of the Board of Inspection and Survey. In general, the ship was built in accordance with specifications and was in generally good material condition.

41. That HY-80 steel has been used in the construction of all nuclear submarines, including THRESHER, since the streamlined single screw hull was adopted. Nuclear submarines make many more excursions to test depth than battery submarines have made in the past. This increased number of cycles and the paucity of knowledge in the fatigue strength of HY-80 require periodic surveillance of submarine hulls.

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42. That THRESHER's main propulsion plant consisted of a model S5W nuclear power plant.

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43. That silver braze joints and flexible hose connections were extensively used in vital piping systems throughout the ship in accordance with usual submarine building practice and the specifications.

44. That the factors of safety relative to test depth of the compartments in THRESHER were as follows:

- Engine Room
- Auxiliary Machinery Space
- Control Space and Reactor Compartment

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45. That a high pressure hydraulic system similar to those in preceding streamlined, single screw submarines, was installed in THRESHER to provide the forces required under high speed maneuvering conditions.

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46. That as compared to the SKIPJACK, the immediately preceding class of attack submarine, THRESHER had:

- a. An increase in test depth from B_1 feet to B_2 feet.
- b. About the same reserve buoyancy.
- c. About the same high pressure air bank capacity.
- d. While at test depth:
 - (1) A reduction in the amount of ballast which could be blown from B_1 per cent to B_2 per cent.
 - (2) A reduction in the rate of blowing ballast from B_1 tons per minute to B_2 tons per minute.

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47. That the increasing operating depths of submarines has compressed the time available in which to take effective damage control action with respect to flooding. The shortness of time available to control flooding is not well recognized. The table below indicates, for THRESHER, in tons per minute, the rates at which water can enter through a leak, the maximum rate at which it can be discharged by drain pump or by blowing tanks, and the ratio of maximum rates of taking in water to getting rid of it.

Depth in Feet	Flooding Rate	Discharge Rate Drain Pump / Air Blow	Maximum Ratio
	Size Hole Inches		Flooding to Discharge 2" Hole
	2" / 4"		

T B_1

All rates in tons per minute.

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48. That the Bureau of Ships design criteria for air system ballast tank blow capacity is that there should be capability to blow all main ballast tanks' B_1

There is no modification to this criteria for depth of blowing or for test depth of the ship involved. There are no requirements relative to the mechanical design of systems which would prevent the formation of blockages due to ice which may form during an extended blow. There was no provision for emergency deballasting by means other than air. Dehydrators were not installed.

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49. That the B_1 psi reducing valves in the main ballast tank blow system of THRESHER were fitted with conical mesh strainers.

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50. That in blowing the main ballast tanks of submarines operating at shallower depths, the tanks can be blown completely dry in a relatively short time.

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B1 This requires a sustained period of blowing.

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There is no requirement in the specifications for building ships to completely blow down the air banks through the main ballast tank blowing system. There have not been promulgated any test results which show as a result of such a full blow down:

- a. The temperature of various components of the air blowing system.
- b. The workability of components at these temperatures with frozen moisture from the air system complicating the situation.
- c. The low temperature effects on the blow system piping and component materials.
- d. The required air dryness to prevent icing.

Under a test required by the court, strainers in the reducers of the TINOSA were blocked and ruptured by the formation of ice in about thirty seconds.

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51. That the high pressure air system of THRESHER Class submarines was so designed that in event of loss of electrical power to the ballast control panel, air banks 2, 3 and 4 would automatically be shut off and air bank #1 would be opened up slowly. It takes thirty seconds to get valves fully open again; this is because of the 200 psi/sec. allowable pressure rise to prevent dieselization; thus after loss of electrical power or significant voltage drop, there is no air blowing capability for some period between 10-50 seconds.

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52. That all sea water system hull and stop valves in THRESHER could not be remotely operated at two separate stations using hydraulic operators, and there was no specified requirement for this capability.

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53. That the auxiliary sea water system in THRESHER was a high pressure system, consisting of two six-inch supply headers and two four-inch discharge headers so arranged in the ship to provide for a loop operation.

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54. That the Ship Information Book and working plans for THRESHER Class auxiliary sea water system call for cross connection of this system as the normal mode of operation. Under this condition it can be necessary to close sea valves in both the auxiliary machinery space and the machinery space to stop a leak in either.

