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CIVIL AERONAUTICS BOARD

File No. 1-0

AIRCRAFT ACCIDENT REPORT

ADOPTED: January 14, 1959

RELEASED: January 20, 1959

PAN AMERICAN WORLD AIRWAYS, INC., BOEING 377, N 90944,
 IN THE PACIFIC OCEAN, BETWEEN HONOLULU AND SAN FRANCISCO,
 NOVEMBER 9, 1957

The Accident

Pan American Flight 7, a Boeing 377, N 90944, was lost in the Pacific Ocean approximately midway between San Francisco, California, and Honolulu, Territory of Hawaii, on November 9, 1957, at 1627 local time. An extensive sea and air search over thousands of square miles of ocean ensued. Bodies of 19 of the 44 occupants were found as were small and light aircraft parts and cargo.

History of the Flight

Clipper 944,^{1/} a regularly scheduled around-the-world flight, originated at San Francisco with its first stop scheduled at Honolulu. It departed San Francisco at 1951^{2/} on November 8 estimating arrival at Honolulu at 0550, November 9. There were 36 passengers and a crew consisting of Captain Gordon H. Brown, First Officer William P. Wygant, Second Officer William H. Fortenberry, Flight Engineer Albert F. Pinataro, Purser Oliver E. Crosthwaite, Stewardesses Yvonne L. Alexander and Marie L. McGrath, and Flight Service Supervisor John E. King.

The flight plan specified a cruising altitude of 10,000 feet and a true airspeed of 226 knots. Gross weight at departure was 147,000 pounds, the maximum allowable, and the weight included fuel for approximately 13 hours. Good weather was forecast for the duration of the flight.

All required position reports were made and Clipper 944 reported to Ocean Station vessel "November" at 0030; its position was fixed by radar as 10 miles east of the vessel. The last position report, at 0104, was routine with no indication of anything unusual.

The next scheduled position report, due at 0204, was not received and 30 minutes thereafter the flight was designated unreported.

^{1/} Company designation of Flight 7, using the last three numerals of the aircraft number.

^{2/} All times and dates herein are Greenwich unless otherwise noted and are based on the 24-hour clock; all distances are in nautical miles.

USCOMM-DC-25606

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Investigation

Search and Rescue operations were initiated immediately. Coast Guard surface vessels, air carrier aircraft, Air Force aircraft, and the U. S. Navy aircraft carrier "Philippine Sea," using its aircraft, participated.

On November 14, the fifth day of search, aircraft from the carrier located bodies and parts of wreckage some 940 miles east of Honolulu and approximately 90 miles north of the flight's intended track.^{3/} The next day additional bodies were recovered making a total of 19. Fourteen of these wore lifejackets. Bodies and material were taken aboard the carrier. Continuing intense search was unproductive and was abandoned on the evening of November 15.

Meanwhile, investigating groups had been formed under the direction of the Civil Aeronautics Board. Two Board investigators, representatives of Pan American World Airways and the CAA, and two pathologists of the Armed Forces Institute of Pathology on loan to the Board, were flown to the carrier, then at sea en route to Long Beach, California. This permitted initiation of the investigation a full day before the carrier docked. The wreckage was briefly examined by the medical members and investigators with the prospect of gaining some insight of possible medical problems that might be encountered. External examination of the bodies was made, carefully noting all external injuries. There was no evidence of foul play found on any of the recovered bodies. Tentative identification was established in those cases where possible. All valuable personal items were inventoried and preserved under the supervision of one of the ship's chaplains.

Preliminary examination of the limited amount of material aboard the aircraft carrier established that it was from N 90944. All wreckage was removed to a restricted area at the Pan American overhaul base at San Francisco where further examination was made by Board investigators. Various pieces were identified individually and relative to one another and a detailed examination of the pieces was made.

The recovered material consisted chiefly of fuselage secondary structure, fuselage interior trim and equipment items, and numerous separate packets of mail and mail bags. Only one piece of wreckage from parts of the aircraft other than the fuselage was recovered; this was a section of engine cowl support ring, which was found imbedded in a floating pillow. It could not be determined from which powerplant this piece of ring came. No portions of the main airframe structure were found. The recovered fuselage pieces were generally from the area ahead of the rear pressure bulkhead. The pieces were from both above and below the cabin floorline, and a somewhat greater amount of the material had come from the right side of the fuselage.

Some of the recovered pieces bore distinct evidence of fire damage. However, it was determined that the fire damage on all pieces was on those portions which floated above the water. No evidence of inflight fire was found on any of the recovered fuselage material. Fire markings were fairly uniform over material from all positions in the fuselage, including mail and cabin material, and each charred piece had a definite waterline below which

^{3/} See Attachment A, geographical positions.

