U.S.S. SALT LAKE CITY (CA25)

Gunfire Damage

Bering Sea
26 March, 1943

Class.....Heavy Cruiser	Length (O.A.).....585 Ft. 6 In.
Launched..... 23 Jan., 1929	Beam (O.A.)..... 65 Ft. 3 In.
Displacement.....9,100 Tons	Draft (Prior to Damage)
	Forward..... 21 Ft. 5 In.
	Aft..... 22 Ft. 0 In.

Reference:

(a) C.O. SALT LAKE CITY ltr. CA25/A16-3, Serial 001, of 1 April, 1943 - (Action Report).

(b) Comdt. NYMI ltr. CA25/L11-1(27-D3a-576615) of 28 July, 1943 - (War Damage Report).

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SECTION I - SUMMARY

1. USS SALT LAKE CITY, while operating in the Bering Sea with other surface units on 26 March, 1943, engaged a Japanese force. Throughout a 3-1/2 hour running battle, damage was caused by five projectiles. Four of these struck the vessel and the fifth, although a short, detonated sufficiently close to the ship to cause damage and, accordingly, also is classified as a hit. Only one caused serious damage, detonating in a fuel oil tank abaft the after engine room. The flooding caused by this projectile resulted in a 4-degree port list. While removing this list a salt water ballast transfer line was inadvertently connected into a fuel oil suction line. This extinguished fires under all boilers and stopped SALT LAKE CITY dead in the water for three minutes until the cause was located and corrected. Fortunately, this casualty occurred just after the enemy force turned away to break off the engagement. Otherwise, the damage was not of a serious nature.

2. After the action SALT LAKE CITY received temporary repairs in the Alaskan area. From there she proceeded to Navy Yard, Mare Island, where all battle damage was repaired and many authorized alterations were accomplished. SALT LAKE CITY returned to service on 17 May, 1943.

3. SALT LAKE CITY experienced operational difficulties with the steering gear on two occasions during the engagement. Ordinarily, matters which are not the result of damage by enemy action are not included in damage reports. In this case, however, the importance of the equipment involved and the fact that difficulties with it were a handicap to SALT LAKE CITY while in action warranted some comment. An analysis of the casualties, with a description of the measures taken to prevent recurrence, therefore, have been included in this report, and will be found in part D of Section III.

SECTION II - NARRATIVE
(All Photos and Plates I, II and III)

4. This report is based on the data supplied with the references. Photographs of damage were furnished by Navy Yard, Mare Island. The plates were prepared from plans supplied by Navy Yard, Mare Island. The numbers of the hits shown on the photographs and plates are the same as those arbitrarily assigned by the Commanding Officer in reference (a) and Navy Yard, Mare Island, in reference (b). The numbering does not indicate the chronological sequence in which the hits were received.

5. On the morning of 26 March, 1943, SALT LAKE CITY was operating with a Cruiser Task Group south of the Kormandorskie Islands and west of Attu, Aleutian Islands. This task group was composed of one heavy cruiser, one light cruiser and four destroyers. The wind was about 8 knots from 165 degrees true and there were gentle swells on the sea from the northwest. The sky was overcast and visibility was exceptionally good.

At 0830 contact was made with a Japanese force. This force was composed of two heavy cruisers, two light cruisers, six destroyers and two transports. Fire was opened by the leading enemy cruiser at 0840. It was returned by SALT LAKE CITY two minutes later. The engagement soon developed into a running fight which lasted about 3-1/2 hours, during which the two enemy heavy cruisers trailed SALT LAKE CITY on the port and starboard quarters at ranges of 16,000 to 24,000 yards. Smoke was employed and apparently obscured the enemy's point of aim inasmuch as but five hits were received despite a steering casualty which caused rudder angles to be limited to 10 degrees. It was reported that the fire control radar and main battery directors were damaged by blast and shock from SALT LAKE CITY's own gunfire. This made it necessary to use the turret telescopes and the SG radar for fire control purposes.

