SECTION IV

U.S.S. OMMANEY BAY (CVE79)

and

U.S.S. MANILA BAY (CVE61)

Kamikaze Damage

Off Luzon

4 and 5 January 1945

Class .....CASABLANCA (CVE55)	Length (O.A.).....512 Ft. 3 In.
Commissioned-CVE61...October 1943	Beam (O.A.).....108 Ft. 1 In.
CVE79..February1944	Draft (Estimated Mean,
Displacement(Full Load)..... 10,400 Tons	Before Damage)... 20 Ft. 0 In.

References:

(a) C.O. OMMANEY BAY ltr. CVE79/A16-3, Serial 001 of 4 February 1945 (Action Report).
(b) C.O. OMMANEY BAY ltr. CVE79/L11/A9, Serial 002 of 3 February 1945 (War Damage Report).
(c) C.O. MANILA BAY ltr. CVE61/A16-3, Serial 001 of 23 January 1945 (Action Report).

Plates IV-1 OMMANEY BAY - Kamikaze Damage
IV-2 MANILA BAY - Kamikaze Damage

Photographs 4-1 to 4-5 (Furnished by C.O. MANILA BAY)

NARRATIVE

4-1. OMMANEY BAY and MANILA BAY were two of six CVE's comprising Seventh Fleet Task Unit 77.4.2 for operations incident to the landing of the U.S. Sixth Army in Lingayen Gulf in January 1945. During the preliminaries of this landing, the carriers were subjected to frequent well-executed Kamikaze attacks. The Task Unit left Kossol Roads on 1 January and proceeded via Surigao Strait and the Mindanao and Sulu Seas to the waters off the west coast of Luzon, providing air cover to amphibious forces en route. Until the evening twilight of 4 January, little enemy air activity had been noted. The sea had remained calm, the wind light and the visibility excellent.

4-2. Just before dark on 4 January, an undetected twin-engined Kamikaze plane approached OMMANEY BAY out of the sun nearly dead ahead. It strafed the ship as it approached and then crashed down and aft through the after end of the open bridge, penetrated the starboard side of the flight deck, started a fire among the gassed and armed planes on that deck and came to rest on No. 1 sponson starboard. Two bombs were reported to have been carried, one of which apparently detonated among the fully armed and gassed planes in the forward end of the hangar, while the other was believed to have penetrated deep into the ship where it disabled the forward boilers. Burning gasoline was sprayed about the hangar. The hangar filled with smoke and the after machinery space filled with smoke and steam. The forward machinery plant was disabled. Fire main pressure failed forward. The hangar gasoline fire spread aft rapidly. Interior communications were disrupted and control of the situation was never regained . Fire main pressure aft was lost and all hangar sprinkling and water curtains failed to function when turned on. After about forty minutes there appeared no prospect of bringing the fire under control and the ship was abandoned. A few minutes later, a heavy explosion attributed to torpex-loaded torpedo warheads blew off the after part of the flight deck. About one hour and a half after this explosion, an accompanying destroyer fired one torpedo into the hulk. It broke in two in the mid-length. The forward half remained afloat a few minutes, but the after half sank immediately.

4-3. During evening twilight of the following day, a prolonged air attack was made against the formation and MANILA BAY was crashed by tow ZEKES with bombs. The first Kamikaze's point of impact was very near to that of the plane which hit OMMANEY BAY. It dived steeply from the port beam, passed through the flight deck at the base of the island and came to rest at the gallery level. A bomb carried by the plane apparently detonated between the gallery and hangar decks. It ignited an intense fire in fully gassed planes in the hangar. A few seconds later the second ZEKE glanced over the bridge, carried away the starboard yardarm, and crashed

into the water alongside. The conflagration resulting from the first hit was promptly brought under control as were several smaller fires. Extensive damage to I.C., radar, and radio circuits was incurred but was later partially repaired. The damaged flight deck and plane handling gear were repaired underway by the ship's company and within 48 hours the ship resumed her scheduled part in the operations, after which she returned to San Diego for permanent repairs.

4-4. Although penetration was somewhat deeper in OMMANEY BAY, the initial damage to the two ships was of comparable severity and in a similar location. The fatal factor in OMMANEY BAY was the complete surprise effected by the attack, which resulted in loss of fire main pressure aft. Fire paralyzed the ship before her personnel could organize to combat it. The fact that she remained afloat for two and one half hours after being hit and then did not sink until torpedoed by a friendly vessel clearly demonstrated that fire was responsible for her loss. MANILA BAY provided a marked contrast. Her damage control organization was in immediate readiness when the hits occurred. A conflagration similar at the outset to that in OMMANEY BAY was brought under control with exceptional despatch and effectiveness. Not only did the ship survive but it succeeded in carrying out virtually the complete schedule of operations for the following two weeks. A total of 397 sorties were flown with very little reduction in efficiency. From the standpoint of damage control, the resiliency and resourcefulness demonstrated in the case of MANILA BAY was outstanding among small carriers.

DAMAGE IN OMMANEY BAY

4-5. Considering the handicaps under which it was prepared, the damage report of OMMANEY BAY is remarkably complete, but it is inevitable when a ship has been lost immediately following enemy action that it will be difficult to ascertain in close detail the damage incurred and its cause. The Commanding Officer of GAMBIER BAY commented in the foreword of his action and loss report, reference (a) of Section III, that a report prepared under such circumstances "must be weighed in the light of the vagaries of the human memory under stress." Similar discretion may be applied in evaluating the abstract from reference (b) of this Section which follows:

> "PART I-GENERAL....
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> "2. The sea was calm, visibility unlimited, eight to ten knots wind from the North. The course of the ship was 290°T., (on Zig Zag leg - base course 330 °), speed 15 knots.

"3. The draft of the ship was 19 ft. 6 in. forward and 20 ft. 8 in. aft. There was no change in list or trim (after damage).

"4. The ship was cruising with the Gunnery, Hull and Engineering Departments in Condition of Readiness III. The Air Department was in Condition Eleven (11). The Engineering Department was operating under the split plant system. Number one generator was supplying power forward and number three generator was supplying power aft. Number one fire pump was supplying pressure to fire main forward loop and number five fire pump was supplying pressure to the after loop. Main engine speed was 135 RPM's. Condition Baker was set throughout the ship, with the following exceptions:

(Y) watertight doors 2-136-1 and 2-152-1 were open to facilitate serving of supper. The fire main was segregated into two loops, valves 2-110-2 and 2-113-1 were closed.

"5. All planes were fueled to capacity, and the gasoline system was purged with inert gas. Cofferdams around gasoline tanks were charged with inert gas.