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charring did not occur. Laboratory tests of the charred pieces disclosed no evidence of prohibited or explosive material.

Board investigators carefully examined the recovered debris for evidence of an inflight explosion. This examination included a thorough inspection of recovered items of cargo, passenger effects, and mail. No evidence of an inflight explosion in the fuselage was found.

Cargo manifests were examined to determine whether any explosive or otherwise dangerous material was aboard. A shipment of sodium sulfide had been in the forward cargo compartment. A check with the shipper disclosed that the packaging consisted of one pound in a sealed glass container and one-fourth pound also in a sealed glass container padded from each other and the shipping container, which was a wooden box 13 inches by 11 inches by 9 inches. It was further learned from the shipper that the material consisted of crystalline sodium sulfide of the highest ACS (American Chemical Society) grade of purity and was the only chemical compound shipped in the box. It had been packaged in accordance with prescribed regulations.

Sodium sulfide is a chemically reactive flammable solid. It is normally shipped in airtight containers in a yellow crystalline form which even if exposed to air would be safe to handle and to transport. Crystalline sodium sulfide in contact with moisture would generate hydrogen sulfide gas, which is toxic, at a slow detectable rate. The amount of hydrogen sulfide generated would not be great or dangerous before its very foul and characteristic odor of rotten eggs would alert the crew to take emergency procedures - i. e., use a smoke mask, and depressurize the aircraft and ventilate. This material is rather widely used industrially and its shipment by air is not uncommon.

Also included in the cargo was a package containing a small amount of radioactive medicine which had also been packaged in accordance with prescribed regulations. It was reported to have been sealed in a Babbitt metal capsule about one inch long contained in a hermetically sealed can. This can was then placed in a cardboard carton which was identified by a label indicating radioactive material.

Neither of these two shipments was recovered but there is no reason to suspect that either one contributed to the accident. The remainder of the cargo consisted of routine mail, baggage, and express shipments which included several barrels of tranquilizer and several shipments of movie film of the "Safety" type.

N 90944 was equipped with two complete high frequency radio transmitting and receiving systems. The two systems were also equipped with SELCAL which provides ground-to-air selected calling, eliminating the need for continuous pilot monitoring of the high frequency communication equipment of the aircraft. The ground equipment generates pre-set coded tones which are transmitted on voice communication frequency. On receipt of the particular tone code the aircraft decoder activates the cockpit call chime and signal light. This SELCAL phone is on the control pedestal between the pilots, readily usable by both.

In addition to SELCAL, the conventional equipment was available to the crew by activating a toggle switch for either system. In either system it is necessary to depress the microphone button to transmit. Additionally, the

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aircraft had two separate very high frequency systems and two automatic direction finding receivers providing aural reception and radio bearings from the stations in the low frequency and broadcast band.

Air-to-surface and surface-to-air communications on very high frequency during takeoff and immediately following departure of Clipper 944 on November 8 were routine and normal. These included clearances with the San Francisco tower, radar departure control, and CAA Air Route Traffic Control Center. Upon reaching cruising altitude (10,000 feet) at 2009 Clipper 944 switched over to company frequency and contacted ARINC (Aeronautical Radio, Inc.), which handles all company surface-to-air communications for Pan American. A schedule was established for position reports from the flight at four minutes past each hour and an "operations normal" report at 34 minutes past each hour.

At 2105 Clipper 944 made its first routine position report, which indicated the flight was proceeding as scheduled. Thereafter, Clipper 944 continued to report its progress as scheduled at 4 and 34 minutes past the hour through its last position report of 29°20'N. and 141°35'W. at 0104. Prior to this position report Clipper 944 established radio communication at 0030 with Ocean Station "November" and two radar fixes were obtained by that vessel which fixed the position of the aircraft as bearing 243 degrees true range 43 miles from the vessel at 0040, approximately 10 minutes ahead of schedule. At that time Ocean Station "November" was 29°59'N. and 140°08'W. With this information it is probable that Clipper 944's navigator estimated his position, at 0104, as an average between his own estimate of his position and the correction indicated by the radar fixes.

The Board considered it entirely possible that an emergency message might have been sent from the flight after the 0104 position report and that such message might not have been heard. Pursuing this possibility the ARINC recording tapes for the frequency in which such message would be recorded were carefully examined. Initially nothing was apparent. However, repeated playbacks of the tapes of the period following the 0104 position report disclosed previously unknown transmissions which were extremely weak and subject to varied and conflicting interpretation.