7. During the engagement about 200 8-inch projectiles fell within 30 yards of SALT LAKE CITY. Five of these caused damaged, as described below. In the remainder of this report the five damaging projectiles are designated as follows:

	Time	Designation
First Projectile	1010	Hit No. 1
Second Projectile	1059	Hit No. 3
Third Projectile	1103 (?)	Hit No. 2
Fourth Projectile	closing stages	Hit No. 4
Fifth Projectile	closing stages	Hit No. 5

(These designations were adopted to conform with references (a) and (b).)

8. Hit No. 1 struck the main deck between frames 8 and 9. Hit No. 3 struck the starboard plane and catapult, setting the plane on fire. Hit No. 2 was estimated by the Commanding Officer to have struck at about 1103. At this time, a 4-degree port list began to develop and the after gyro room began to flood. The chronological sequence of hits No. 4 and No. 5 is unknown inasmuch as numerous projectiles were falling close aboard during the closing stages of the action. At 1155, about 50 minutes after hit No. 2, fuel oil was contaminated with salt water when operating personnel attempted to shift salt water ballast in order to remove the list. Fires under the boilers were immediately extinguished and SALT LAKE CITY was stopped for three minutes. After the fuel oil lines were cleared and boilers relighted, SALT LAKE CITY was able to gradually build up speed to 28 knots and operate in approximately the same manner as she did before the casualty occurred. During the time SALT LAKE CITY was dead in the water, a torpedo attack was executed by the U.S. destroyers. Although SALT LAKE CITY's supply of ammunition was low, some had been reserved for last minute eventualities. No. III mount, however, had previously expended all of its AP allowance and was receiving ammunition from the forward magazines. The last salvo was fired at 1204 as the enemy was retiring to the west.

9. The principal damage suffered by SALT LAKE CITY was caused by the 8-inch projectile (hit No. 2) which penetrated the port shell between frames 102 and 103 just below the first platform (photo 6 - plate III). This projectile was falling at an angle of about 45 degrees

when it struck the water off the port quarter of SALT LAKE CITY. It did not detonate or ricochet but passed downward and pierced the hull underwater (photo 7). It passed through fuel oil tank D-4-F (100% full of fuel oil) (photo 8) and then traveled downward, forward and inboard. In following this course it passed through swash bulkhead 100 (photo 10), the outboard bulkhead of No. 4 shaft alley and was deflected inboard by No. 4 shaft. Continuing on, it passed through the inboard bulkhead of No. 4 shaft alley between frames 98 and 99 (photo 11) and into the forward part of fuel oil tank D-2-F where it detonated, rupturing the inboard and outboard boundaries of this tank. D-2-F was 80% full at the time. This projectile traveled approximately 28 feet within the ship to the point of detonation.

10. The immediate effects of this hit were to flood No. 3 and No. 4 shaft alleys with a mixture of oil and salt water and contaminate fuel oil tanks D-4-F and D-2-F. The after gyro room D-501-E flooded to the overhead through three fragment holes in the port bulkhead. Five-inch AA handling room D-401-M flooded to the overhead from the gyro room through a hatch which was not watertight, (presumably designed as a watertight hatch, but not fully effective) and 5-inch AA magazine D-402-M flooded completely from D-401-M through two doors left partially undogged by personnel evacuating these spaces. The laundry was flooded to the waterline (about 3-1/2 feet above the first platform) with a mixture of water and oil which came up through ruptured first platform deck plating and a damaged manhole cover to D-4-F. The athwartship passage at frame 98 on this level likewise flooded to the waterline through the doorway leading from the laundry which was open. Ice machine room D-301-E flooded slowly to a depth of about one foot through a door which was improperly dogged and through an unblanked small cable hole in the inboard bulkhead of this compartment just aft of bulkhead 97. The after engine room flooded to a depth of about five feet as a result of leakage through the bulkhead stuffing boxes on No. 3 and No. 4 shafts, a fragment hole and damaged fuel oil manifold connections on bulkhead 97. This combined flooding resulted in a 4-degree list to port.