"6. Nine torpedoes, complete with warheads, were stowed in racks on Hangar Deck, six (6) to port between frames 155 to 168 and three (3) to starboard between frames 155 to 160.

"7. Dinner was about to be served in the wardroom and supper was being served to the crew.

"PART II - STRUCTURAL DAMAGE....

"8. When the enemy aircraft crashed into the ship the first point of contact was the top of the open bridge at frame 62. The after end of the open bridge was destroyed and all superstructure above collapsed. The plane crashed into the starboard side of the Flight Deck at about frame 70. Immediately following the crash the Flight Deck and planes forward on starboard side burst into flames. A bomb exploded on the Hangar Deck forward starboard side at approximately frame 76. A second bomb exploded in GSK Storeroom (A-407-A) or in lub oil tanks (A-408-Lub and A-409-Lub.). All communications and power were out in the forward part of the ship.

"9. The following structural damages were incurred:

(a) Island Structure - The after half of the open bridge was destroyed and all the superstructure

above collapsed on the Flight Deck just aft of the island.

(b) Flight Deck - Gasoline and ammunition from the torpedo plane aft of the island began to burn immediately. As a result of the strafing, gasoline was leaking from the planes. Fire spread aft on the Flight Deck. Dense black smoke engulfed the entire starboard side aft.

(c) Gallery Deck - Flames shot up from Hangar through open hatch-way to light lock (Fr. 101 Port) and made this passage impassable. The deck and bulkheads of the Squadron Ready Room were buckled, part of the overhead collapsed, and furniture was thrown about. No. 12 Clipping Room (Fr. 102-107 Port) caught on fire and ammunition commenced exploding. As the fire progressed ammunition became ignited in other clipping rooms. The communication and power cables in the trunk lines along the starboard under side of the Gallery Deck were severed at about frame 80 by the plane and bombs.*

(d) Hangar Deck - A large hole was blown in the deck, starboard side, by a bomb at about frames 76 to 82. As a result of the explosion the planes forward were destroyed and burning gasoline was sprayed about the hangar. All planes on the Hangar Deck were fully gassed and armed with (machine gun) ammunition.** Planes and debris were piled up throughout the Hangar Deck. Ammunition exploding caused projectiles to ricochet around the deck. Shrapnel penetrated the bulkheads at frames 32 and 48, the forward and after sides of the CPO Quarters, and the force of the explosion collapsed several sections. The bulkheads of the Oil King's

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* Reference (a) further states that all bridge power, communications (including communication with the enginerooms) and steering control were lost immediately.

** The number of planes on the flight and hangar decks at the time of the attack were not reported. Planes on the hangar deck had not as yet been degassed for the night, but all bombs and rockets were in the magazines, and the gasoline system was purged.

Shack, Master-at-Arms Office, and Torpedo Work Shop, frames 85 to 115 port side, were buckled and blown in. Buckheads of the after uptake frame 118 to 120 port were ruptured by the explosion. Inboard bulkhead of the Deck Office, frame 105 starboard was blown outboard. The bulkheads and deck of stateroom 0121 were blown in. Starboard side bulkhead of the forward elevator was ruptured and buckled. A dense gray smoke spread throughout the Hangar Deck, followed shortly afterward by heavy black smoke.

(e) Second Deck - The starboard side of the Sick Bay was demolished (Fr. 72 to 82). The firemain was ruptured between frames 77 to 80. There was a large hole in athwartship watertight bulkhead, starboard, at frame 82.

(f) First Platform Deck - Junior officers country (Fr. 66 to 82) lights were knocked out, gear, clothing, etc. strewed about deck, which was covered with oil, and the space filled with dense smoke.

(g) Second Platform - There is strong reason to believe that a second bomb caused damage to the GSK Storeroom, (A-407-A),or Lub Oil Tanks, (A-408-Lub and A-409-Lub). Fuel or lubricating oil was noted in the junior officers country immediately after the explosion.

(h) Forward Engine and Boiler Room - No. 1 Boiler and the steam lines from the forward Boiler Room were ruptured. All fires under No's. 1 and 2 boilers were extinguished by the explosion. The fuel oil service pumps were blown from their bases and fuel oil covered the deck.

(i) After Engine Room - Communications with the bridge were disrupted. Dense smoke entered via the uptake due to rupture of uptake bulkheads on the Hangar Deck.

"PART III CHRONOLOGICAL ORDER OF EVENTS

1712 - Enemy aircraft crashed into the open bridge (Fr. 62). A bomb presumed to be a 220 kilogram delayed fuse bomb penetrated the Flight Deck and exploded on the starboard side of the Hangar Deck between frames 74 to 82. A second bomb, penetrated to the Second Platform Deck and detonated in or near the GSK Storeroom.

1712 - General Quarters sounded faintly in some parts of the ship. Lights, communications and power went out throughout the ship. Black smoke and fire came from the forward half of the Hangar Deck.

1713 - The Forward Engine Room was out of commission, which resulted in permanent loss of power and fire main pressure forward. Fire main pressure gauge on forward loop (located in line leading to fire plug 2-97-2) registered zero. Turned on emergency lighting.

1713 - 1/2 - Fire main stop valves (2-110-2 and 2-113-1) were checked and found to be closed. Lights were restored in after part of the ship. Heavy black smoke began to enter wardroom, After Engine Room Spaces, C.P.O. Quarters and living spaces forward.

1715 - Fire hose was led out on Flight Deck from fire plug 02-192-2, one small gush of water was reported, then pressure failed. Fire main stop valve 2-113-1 was opened by Repair V Officer on report that Forward Fireroom was unable to furnish fire main pressure forward. Rupture in fire main forward was not known by the Repair V Officer. Other fire fighting parties reported no water pressure on Flight Deck. Remote and local control valves for Hangar Deck Sprinkling System and water curtains were turned on but did not function. Attempt was made in forward part of the ship to extinguish fires with CO_2 bottles from Repair II. Fire on Hangar Deck was spreading aft with plane ammunition detonating. Sprinkling system to clipping rooms turned on but no water pressure. Bled off high pressure air banks in catapult spaces.

1730 - Destroyers were unable to get alongside amidships to pass fire hose due to intense heat of fires on Hangar Deck.

1736 - Abandoned After Engine Room due to intense smoke. No. 3 and No. 4 boilers were secured. Feed pumps were left operating to raise boiler water level. Throttle to fuel oil service pumps was secured. Engineering personnel made their way aft via uptake to Second Deck, then to fantail.