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55. That the constant vent system in THRESHER was directly connected to the auxiliary sea water system and utilized piping, flexible hoses and flexible couplings from the various components to join them to the auxiliary sea water piping system. This cross-connected the auxiliary sea water system.

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54. That the Ship Information Book and working plans for THRESHER Class auxiliary sea water system call for cross connection of this system as the normal mode of operation. Under this condition it can be necessary to close sea valves in both the auxiliary machinery space and the machinery space to stop a leak in either.

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55. That the constant vent system in THRESHER was directly connected to the auxiliary sea water system and utilized piping, flexible hoses and flexible couplings from the various components to join them to the auxiliary sea water piping system. This cross-connected the auxiliary sea water system.

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56. That the normal operating mode of constant vents as set forth in the Ship Information Book and plans for THRESHER is for them to be open.

~~(CONF)~~

57. That the specifications for building submarines do not require a low pressure auxiliary sea water system.

~~(CONF)~~

58. That the normal operating modes of the auxiliary sea water, main sea water, air conditioning and trim and drain valves in THRESHER called for them to be fully open to reduce friction losses and noise in the systems.

~~(CONF)~~

59. That vital electrical switchboards installed in THRESHER were protected from water dripping, but not fully from spray from below or from mechanical derangement from a water stream.

~~(CONF)~~

60. That certain alternate and supplementing identical equipments were located in close proximity to each other. For example the two lube oil pumps for each ship's service turbogenerator set on THRESHER Class are set in a lower level pocket just to port and starboard of the centerline near Frame 81; control oil for ship's service turbogenerator throttles is supplied by these lube oil pumps. The 400-cycle motor generator sets are located in close proximity in the engine room.

~~(CONF)~~

61. That the B_1 KW ship's service motor generator sets and their electrical switching and other connections are located in the auxiliary machinery space in close proximity. They provide for conversion of B_1 volt A. C. to B_1 volt D.C. under normal conditions of the Ship's Service turbogenerator sets providing power, or, when power is provided by the battery or the diesel generator, convert B_1 volt D.C. to B_1 volt A.C. Much of the ship's vital electrical and indicating equipment is supplied from B_1 volt A.C. sources (or transformed therefrom).

~~(CONF)~~

62. That a casualty to BARBEL during the latter stages of THRESHER's construction, focused attention on the inadequacy of quality assurance methods employed in fabrication of silver braze joints in submarine construction by Portsmouth Naval Shipyard prior to 1961.

~~(CONF)~~

63. That subsequent to an investigation of the BARBEL casualty, silver braze joints in THRESHER's vital systems were subjected to visual examinations, mallet tests, chemical material re-identification tests, hydrostatic tests and hydraulic pressure cycling tests.

64. That there was no extensive retrofit of silver braze joints in THRESHER.

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65. That quality assurance procedures employed at Portsmouth Naval Shipyard during THRESHER's construction period, consisted in general of mechanic and line supervision, with some system tests being conducted by inspectors.

66. That hull production processes during THRESHER's building period did not include the use of all the techniques and safeguards for hull surveillance which now exist.

67. That the ultrasonic method of testing silver braze joints was not available for use during THRESHER's construction period.

68. That during THRESHER's construction, x-ray techniques were used extensively for non-destructive testing of welds, forgings and castings. Some ultrasonic testing was used to detect internal flaws in steel plates. To supplement these techniques, and wherever possible, hydrostatic pressures were applied to pressure vessels and piping systems. These test pressures were, in general, one hundred and fifty per cent of the designed working pressures. In the case of those piping systems exposed to sea pressure, this test pressure was also equal to that sea pressure expected to cause collapse of the hull. Hydrostatic pressure testing is a standard engineering technique and was the best non-destructive method of testing silver braze piping joints available at the time of THRESHER construction.

69. That the Ship Information Books (S.I.B) for THRESHER were prepared by an outside firm under subcontract from the Portsmouth Naval Shipyard; the subcontractor used an SS(N) 588 Class Ship Information Book as a guide and virtually copied large portions of it, although many systems on THRESHER were quite different. The THRESHER Ship Information Book was, accordingly, not approved by the Bureau of Ships; a temporary book was provided. The finally approved version was not available to THRESHER even at the end of the post shakedown availability.

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