11. As an immediate damage control measure, flooded compartments were covered with CO_2 to prevent the possibility of fires. The 4-degree port list was removed by pumping overboard the salt water ballast in the port boiler room wing tanks using the fire and bilge pumps. Attempts to stop flooding of the after engine room by plugging the fragment hole and other leaks in bulkhead 97 proved unsuccessful. In order to control the inflow of oil and water into the engine room, two fire and bilge pumps and the main circulating pump were used - about 10 minutes were required to pump down to a safe level. Intermittent pumping was then required every 15 or 20 minutes. Throughout this whole period No. 3 and No. 4 shafts remained in operation although they were submerged in fuel oil and were fouled by damaged plating.

12. The detonation of the projectile in D-2-F caused rupture and deflection of the inboard longitudinal bulkhead bounding No. 3 shaft alley. The lower strake of the bulkhead plating between frames 98 and 99 was blown into the shaft alley and around No. 3 shaft (photo 12). Fuel oil suction lines passing through D-2-F were severed and torn loose at the

bulkhead connection (photo 11). This caused contamination of the after fuel oil tanks. Contamination of these tanks was not a factor because no service tanks were involved.

13. Numerous fragments from hit No. 2 were found in D-2-F (photo 16). One of the larger fragments penetrated bulkhead 97 (photo 14) four feet from the point of detonation, thus permitting leakage into the after engine room. Three small fragments penetrated the port bulkhead of the after gyro room (photo 13), about seven feet from the point of detonation. These fragment holes caused flooding of this compartment. The fragments passed through about two feet of liquid in D-2-F before entering the shaft alley.

14. No. 4 shaft was damaged by the impact of the projectile which gave the shaft a permanent deflection of approximately 0.230 of an inch (photo 10). No. 3 shaft also was found to have a slight permanent deflection (approximately 0.050 of an inch) apparently caused by the force of the detonation. The continued operation of these two shafts caused distortion to the shaft glands at bulkhead 97. The forward spring bearing of No. 3 shaft (photo 13) was also broken.

15. The bounding bulkheads of fuel oil tank D-4-F (100% full of fuel oil) were distorted. The overhead (first platform) was forced upward and buckled. In addition, one of the manhole covers was blown off and some riveted connections were torn loose from deck members (photos 9 and 15). It was this damage which permitted flooding on the first platform.

16. The other four hits on SALT LAKE CITY caused only superficial damage although they were all 8-inch projectiles. The hit on the starboard plane (hit No. 3) was probably the most severe of these since, besides demolishing the plane, it resulted in severe personnel casualties, started a small fire and caused miscellaneous fragment damage to topside equipment (photos 19, 20 and 21). It appears to have been an instantaneously-fuzed projectile. The detonation was of high order and irregularly-shaped fragments, 1 to 4 inches in diameter, were found. Damage to equipment and structure occurred at the point of impact and throughout a considerable area topside as the result of fragmentation. The starboard plane and launching gear were damaged. From this point fragments spread in the form of a cone forward and to port. Fragments penetrated the deck, forward stack and the ship's structure at various locations between frames 40 and 75 at distances as great as 120 feet from the point of detonation. Fragmentation in the immediate vicinity of the detonation was severe. The after end of the starboard catapult was badly damaged and the wood deck on the starboard side of the superstructure deck between frames 72 and 74 was perforated. Other fragments damaged the main deck and one penetrated to the second deck (photo 21). The main deck is composed of two inches of wood laid on top of 9-pound medium steel plating. The wreckage of the starboard plane was set on fire immediately. The wreckage was jettisoned and the fire was quickly extinguished.