1740 - Started to lower wounded over the side from forecastle. Destroyer came alongside starboard bow, but backed clear immediately when carrier drifted down and damaged the port wing of the destroyer bridge.

1745 - Gunnery Officer ordered men and officers to abandon ship from fantail.

1750 - Captain ordered abandon ship from forecastle-wounded were in process of being removed.

1812 - Captain was last man to abandon ship.

1818 - Torpedoes detonated* on after end of Hangar Deck. The Flight Deck aft collapsed and the ship was burning throughout. The ship took a small list to starboard. Intensity of fire remained such as to insure that the ship was practically gutted during the next hour.

1940 - The OTC ordered the USS BURNS to sink the USS OMMANEY BAY by torpedo.

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* Reference (a) indicates that two heavy explosions occurred aft on the hangar deck at 1818.

1958 - USS OMMANEY BAY was sunk by torpedo from USS BURNS."

DISCUSSION OF THE LOSS OF OMMANEY BAY

4-6. The plane which crashed OMMANEY BAY was tentatively identified as a FRANCES, one of the largest types known to have been employed in Kamikaze attacks. Its normal bomb load was 1100 pounds. The size of plane is consistent, therefore, with the size of the bombs (two of 500 lb. each) suggested in reference (a); however, the limited extent of damage both in way of the flight deck and the underwater shell indicate that the blast effect was considerably less than normally caused by the detonation of two bombs of that size in the locations reported.

4-7. There appears to be an absence of direct evidence to support the belief that a large bomb detonated below the first platform level. The GSK Storeroom was situated well below the waterline, on the tank top, between the gasoline tanks and the forward engineering space. The detonation in that compartment of a large bomb would probably have resulted in flooding from the sea and might have caused the rupture of the gasoline tanks by fragment attack. Neither event appears to have taken place. The absence of reports of gasoline vapor explosions in the subsequent fire and the absence of any list or increase in draft prior to the torpedo warhead explosion aft in the hangar an hour later would support the conclusion that the hull and gasoline tanks remained intact. The oil observed on the deck in the J.O. Country could have come down from damaged aircraft, servicing drums, or arresting gear in the hangar.

4-8. Reconstructing the event on the basis of direct evidence only and disregarding the conclusions reached by the ship's report as to the locations and number of bomb blasts, it seems quite possible that only one large bomb detonated and that this occurred near the uptakes of No. 1 Boiler, close to the starboard side, at or slightly below the hangar deck. This would explain the small amount of damage to the flight deck, the absence of flooding from the sea, and the damage in the starboard side of sick bay.

4-9. The immediate occurrence of large quantities of dense smoke in the hangar was typical of bomb blasts and ensuing gasoline fires which have occurred in hangars containing numerous gassed aircraft. Reference (b) stated that the bulkheads of the after uptakes, frames 118 to 120 port, were ruptured by the detonation of the bomb at frames 76 to 82 starboard. It is reasonable to surmise, therefore, that the forward uptakes, which were much closer to the detonation, also were ruptured. This circumstance would have contributed to the suddenness with which black

smoke filled the hangar. The forward and after uptakes enter selective Y connections just under the flight deck so that smoke can be released through either the port or starboard stacks, depending on the relative wind. At the time of the action, the relative wind was on the starboard bow, hence the port stacks were in use. Thus, the bomb blast could have permitted stack gases from the uptakes to enter the hangar.

4-10. The loss of OMMANEY BAY was due to the rapid extension of the fire throughout the hangar and to the inability of the ship's personnel to develop any coordinated fire fighting effort after the hit. The factors which prevented effective damage control were the loss of communications in a ship not initially at battle stations, and the rapidity with which smoke engulfed the hangar and the second deck spaces in the vicinity of the hit, such that personnel were unable to proceed to their battle stations. As a result, the potential effectiveness of the sprinkling system, water curtains, etc., was never realized although the fire protection installation and nature of damage were such that it appears to have been possible, even after valve 2-113-1 had been opened and abandoned, to regain control of the situation by the employment of valves in the as-yet unaffected parts of the ship. The closure of fire main valves 2-135-1 and 4-134-1 in the after crew's messing compartment and in the after engineroom, respectively, would have permitted the two pumps in the after engineroom to maintain pressure on the main in the after end of the ship. By closing valves 3-112-2 in the generator room two additional pumps could have been put on the after loop. The then operative section of the fire main would have included the water curtains and sprinkling system abaft frame 132 in the hangar. The experience of other carriers indicates that use of the hangar sprinkling system could have prevented the detonation of the warheads stowed aft in the hangar and also might have allowed the fire fighting party to organize and extinguish the fire.

4-11. An excellent illustration of a case in which fire fighting was effective despite similar handicaps was SALAMAUA (CVE96) (See Section VII - J), a sister ship in the same task unit, which was hit near frame 130 starboard by a single-engined Kamikaze plane nine days later. The plane penetrated to the hold. Two bombs were carried. One passed out through the starboard side above the waterline without detonating, but the other detonated near the first platform level. It caused extensive flooding and an 8 degree starboard list. When hit, SALAMAUA was in Material Condition ABLE EASY and the arming of aircraft was proceeding in the hangar. Electrical power was lost immediately, communications were severed, the after fire main loop carried away and dangerous fires broke out in the hangar. Although the after engineroom was flooded and evacuated, power was promptly restored from the forward plant. The forward fire main loop remained intact. Fire parties were organized and, under the protection of water curtains and sprinklers

in the forward end of the hangar, hoses were led aft. The fires were extinguished in about half an hour and the ship was able to proceed to Leyte Gulf on one engine.

4-12. The difficulty OMMANEY BAY encountered with the problem of smoke forcing evacation of otherwise undamaged engineering spaces occurred frequently in carriers suffering hangar conflagrations. Use of RBA has been one defense against it. All damage control personnel should receive training in the use of this apparatus and it is highly advantageous for all hands to understand its capacity and limitations. The current allowance for the CVE105 Class is 180. In the engineering spaces air line hose masks, converted from standard gas masks and connected to the low pressure air line were rigged in several carriers in the latter part of the war. These masks were successfully used in ENTERPRISE (CV6) and RANDOLPH (CV15) but HANCOCK (CV19) found that a casualty to the L.P. main made it necessary to use RBA. Present installations of air line hose masks employ independent air banks in lieu of the L.P. air main. Numerous carriers suffered personnel casualties or lost services of an engineering space, particularly boiler rooms, due to the failure to provide adequate emergency breathing arrangements for personnel on watch in spaces which became smoke-filled but were otherwise intact.