17. Hit No. 1 caused only minor damage. No fires were started and only minor flooding occurred (photo 2 - plate II). The projectile struck the main deck between frames 8 and 9 starboard, six feet from the centerline of the ship (photo 3), continued downward and forward on

the starboard side, passing through the second deck and the starboard chain pipe where it was deflected slightly to the right (photo 4). Continuing on, it penetrated the first platform and bulkhead No. 4 (photo 5) where it was deflected sharply to the right causing it to pass out of the hull through the starboard shell just forward of No. 4 bulkhead about seven feet below the first platform at the waterline. Although the projectile did not detonate within the ship, the existence of numerous loose rivets on the starboard side of the bulbous bow structure forward of frame 4 indicates that it detonated below the water's surface not far from the bow. This projectile traveled approximately 30 feet within the vessel.

18. The flooding forward occurred as a result of the exit hole made in the shell by hit No. 1. This hole at the time was underwater due to the height of the bow wave at this point. This, plus a slight increase in the water level within the ship caused by the velocity of the water entering the hole, resulted in flooding above the external waterline. Uncontrolled flooding was not extensive and was contained forward of bulkhead No. 10.

19. Peak tank A-1-W, chain locker A-501-E and storeroom A-501-E were all flooded to the overhead in a short time. Partial flooding occurred in storerooms A-301-A and A-302-A soon afterwards. The peak tank flooded immediately and caused additional flooding through the hole in bulkhead No. 4 into A-501-E. The chain locker below this compartment flooded through the second platform hatch at frame 5. This hatch apparently was jarred open by shock. The water level inside the vessel, somewhat higher than the external waterline as described previously, was high enough to cause flooding of second platform compartments to the overhead and partial flooding of two first platform compartments. A-302-A flooded through the projectile opening at frame 5 on the first platform deck. The flooding of A-301-A occurred through the hatch at frame 3, which also was jarred loose by shock.

20. In an effort to control the extent of flooding, bulkhead No. 10 was shored. The loose hatches were secured, the hole in the first platform was plugged and the damage water in A-301-A and A-302-A pumped overboard. The references did not state how the water was removed.

21. The remaining two hits (No. 4 and No. 5) were shorts on the port side in the vicinity of hit No. 2 (photo 6). Hit No. 5 tore a piece out of the bilge keel (photo 18) and hit No. 4 cracked a frame and dented plating causing some rivets to leak (photo 17). Both of these shorts probably were 8-inch projectiles inasmuch as only heavy cruisers were firing at SALT LAKE CITY during the period in which these hits occurred.

22. Upon arrival at a repair ship, a temporary patch, over the hole in the port shell at frame 102, was installed by using a cofferdam. Following the repair of the shell and subsequent plugging of the small hole at frame 98 port, all compartments except the gyro room were cleared with a submersible pump and by bucket brigades. Considerable difficulty was experienced in removing the mixture of oil and salt water which had congealed due to low temperatures. Four days and nights were consumed at the task.

23. In addition, temporary patches were installed over the holes in the starboard shell plating and all flooded compartments forward were unwatered. SALT LAKE CITY then proceeded to Navy Yard, Mare Island, where all battle damage was repaired and many authorized alterations were accomplished. The vessel was placed back in service 17 May, 1943.

SECTION III - DISCUSSION

A. Type Projectiles (Photo 16)

24. A comparison of the fragments recovered from hit No. 2 (photo 16) and from hit No. 1 with fragments recovered by SALT LAKE CITY from an 8-inch projectile hit on 12 October, 1942 indicated that all of these projectiles were of the same size and type. The projectile fragments recovered from the hit on 12 October, 1942 have been analyzed in detail by the Bureau of Ordnance. This projectile was of the 8-inch common type with a delay action type fuze which apparently detonates after a travel of about 30 to 40 feet from point of impact. This projectile has been calculated to weigh about 251 pounds and to contain a bursting charge weighing about 17.6 pounds.

25. The fragments recovered from hit No. 3 were not in sufficient quantity to indicate the size of the projectile. At the time of the hit, however, SALT LAKE CITY was under fire from the two enemy heavy cruisers. It is, therefore, concluded that this was also an 8-inch projectile. In this instance, however, the projectile detonated upon impact indicating that this was probably an 8-inch high capacity projectile with a nose fuze set for instantaneous detonation. Fragmentation was complete and fragments were distributed as far as 120 feet from the point of detonation.

26. The two shorts, hits Nos. 4 and 5, were probably 8-inch projectiles inasmuch as SALT LAKE CITY was under fire from enemy heavy cruisers when damage from them was received.

B. Flooding and Damage Control

27. Flooding on SALT LAKE CITY fortunately never became serious though numerous projectiles detonated underwater in the vicinity of the ship and at least one detonated sufficiently close aboard to cause leakage through the hull.

28. It will be noted on plate III that hit No. 2 detonated within four feet of the after bulkhead of the after engine room. Only one fragment penetrated this bulkhead. The fuel oil in the tank in which the projectile detonated seems to have been effective in reducing the range and velocity of fragments. Attempts to stop the flooding of the after engine room by plugging the fragment hole and the other leaks in bulkhead 97 around the shaft stuffing boxes were unsuccessful. The liquid level rose to the lower floor plates before the flooding was checked. The main circulating pump and two fire and bilge pumps were required to overcome

the rate of leakage into this space. Considerable difficulty was experienced with the pump suctions from rags in the bilges. It appears that these rags were initially stowed in buckets on the lower floor plates.

29. Flooding caused by the hit forward (hit No. 1) was not serious. Flooding boundaries were established and the amount of liquid admitted was never more than an inconvenience.

30. An examination subsequent to damage revealed several holes in the watertight bulkheads aft of the ice machine room D-301-E which had not been blanked off upon removal of electric cable. Had D-301-E flooded completely, one or more compartments aft of this space probably would have flooded. In paragraph 10, it was noted that water which entered D-301-E came through a small cable hole, which had not been blanked off, and through the watertight door in the longitudinal bulkhead which apparently could not be dogged tight. Routine air testing of compartments is for the purpose of detecting deficiencies of watertight integrity and should reveal such defects as these.

31. Immediately after hit No. 2 occurred, damage control personnel blanketed damaged compartments (as manifested by flooding) with CO_2 in order to prevent the possibility of fuel oil fires or the formation of explosive vapors. Although this precaution probably reduced the possibility of the ignition of fuel oil vapor from chance electrical sparks, it would have been of little value had subsequent hits ruptured the boundaries above the liquid in the spaces concerned. Hit No. 3, on the starboard catapult, ignited the aircraft. The fire was quickly extinguished and the plane jettisoned. The references do not explain how the fire was extinguished, but the following statement in reference (a) is significant: "The experience gained in the Firefighters' School in Pearl Harbor was invaluable in controlling the fire which occurred. New firefighting equipment is considered invaluable."

C. Contamination of Fuel Oil

32. The contamination of fuel oil with salt water, ultimately resulting in the loss of steam, more seriously reduced the fighting efficiency of SALT LAKE CITY than any other single casualty received during the engagement. This occurred when engineering personnel attempted to remove the 4-degree port list by pumping out the salt water ballast in the port boiler room wing tanks. Through an error the ballasted wing tanks were connected into the fuel oil suction line and the fires in all boilers were quickly extinguished. The error was immediately corrected. The line was purged and within three minutes clean oil was restored to the boiler burners.

D. Damage and Repairs to the Steering Gear

33. Although the steering gear received no direct damage, difficulty was experienced in its operation on two separate occasions.

It did operate satisfactorily, however, throughout the major portion of the engagement. This equipment was tested severely by the high speed maintained for several hours, frequent and radical changes of course and the shock of firing the after 8-inch mounts dead astern.

34. Although the references do not detail the failures, it appears that early in the action the automatic limit stops failed to operate when the rudder was put hard over to the right. This failure apparently was caused by air in the limit stop hydraulic system. The replenishing tank may not have been full prior to the action or oil may have been lost during the engagement. After this casualty rudder throw was arbitrarily limited to 10 degrees. It was reported that this measure was taken for reasons of safety, although the necessity for such drastic curtailment of rudder angle is not apparent. The second failure occurred later in the engagement when the clutch control wheel began to turn automatically from vibration and disengaged the hydraulic motor. The auxiliary steering engine, a diesel-driven unit installed by the ship's force, was used to regain control of the rudder. It is not clear why the clutch was not re-engaged.