4-13. Although the preliminary design of ventilation systems on combatant ships generally provides two primary sources of air supply for major spaces, particularly machinery spaces, practical difficulties which arise during the design development and building periods result in the elimination of dual sources of air in some of the spaces. The use of dampers on ventilation supply ducts has been considered as an alternative method of reducing the smoke hazard in machinery spaces, but the capacity of machinery space ventilation systems is based on the quantity of air required to maintain a temperature in which men can work. Service experience has demonstrated that the shutting down of supply ventilation in way of main engineering spaces while machinery is operating will result in a sharp rise of the ambient temperature, probably to temperatures approaching 180° within a short period of time. Therefore the damping of supply ventilation is not a very satisfactory solution of the problem. Fog sprays for cooling personnel wearing breathing equipment have been employed in some cases where excessive heat made the compartment otherwise untenable.

4-14. The survivors of OMMANEY BAY recommended several alterations to improve the damage resistance of the CVE 55 Class. These included the addition of Diesel fire pumps in the ends of the ship, bridge controls for sprinkler valves, and duplicate port and starboard I.C. circuits. None of these features could be accomplished in the CVE 55 Class, but the first and third recommendations were incorporated

in the CVE 105 Class. The second suggestion is considered to have more disadvantages than advantages and has not been provided in any carrier.

4-15. It is not apparent that any of the suggested changes would have altered the fate of the ship in the incident which resulted in her loss. The occurrence of the bomb blast in a highly vulnerable spot combined with the presence of a number of fully fueled planes in the hangar and the absence of any warning whatsoever of the attack, constituted a set of circumstances which, in an unarmored carrier, could not be guarded against effectively by any reasonable alterations. With the then existing segregation of the fire main on OMMANEY BAY, the suggested additional fire pumps could not have helped even if they had been available. As it was, four intact and available pumps proved useless. It is doubtful if bridge controls for the hangar sprinkling system could have been used because of the suddenness of the attack and the likelihood that such controls would have been disabled,as was virtually every other circuit running to the bridge. Duplication of I.C. circuits, while undoubtedly desirable, is similarly inadequate protection against severe damage just under the island.

4-16. Some concern may be felt as to the reason OMMANEY BAY broke in half after a single torpedo hit amidships. This can be logically accounted for. In the intact full load condition calculated maximum hogging stresses for the CVE55 Class were high.* The fire and explosions in the hangar undoubtedly reduced substantially the strength of the upper flange of the hull girder in OMMANEY BAY. The second deck, the only other continuous deck, was probably also severely damaged in way of the torpedo warhead detonation. BURNS' torpedo heavily damaged the underwater shell amidships and subjected the ship momentarily to severe hogging, with consequent complete failure of the hull girder.

DAMAGE IN MANILA BAY

4-17. At 1650 on 5 January, MANILA BAY went to General Quarters and set Material Condition ABLE because of numerous contacts with enemy aircraft which continued for about one hour. Formation speed was 15 knots. Eight VF's had been launched to serve as a combat air patrol before the ship went to General Quarters. Previously, on the basis of a report of the presence of suitable Japanese surface targets, preparations had been made to launch a strike of torpedo planes, but these had not yet taken off. Arming and gassing of the 23 aircraft onboard was proceeding as shown in Plate IV-2. At 1746, about six Kamikazes attacked the formation. They came in close to the surface out of the sun on the port beam (ship's course 000°T.). Two ZEKES selected MANILA BAY as their target and executed an expert approach, weaving and strafing as

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* See paragraph 3-50 for further discussion.

they came in at high speed. About a thousand yards from the ship they pulled up sharply into a climbing turn then dived steeply into the ship from an altitude of about 800 feet. Heavy anti-aircraft fire damaged both planes and apparently interfered with the aim of the second attacker, but both hit their target. The first smashed through the flight deck at the base of the island and the second glanced over the bridge and carried away the starboard yardarm.

4-18. The two hits damaged the flight and gallery decks, ignited intense gasoline fires at the base of the island and below it in the hangar, interrupted steering control and cut all radio, radar, sound-power and ship's service telephones, and MC circuits and annunciator systems with the exception only of the LC (gyro compass) circuit and of parts of the JA and JY circuits. Hangar sprinkler No. 1 and hangar deck water curtain No. 1 in the forward end of the hangar were destroyed from the centerline to the starboard side. The structural damage consisted mainly of a hole about 16 feet in diameter in the flight deck between frames 68 and 80, jamming of the forward elevator and bowing of its platform, extensive fragment damage to the hangar deck with minor damage on the second deck, and extensive blast damage to non-structural bulkheads in the gallery, upper and hangar decks within about a 40-foot radius of the hit. The main propulsion plant remained intact, but the loss of power on the MB circuit (engine order telegraph) apparently caused the indicator on the annunciators to drop to "Stop". On the basis of this signal, throttles were closed and remained so about 15 minutes until ahead orders for both engines were confirmed by the bridge.

DAMAGE CONTROL IN MANILA BAY

4-19. As the first plane plunged through the flight deck and came to rest in the radar transmitter room, fires broke out in that compartment, in Radio II, on the flight deck, in clipping rooms on the gallery deck, and among parked aircraft in the hangar. The excellent fire fighting measures then taken are best described in the words of the action report, reference (c).

> "Time 1748 - Japanese plane crashed through flight deck. All hangar water curtains and sprinklers, second deck passage sprinklers (frames 47 to 66), third deck sprinkler (frames 66 to 82) and sprinklers to magazines C-302-2A, C-302-1A and C-302-1M turned on immediately, both at control panels on hangar deck and at control valves on lower decks. This was in accordance with pre-arranged damage control procedure in this ship. Grove valves operated perfectly and the hangar was inundated almost immediately. Less than 5 seconds elapsed between the hit and the time water started flowing.

"The two TBM's farthest forward and the TBM next aft on the port side in the hangar were riddled by shrapnel and set afire. These planes were fully gassed. The second TBM on the starboard side was damaged and gasoline from ruptured tanks added to the fires. Curtain and sprinkler water kept the fire down on exposed surfaces but fire underneath the planes spread rapidly toward port side of hangar. Fire Station 1-82-1 was destroyed and Fire Station 1-84-2 was untenable as it was in midst of the fire area. Fire party from Repair II led hoses from the fire stations on the second deck through the port door in forward elevator pit and also led hoses through scuttle 1-82-1 to fight burning planes from forward. These men wore rescue breathing apparatus and asbestos suits. Fog and foam was used on the planes. Foam was tried on the gasoline fires underneath the planes but sprinkler and curtain water broke up the foam. However, the abundance of sprinkler and curtain water plus local applications of fog soon thereafter broke up all gasoline fires, held down temperatures and restricted air so that flarebacks or new fires could not form. All hangar doors were closed during this phase of firefighting.

"Hoses were led by Repair five fire party through hatches 1-100-1 and 1-114-1 to the hangar deck and open nozzle and foam used to fight fire over number one sponson doors, and in Crews Shelter (A-0209-3L) and in Clipping Room #7 (A-0210-1M) both of which were demolished and exposed to the hangar.

"Hoses from hangar deck fire stations were used to confine the spread of hangar deck fire to an area forward of frame 90 and to fight the fire in the planes from aft. They also aided in fighting fires which were started by hot or burning shrapnel in Flight Crews Ready Room (forward air intake), Clipping Room (A-0209-2M) and other small fires in the spaces whose bulkheads had been destroyed or buckled and were now exposed to the hangar.

"Fires on the flight deck near vicinity of the crash and in the island structure were fought with open nozzle, fog and foam. All Fire Stations except 02-75-1, which was destroyed, were manned. Streams from flight deck hoses through the hole in the flight deck aided in putting out fires in the demolished spaces, Radio II, Radar Transmitter Room, Shelter (A-0209-3L) and Clipping Room #7 (A-0210-1M). Hoses from gallery deck stations 02-52-1 were also used on fires in Radio II and Radar Control.

"Time 1755 - Fires in Radio II, Radar Transmitter Room, Radar Control and on flight deck are out.
"Time 1802 - Fire in hangar under control.
"Time 1803 - Turned off all water curtains and sprinklers."

4-20. At 1804, it was noticed that a 4 degree port list had developed due to the effect of the sprinkling water which had failed to drain off. In the hangar the three doors on the port side leading outboard were opened to drain off what was described as ankle deep water. Water was allowed to spill through hatches in the hangar deck and lower decks to cofferdams A-912V and A-915V, the shaft alleys and the bomb stowage whence it was disposed of by main and secondary drains and submersible pumps. Portable gasoline pumps were used to clear the elevator pits. To correct the port list bottom fuel oil tank B-905F, previously empty, was filled with fuel. The source of this oil was not reported but it was probably from a similar tank on the port side. While this transfer was in progress, the ship rolled through the upright to a 4 degree starboard list which it assumed by 1815. At this time the starboard sponson doors were opened to spill overboard water pocketed in the hangar. Within five minutes the removal of loose water reduced the list to 1 degree starboard.

4-21. After 1820, with list and flooding under control and all fires extinguished, the ship was underway, steering with the engines. Communication with other vessels was accomplished by Aldis lamp. On the bridge, messengers were the only means of maintaining communication with the damage control and engineering departments. As the effort to re-establish electrical circuits progressed, numerous small fires rekindled in the damaged spaces but were quickly brought under control. At 1825, steering control was established at Batt. II and by 1900, the ship resumed her position in formation. Half an hour later, intership communications were being carried on from MANILA BAY using the VHF gear in a plane on the flight deck. It is of interest to note that a similar rig was also the only means of radio communication available on SANGAMON (CVE26) after her action of 4 May 1945. The pumping out of sprinkling water continued until 2300 when GSK Storeroom A-407A and the cofferdams below it were finally emptied.

4-22. The scope and thoroughness of emergency repairs accomplished by the ship's force of MANILA BAY to permit the ship to carry out its mission are worthy of description in greater than usual detail. Therefore, the action report is again quoted:

"(a) Hole in Flight Deck - Damaged planking was cut back to a straight edged clearing 18 by 18 feet. The 16 foot hole downward through the steel decking was bridged with 2"x 12" planks. These were supported by a 6" x 6" beam and a

6" x 6" post wedged against sheared web of transverse main girder, frame 72. Planking was covered with sheet metal. A slightly uneven surface capable of supporting one wheel of a TBM when pushed over it resulted from this repair.

"(b) Structural Damage, Gallery Deck - Buckled fore and aft beams between main transverse girders frames 72 and 78 were cut out. Demolished starboard 30 feet of arresting gear catwalk frame 74 was cut out. A new catwalk of steel pipe and sheet metal was manufactured and installed. Damaged and bent barrier and arresting gear guide piping under flight deck in this area was removed and new arresting gear wires were strung openly. Demolished deck in Shelter, A-0209-3L, and Clipping Room, A-0210-1M, was cut out and the deck opening covered with canvas to exclude light and weather. Buckled joiner bulkheads in gallery deck were temporarily repaired by forcing and shoring. Buckled steel channel supporting #1 Motor Whaleboat falls and fairleads was heated and drawn partly back into shape.

"(c) Electrical Repairs - The first circuit established was emergency AC power from the Interior Communications Room to an SQ Radar set on forward part of Flight Deck. To effect immediate repairs to other electrical circuits, it was of utmost importance to inspect and be positive of the soundness of the circuit beyond the necessary splices and jumpers. Lengths of cable previously made up on board for Direct Current Casualty use were used to carry power to essential circuits while these inspections were made. Original cables were not often damaged beyond the area of the bomb hit but in several instances shrapnel was found in parts of circuits well outside that area. Jumpers were then spliced in place of the defective wiring.

Telephone circuits were left untouched at first and direct lines of emergency sound-powered phones used in place of defective circuits. These phone sets were of various lengths from 100 to 300 feet. They had been made up and placed in different parts of the ship for just this purpose, and resulted in restoration of essential communication in the shortest possible time and at a time when the electricians were urgently needed to restore necessary power and lighting circuits.

"(d) Radio Repairs - Temporary repairs were effected to produce the maximum external communications efficiency consistent with the amount of damage sustained. The repairs made can be roughly divided into two groups.

(a) Repairs to Power Lines

Temporary power lines were run to the following radio equipment:

2 - TBS transceivers (in CIC § Air Plot)
2 - Speaker Amplifiers (in CIC)
10 - Receivers (in Radio I)
2 - ECM's
1 - MAN transceiver (in CIC)
2 - BC - 640 transmitters (Radar Control)
2 - BC - 639 Receivers (in CIC)
1 - TBH Receiver (in CIC)
1 - TCE (transmitter in CIC)
2 - 233A VHF transceivers (in CIC)

(b) Repairs to Equipment

Two damaged TBS antennas repaired (Both will require complete adjustment).

Antennas for MAN and SCR 610 transceivers were repaired. Several coaxial transmission lines to VHF antennas were replaced. One is jury-rigged due to shortage of coaxial and the others are not completely secured.