35. During the repair of SALT LAKE CITY at Mare Island, alterations were made to the steering equipment to correct the causes for the failures described above. The low pressure hydraulic automatic limit stop system was removed. An automatic mechanically operated by-pass valve was installed in the high pressure hydraulic system which operates when the rudder approaches its limiting angle. When this occurs the valve by-passes the oil supply for the hydraulic motor (B-end) thereby stopping the screws.

36. In order to insure that unclutching of the hydraulic motors by vibration will not recur, a special weight was placed on the wheel which operates the clutch in order to restrict the free spinning of this wheel. This type of lock was preferred to pinning the wheel since with this arrangement the wheel could be turned quickly in an emergency without the necessity of first removing a pin.

37. In addition to the above alterations, a follow-up system was designed and installed at a later availability. The lack of follow-up control had been a handicap as it made accurate control of the rudder difficult.

38. It was noted in paragraphs 4 and 34 that a diesel unit was used to return the rudder amidships. This diesel unit was installed by the ship's force as an emergency source of power to the steering gear. The Bureau has authorized a similar installation on PENSACOLA. In general, the use of a diesel engine for emergency steering power is open to question and was authorized on these two vessels only because of the admitted deficiencies of the equipment installed. The objections to a diesel installation such as that on SALT LAKE CITY are:

(a) It does not provide for the contingency of a flooded steering gear room.

(b) Diesels, suitable for such installations (a type DA was installed on SALT LAKE CITY) have cylinder blocks of cast iron. Thus,

shock to the vessel of sufficient intensity to result in loss of all power to the steering gear motors may result in damage to the diesel engine. In addition, under heavy shock conditions, the diesel engine is a potential source of secondary missiles which may injure personnel and damage adjacent machinery.

(c) The space required for the installation makes maintenance of the primary equipment difficult.

(d) The air supply and exhaust necessitate piercing the armor box around the steering gear room.

39. On vessels with hydraulic ram steering gears, the installation of an emergency diesel unit, similar to that on SALT LAKE CITY, would require some means of preventing the diesel engine from being overloaded in the event of high speed with large rudder angles. In addition, a means of preventing the engine from overspeeding in the event of low or negative torque on the rudder would have to be supplied.

40. Inasmuch as an emergency source of steering power is desirable, particularly in the event of damage, the Bureau has recently designed a compact remote controlled emergency hydraulic submersible pump unit which may be used to control the rudder in event of flooding or other casualty to the main source of steering power. This installation has all the advantages of the diesel-driven unit without the disadvantages discussed above. When available, the installation of this submersible emergency steering unit will be made on all cruisers and carriers with hydraulic ram steering gears. In the interim, a hand-operated emergency hydraulic steering unit has been authorized.

E. Comments and Recommendations Made by the Commanding Officer

41. The Commanding Officer, in reference (a), furnished some notes and recommendations, some of which are briefly discussed below:

(a) "The electric submersible pumps which are now being issued to cruisers are not satisfactory. These pumps will not pick up heavy oil. They soon overload and burn out."

The present portable submersible pumps were not designed for pumping fuel oil and the motors are apt to give trouble when pumping heavy liquids. This is particularly true in the case of the D.C. driven electrical submersible pumps which were aboard SALT LAKE CITY. Although the A.C. driven electrical submersible pumps are more rugged, they are not designed for pumping fuel oil and should only be used for this purpose in instances of emergency. It is noted, however, that the gasoline driven portable pump is a rotary type pump and may be used to pump out spaces that are contaminated with fuel oil provided that cooling water for the gasoline engine is procured from a separate source. The gasoline portable pumps now in service receive cooling water from the discharge side

of the pump; to pump oil, therefore, it is necessary to detach this connection and provide an independent source of cooling water. In addition, the new 50-foot head portable submersible pumps (both A.C. and D.C.) probably will be more effective in removing fuel oil than the older 25-foot head pumps, such as were aboard SALT LAKE CITY. In any event, the Bureau is actively investigating the practicability of supplying a portable submersible pump to the forces afloat which will be effective when used for the removal of oil from interior spaces.