(NOTE: The number of new coaxial lines run was possible because of a large inventory of PT 50 and BT 70 cable).

The MAN receiver was repaired but the transmitter component is still inoperative.

Several damaged receivers in Radio I were placed in operative condition but reliability is questionable.

2-BC-640 transmitters which were soaked with salt water were dried out but are not working satisfactorily due to water still in transformers, etc. These are not operative.

1-233 A VHF transceiver was placed in operation.

Both ECM's have been temporarily repaired but are not in fully satisfactory condition.

Temporary repairs were effected permitting receivers in Radio I to be patched to CIC speaker amplifiers through the damaged control panel in Radio II.

With assistance of the C § R Department all destroyed radio transmitters and equipment in Radio II have been cut up and jettisoned.

"(e) Radar Repairs - No repairs were possible in Radar Transmitter Room as that space and equipment therein including the SG transmitter-receiver was completely demolished.

The SK coaxial system was repaired in 3 places with temporary copper patches. One selsyn in the SK pedestal was replaced and cables spliced where damaged by shock or shrapnel. The high voltage transformer and numerous resistors and capacitors damaged by salt water were replaced. The SK Radar is now in fair operative condition. New Coaxial cables were run to the BL and BK and two patches were made in the BL antenna system. The parts of the BL transmitter-receiver damaged by salt water were replaced.

"(f) Forward Elevator - Platform was jammed into port forward corner of elevator well at flight deck. Sledge hammers and wedges were used to pry the platform loose and free the elevator. Thereafter attempts were made to eliminate the four-inch bulge about 20 feet across in the elevator platform but bracing and supports under the platform were too badly sprung and were so pulled loose at welds that the repair could not be effected. However the 4 inch upward bulge about 20 feet across in flight deck forward of elevator was successfully pressed out. This was accomplished in the following manner:

> Holes were drilled through flight deck on either side of fore and aft flight deck beams in vicinity of the bulge. 7/8" wire straps were passed around these beams and brought to form a loop on the flight deck. A 6 x 6 timber was passed through the loop at the deck, a jack placed on top of it and a 6 x 6 timber placed between the jack and the top of loop. Four such loops were used at one time with two 12 ton screw jacks and two 5 ton hydraulic jacks. When the deck was pressed down to the place where the plating had torn away from the beams, the plating was re-welded to the beams and the jacks removed.

"(g) Piping - High pressure air line was temporarily repaired with new sections of line connected by high velocity power bonding sleeves. These connections however are unreliable under 3,000 lbs. air pressure and had to be silver soldered to make a reasonably tight joint. Low pressure air piping between frames 68 and 80 was renewed.

"(h) Sprinkler #1 and Water Curtains #1 - These were destroyed from center line to starboard. A two pipe starboard section of Water Curtain #1 was manufactured by welding 30 pieces of 1/2-inch pipe, 4 inches long at regular intervals to lengths of 2-1/2-inch pipe. The nipples were flattened at one end to form a spray head. On tests the spray therefrom proved highly satisfactory. A new section of water sprinkler #1 was manufactured and installed.

"(i) Ventilation - Ventilation sets 1-76-1 and 1-79-1 with their

intakes, heaters and vertical ducting were completely demolished and had to be cut away and thrown overboard. 1-79-1 supplies Sick Bay. A temporary system for Sick Bay was first rigged using the blower from Airplane Boom Resistor Room on the remaining supply duct. However, this was unsatisfactory and was overloaded. The exhaust blower 1-79-2 was then used in its place and a reasonable amount of ventilation furnished. There is now no mechanical exhaust from this area. Damaged supply ventilation ducting to A-303-L was repaired.

"(j) Hangar Deck - Shrapnel holes in hangar deck were repaired with welded plates.

"(k) Hatches and Doors - Sprung hatches, doors and frames were straightened as much as possible by sledging and by jacking against strongbacks.

"(l) Fire Fighting Equipment - Strainers, valves, hoses and other firefighting equipment damaged by shock, fire and shrapnel were replaced."

4-23. The record of operations in the Air Department is not usually pertinent to damage control but in the case of MANILA BAY it is of unusual interest. The operation plan called for the ship's aircraft to support amphibious landings in the initial phase of the invasion of Luzon. Despite the considerable handicaps imposed by damage, this was accomplished as indicated in the excerpt of the action report quoted below.

"The flight of 8 VF's from MANILA BAY which had been in the air at the time of the suicide attack and which had landed on NATOMA BAY and STEAMER BAY returned aboard about 1230, 7 January. These planes could have landed the previous day except for the fact that only one barrier was operable.

"Numbers two and three barriers had been badly damaged by the explosion. Number two barrier by an intense effort on the part of the arresting gear crew had been placed back in commission and an emergency jury rig barrier was erected in case either of the other barriers was carried away in a bad crash. The third plane to land engaged the barriers breaking the purchase cable on barrier number one. The next five planes were successfully landed with one barrier and the jury fence rigged and with number 9 arresting wire out of commission.

"Limited flight operations were conducted on 8 January. Having received replacement planes 8 VT's and 2 VF's from SHAMROCK BAY and KADASHAN BAY, and casualties from battle damage having been somewhat restored, it was possible to conduct a fairly full schedule on 9 January. On that day, MANILA BAY planes made 42 sorties. From then on the full schedule assigned was carried out.

"After the bomb damage occurred, the most pressing handicaps to the conduct of successful flight operations were, in the order of importance, lack of a bull horn, sound powered phones, siren, squawk box and wind indicator. Also contributory to difficulties were a jammed forward elevator, two inoperative barriers, lack of night landing lights and the loss of two tractors. The upward bulge of the forward elevator gave a nasty bounce to fighters when flying off. This was considered especially hazardous for pre-dawn launchings and the catapult was therefore used exclusively for such launchings.

"Much credit is due the arresting gear crew who got all three barriers back in commission within a period of 72 hours and to the ship's electricians who restored all inoperative items one by one within a few days by repair or by installation of a satisfactory temporary rig."

PREVENTATIVE MEASURES AGAINST HANGAR CONFLAGRATIONS

4-24. For many years the primary problems in warship protection were the provision of adequate side and deck armor protection, the development of underwater protection systems and the provision of adequately armored and subdivided magazines and powder trains. In carrier design, while these considerations are still important in varying degrees, war experience proved conclusively that the vulnerability of hangars to bomb and suicide plane attack, which will be augmented in any future war by guided-missile and pilotless-aircraft attack, presents one of the principal problems in carrier protection. The necessity for speed and flexibility in aircraft handling operations and the bulkiness of the various components involved therein prevent the employment of armor and segregation to the degree possible in the protection of vulnerable munitions and related equipment in ship types whose primary weapon is firepower. High-octane gasoline and high-explosive ordnance in aircraft in the hangar constitute a threat in battle more serious than anything else present in an aircraft carrier except the magazines. While this threat can be reduced by early warning of attack, it is frequently impossible to avoid attack until such hazards have been removed from the hangar. The urgent need for measures which will prevent, limit or extinguish hangar conflagrations has been repeatedly borne out.