(b) "Fuel oil should be carried in the wing tanks adjacent to the engineering spaces instead of being ballasted with salt water. It is believed that damage by a torpedo in these spaces would be so great that salt water ballast would be of little help whereas oil in these tanks makes fuel readily available to the boiler rooms in event of casualty to the service suction tanks."

On this class of cruisers the two pairs of wing tanks abreast the after engine room are service tanks, and, as such, will probably be approximately half full at all times. Other wing fuel tanks are required to be ballasted with salt water immediately after the oil has been consumed. The reasons for this are set forth in the present "Damage Control Instructions" FTP170-A and the new edition, FTP170-B, which is soon to be issued. The principal reason for keeping liquids (fuel or ballast water) approximately to the waterline in wing tanks abreast machinery spaces is to prevent excessive list when underwater damage occurs. Whether oil or water is present in these tanks at the time of damage is dependent on (a) the sequence of using oil, and (b) the amount of oil which has been used up to the time of damage. With respect to the sequence of using oil the following is quoted from FTP170-B:

"Salt water ballast is preferable to fuel oil from the standpoint of protection, because it removes the fire hazard which is presented by fuel oil in the event of damage which opens the tank top and spreads the tank contents over the upper part of the ship. In previous editions of these Instructions wing tanks abreast boiler rooms have been required to be ballasted with salt water first before other wing tanks in order to remove the fire hazard in this location. However, war experience so far has not indicated that oil in tanks abreast boiler rooms is more hazardous than oil in other tanks which are also adjacent to the side of the vessel. In cases where a sequence for emptying oil tanks is not included on the Flooding Effect Diagram, it is necessary to consider the following, in addition to avoiding fire hazard, in arriving at a proper sequence:

(a) Emptying inner-bottom tanks which are not required to be ballasted for stability purposes, is a step which should be taken early to lighten the ship, thus improving reserve buoyancy and freeboard.

(b) Partial emptying of wing tanks to the external waterline affords the same advantages as (a) above.

(c) Sequence should be such as to avoid extreme trim by the bow or stern.

(d) There is some advantage in using oil from tanks near the ends of the ship at an early stage, because the longer the pipeline leading to the tank, the more the fuel oil system is exposed to damage.

(e) Effective operation on a split-plant basis should not be jeopardized by the sequence adopted."

(c) "Large drainage pumps and a regular main drain should be installed in the engineering spaces or the present main circulators should be so connected that they may be used as drainage pumps without passing large amounts of oil contaminated with water through the main condenser thereby affecting the use of condensers in connection with the engines. During the action, one engine had to be secured as a result of the salt water side of the condenser being seriously fouled by oil."

Although one of the installations recommended above would have been of value to SALT LAKE CITY, in general, it is difficult to justify either installation for the following reasons:

(1) The installation of a main drain would necessitate large penetrations of transverse bulkheads in machinery spaces. In addition, the lead-wiped copper piping now installed would have to be replaced with galvanized steel to preserve watertight integrity, a much heavier material and one more difficult to fabricate.

(2) The modification of the present main circulating pump to provide a direct overboard discharge would require an additional large penetration of the hull, inadvisable for obvious reasons.

(3) War experience has not yet demonstrated the necessity for such installations. Many cases of damage to machinery spaces have occurred and flooding has either been so rapid that no possible drainage installation could have controlled it or else it has been so slow that facilities provided have been adequate, as in this case. The probability of an intermediate case between very rapid flooding, which could not be controlled by practicable pumping capacity, and slow flooding, which is controllable by existing pumping facilities, is so small that the provision of additional pumping facilities is not warranted.

F. Conclusions

42. Damage sustained by SALT LAKE CITY in this action was not serious. The steering gear and boiler casualties, however, placed the vessel in jeopardy while in action.