4-25. The loss of PRINCETON (CVL23), ST. LO (CVE63), OMMANEY BAY and BISMARCK SEA (CVE95) was primarily due to hangar conflagrations following air attack. The three most serious cases of battle damage in CV9 Class carriers were those of FRANKLIN (CV13), 19 March 1945,

TICONDEROGA (CV14), 21 January 1945 and BUNKER HILL (CV17), 11 May 1945; each of which suffered disastrous fires centered in the hangar, with heavy loss of life. Although these ships survived, they, like many which suffered less extensive fire damage, required several months for repairs before they were again ready for action. In each of the seven vessels named there were numerous gassed aircraft in the hangar when the attack occurred and in each case except BUNKER HILL numerous heavy explosive charges were also present in the hangar. In each of the seven cases, damage to, or delays in starting, the hangar sprinkling systems allowed the fires a few minutes head-start which proved impossible to overcome with the facilities provided except where the size of the ship was such that large undamaged areas remained tenable.

4-26. Five ways of reducing the vulnerability of carriers to hangar conflagrations are:

(a) Reduction of the probability of surprise attack
(b) Provision of more adequate fire protection
(c) Reduction of the fire and explosion hazards, primarily gasoline and ammunition in the hangar
(d) Segregation of the hangar by transverse armored bulkheads
(e) Armoring the flight deck, or flight and gallery decks

4-27. The warning of impending attack is most likely to come from search radar. In the CVE105 Class the search radar installation has been improved mainly by the addition of an SP unit to the previously installed SK3 and SG1D radars. The first two are for air targets and the latter is for surface search. The SP unit is used primarily in fighter director work, i.e., to direct the interception of enemy aircraft by the combat air patrol. It is capable of scanning to an elevation of 30 degrees and will range on a single small aircraft with a constant error of less than 200 yards through ranges up to 50 miles. The SK3 used for air search has slightly greater range than the SP but accuracy is less and the maximum elevation is limited to 17 degrees. It indicates range and azimuth only. The need for a zenith search unit is recognized. Makeshift units used for this purpose during the war did not prove satisfactory but the SG6 is designed for this purpose and should be available in the near future.

4-28. Another means to prevent surprise is the method adopted very successfully on ENTERPRISE in the latter part of her distinguished career. This was the simple but strenuous expedient of maintaining General Quarters whenever there was danger of enemy attack and maintaining Material Condition ABLE throughout the period that the ship was in the strike area. With the development of guided missiles

of extremely high speed, long range, and high trajectory, the need for maintenance of maximum closure and readiness for damage control becomes increasingly apparent. At present, ships are not designed to accommodate personnel at battle stations for prolonged periods. This would appear to be a desirable development for the future.

4-29. With respect to provision of more adequate fire protection, the high capacity fog-foam system is the outstanding development. This equipment can deluge a hangar with foam in a very short time and in tests at Edenton, North Carolina, it extinguished fires among parked aircraft, which involved several thousand gallons of aviation gasoline, in less than ten minutes. The system is currently authorized for installation on the hangar decks (monitors, 2-1/2-inch hose outlets and 3-1/2-inch hose outlets), and flight decks (2-1/2-inch hose outlets only) of all operating carriers. It has the advantage of permitting either a distributed or a concentrated application of foam. Monitors, standing approximately 3 feet above the deck at the head of 3-1/2-inch risers, throw a 45 degree cone of fog-foam across approximately 40 feet of the hangar. The alternate positions of monitors on opposite sides of the hangar permit a dovetail coverage of the full length of the deck. When personnel can gain access to the monitors, stream shapers may be rigged which permit a concentrated foam stream to be directed on any burning material within an 80-foot radius of the monitors. The smothering effect of foam reduces to a considerable degree the dense mixture of smoke and vapor formed when hangar fires are combatted by sprinklers.

4-30. The next important fire protection improvement in CVE's has been in the fire main itself and in the capacity and dispersion of pumps. The CVE105 Class has a loop on the main deck, under the hangar deck, which is fed by risers from 12 pumps located in seven well-separated compartments, i.e., the four main engineering spaces and three Diesel pump rooms. By means of cross-connections at the third platform level any of the pumps may serve the main through any of eight risers throughout the length of the ship. It is therefore possible to put at least three pumps on each of three segregated sections simultaneously or to put any combination of pumps on any one section at one time. It is very unlikely with such an arrangement that the ship would be unable to maintain pressure on an intact segment of the fire main.

4-31. In the design of a fire main system for an aircraft carrier without structural subdivision of the hangar, the total pumping capacity provided is based on the amount of water necessary to fight a reasonable number of small fires throughout the vessel while simultaneously sprinkling the largest group of magazines and fighting a gasoline fire in one half of the hangar. The system is then divided into a number of segregated sections, each section containing its own pumps and designed to operate as an independent unit. Since the total pumping capacity for the entire fire main system is designed to enable the system to handle

only a portion of the total fire fighting services installed throughout the vessel, it follows that the pumps within each segregated section will not be capable of simultaneously supplying all the services within that section. It is obviously impractical and undesirable to provide pumping capacity to equal the connected load throughout the fire main or in each of its segregated sections. To date, the segregation of the fire main systems of all carriers except CVB's has been left to the discretion of the operating forces. Since the number of sections into which a fire main is to be divided determines many of the important design considerations such as pump and valve locations, pump and fire main capacity, valve remote controlled operation, etc., it is important that the most favorable segregation be determined as a result of study in the design stage. Accordingly, it is the intention of the Bureau to determine the segregation early in the design of the fire main in order that the best segregation can be provided for each new ship class. Segregation should limit the effects of damage to the section of the fire main actually damaged and thereby maintain a maximum length of the main in operation. Segregation should prevent widespread loss of fire main pressure as a result of localized damage. Subdivision into so many sections that some sections would have no pumps connected, or into so few sections that any given damage would incapacitate long lengths of the fire main far beyond the actual extent of damage, are the obvious limits of sectionalization. The best degree of segregation is a compromise between the extremes mentioned above. Segregation should, despite any local rupture of the fire main, limit the loss of fire main pressure to the damaged area and to the general vicinity of the damage, and permit fighting fires in the damaged area from adjacent undamaged sections, while at the same time the pumping capacity in each undamaged section should remain adequate to control an incipient fire within that section.

4-32. It is important that segregation of the fire main be set prior to entering an engagement and that it be retained at least until receipt of damage whereupon it may be broken to meet the exigencies of the situation. If the damage involves the fire main, the break should be isolated to the smallest extent of the main possible, and then segregation broken, as required, to fight existing fires. If additional pumping capacity beyond that available in adjacent sections to the one disabled is required, segregation valves should be opened to make adequate capacity available wherever it can best be used at the time. Flexibility of control is a highly important feature and should not be hindered by unnecessary insistence upon segregation after known damage to the main has occurred and has been isolated and fire fighting is in progress. After such an emergency has been met, prompt restoration of the segregated system is in order.

4-33. The presence of gasoline in aircraft in carrier hangars was the major factor in the past war in producing hangar damage. It is considered that reduction of this hazard presents the opportunity for securing a marked improvement in the resistance of carriers to battle damage. Several means exist for the reduction of this hazard. One consists of the increase of degassing rates. Inadequate degassing rates have been a matter of concern for some time. Gravity drains which were provided initially were found unsatisfactory. Consequently a 30 GPM air-driven pump for degassing was developed in 1942 and installed at each fueling station. The defueling rate thus obtained still appears inadequate and the Bureau is now developing a high capacity gasoline system for carriers to give a minimum defueling rate of 100 GPM per hose with underwing fueling and defueling connections on the planes. The first installation of the high capacity system is being planned for ORISKANY (CV34).

4-34. The cases of FRANKLIN (CV13)*; PRINCETON (CVL23)†; ST. LO (CVE63)¶; BISMARCK SEA (CVE95)§; and OMMANEY BAY (CVE79)#; in which munitions stowed in or adjacent to hangars detonated as a result of roasting in hangar fires, emphasize the importance of reducing this hazard. The detonation of two 250 Kg bombs among fueled and armed planes in FRANKLIN's hangar initiated a large conflagration.. This was followed in about four minutes by the first of a five-hour long series of heavy explosions of bombs and rockets which demolished a major part of the flight deck and wrecked gallery and hangar deck spaces, but did not result in loss of the ship. A 250 Kg bomb detonated among fueled and armed planes in PRINCETON's hangar and ignited a conflagration which was followed in 10-20 minutes by a series of heavy explosions, either torpedo warheads or gasoline vapor, and in about 4 1/2 hours by the mass detonation of four hundred, 100-pound GP bombs stowed in the torpedo stowage. The entire stern aft of frame 120 and the structure above the main deck aft of frame 105 were blown off and, although apparently not in a sinking condition, she was sunk by our own forces because the tactical situation precluded further salvage efforts. A small bomb, dropped by a Kamikaze shortly before it crashed into the flight deck of ST. LO, penetrated to the hangar, detonated above fueled and armed planes in the hangar and ignited a gasoline fire which was followed in less than a minute by a gasoline-vapor explosion. Five distinct explosions of torpedo warheads or bombs which were located on the hangar deck in the vicinity of the initial bomb detonation followed the gasoline-vapor

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* BuShips War Damage Report No. 56
† BuShips War Damage Report No. 62
¶ Section VI
§ Section VI
# Section IV

explosion over a period of 10-15 minutes. These explosions were climaxed by a heavy detonation, believed to have been some of the munitions in the bomb magazine, after which ST. LO capsized and sank in five minutes. Two Kamikazes crashed the after end of BISMARCK SEA within a period of two minutes and started a conflagration among four fueled planes. The fire could not be controlled because of the many casualties among damage control personnel which resulted from the second crash. Within twenty minutes a violent explosion, probably the warheads on one or more of the torpedoes stowed in the after end of the hangar, occurred. BISMARCK SEA then assumed a small starboard list which gradually increased. An hour after the torpedo warhead detonation, she capsized to starboard and sank. Torpex-loaded torpedo warheads in the hangar of OMMANEY BAY detonated some 40 minutes after a Kamikaze initiated an uncontrollable hangar fire, as discussed in this section.

4-35. Some improvement in the protection of ready service high explosives has been made in the CVE 105 Class by the provision of STS protection in way of the hangar stowage for assembled torpedoes in the after elevator pit. This reduces somewhat the hazard of fragment attack. Means to facilitate the jettisoning of high-explosive charges from the hangar, as were required in SANTEE and SALAMAUA, have been provided the CVE105 Class through the installation of chutes at either end and both sides of the hangar at a height such that bomb dollies can discharge directly into them. A recognized deficiency in all CVE Classes, emphasized by the cases of SUWANEE and SANGAMON, is that no hangar deck side openings are large enough to permit jettisoning aircraft.

4-36. The mere size of hangars has been a major factor contributing to their vulnerability. Without structural segregation, there have been many cases of the free flow of liquids, including gasoline, from side to side and end to end of hangars, unrestricted dissemination of smoke, rapid extension of conflagrations and an open path for passage of blast and fragments. The provision of STS hangar bulkheads and STS doors large enough to permit moving aircraft from bay to bay on the CVB41 Class, thus subdividing the hangar into four bays, is considered a major forward step in decreasing the high vulnerability of carriers. This measure is under consideration for smaller carriers. Where installation is feasible, the transverse bulkheads should reduce the vulnerability of hangars to both fire and fragment damage. Depending upon their ability to resist blast, they should also reduce the extent of blast damage in the hangar. Elimination of the sliding doors, or reduction of the number of these doors in the transverse hangar bulkheads, would, if feasible, further improve the resistance of hangars to damage and furnish additional protection to aircraft stowed therein.

4-37. Armoring the flight deck, or flight and gallery decks, is another means of reducing the vulnerability of hangars. Weight and stability considerations have in most cases in the past precluded the allocation of armor to these large deck areas. The CVB41 Class, however, was provided with a 3.5-inch STS flight deck over the hangar. Although not subjected to war damage, this deck should have defeated Kamikaze planes and the bombs usually carried by such planes and would, therefore, have afforded considerable protection to the carrier hangars. It is probable, however, that future weapons such as pilotless aircraft and guided missiles will be much more lethal than the Kamikaze with greater penetrative ability and destructive power. Therefore, it will become increasingly more difficult to protect hangars by preventing the entry of missiles.

4-38. From the foregoing discussion it is evident that much has been done and much more can be done to reduce the vulnerability of aircraft carriers to the frequent and serious hazard of hangar conflagrations.