Great effort was devoted to determining the content, or the intent, of this transmission. Altogether, more than three months were devoted to this work, using various proven and experimental methods as well as the finest equipment.

Another attempt to understand the message was made by Pan American World Airways. A number of its supervisory flight and communications personnel, accustomed to the abbreviated jargon of air radio communications as well as having had personal experience in previously talking with the crew members, were unable to gain any significant intelligence from repeated playbacks of the recorded message. Despite this comprehensive research, the Board could not definitely establish that any emergency transmissions came from Clipper 944.

Board investigators obtained the identification of 44 other flights which were operating through the area of the last reported position of Clipper 944 during the period 2400 to 0200 on November 8-9. None of the crews of these flights had overheard any calls from Clipper 944 during this period on company

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or any other frequencies, nor did Ocean Station "November" hear any emergency message from Clipper 944 following its last position report at 0104. (All PAA aircraft as well as those of certain other carriers, namely, Northwest Airlines and United Air Lines, transmit and receive on common frequencies.)

When Clipper 944 failed to report at 0134 and again at 0204, the next routine reporting scheduled, both Honolulu, which then had flight guard responsibility, and San Francisco attempted to contact the flight on all frequencies. All subsequent attempts to contact the flight were futile and Search and Rescue was alerted at 0234; search was started immediately. Bodies and debris located by aircraft of the U. S. S. Philippine Sea were at 29°36'N., 144°03'W. The probable point of impact was near 29°26'N., and 143°34'W. The position was computed from known ocean current vectors published by the Hydrographic Office, taking cognizance of reported winds. The position of Lat. 29°26'N., and Long. 143°34'W., is approximately 105 miles west of the last reported position and about 30° off course to the right (north).

On the basis of surface ship reports (including Ocean Station vessel "November") and aircraft weather reports, it is apparent that the weather en route was substantially as forecast. Clouds consisted of scattered to broken cumulus and stratocumulus based at 2,000 to 3,000 feet, tops 5,000 to 8,000 feet, with scattered to broken clouds above 12,000 feet. The overall wind pattern coincided closely with the forecast.

There were no reports of turbulence, icing, lightning, thunderstorm activity, or precipitation of any kind.

The forecast lowest sea level pressure in the accident zone (from 140° to 145° west) was 1018 mbs.; actual values ranged from 1020-1023 mbs.

The winds reported at Ocean Station "November" (averaging the 0000Z and 0600Z observations) were as follows:

2,000 feet: 250° at 8 knots
6,000 feet: 270° at 8 knots
10,000 feet: 250° at 12 knots

The visibility at Ocean Station "November" at 0000Z and 0300Z was reported as 10 nautical miles while the cloud conditions were as follows:

0000Z - less than 1/10 cumulus based at 2,000 feet
2/10 stratocumulus based at 4,500 feet
3/10 cirrus at an unspecified height (but well above flight altitude)
0300Z - 1/10 cumulus based at 2,000 feet
7/10 cirrus at an unspecified height (but well above flight altitude)

Ocean Station vessel "November" also reported the following with respect to the state of the sea at 0000Z, November 9:

- (a) waves coming from 300°
- (b) period of waves: 11-13 seconds
- (c) mean maximum height of waves: 8 feet

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The air temperature at 10,000 feet in the area of the crash was approximately plus 4° centigrade.

Because of the limited amount of wreckage recovered, it became all the more important to determine as much information as possible from the recovered bodies in order to arrive at a better understanding of the emergency that had caused the accident. It was chiefly for this reason that the Board enlisted the aid of expert pathologists familiar with aircraft accident fatalities to assist in the development of all significant information. Their examination of the 19 bodies recovered disclosed that 10 had probably died from drowning. Further, the lack of extensive crash-induced mutilation, together with the general condition of the bodies, suggested that the water impact, although severe, was not sufficiently great to cause complete disintegration of the aircraft.

Life preservers were found on 14 bodies, two of them children. One of the recovered bodies, wearing a life preserver, was one of the stewardesses who was still strapped by her safety belt to a seat.

Bruises and abrasions on the thighs of the captain's and the purser's bodies indicated that their seat belts also were fastened at the time of impact. Similar indications were lacking on other bodies. The medical examination further disclosed that none of the bodies had been subjected to fire before or after impact.

As part of the pathological examination, a series of tests for toxic material was conducted. Initially these tests indicated elevated levels of carbon monoxide in several of the recovered bodies. This preliminary finding indicated (1) the need for further corroborating tests, and (2) that a study should be undertaken to determine how high concentrations of carbon monoxide could have been present in the inhabited portions of the fuselage. To accomplish the latter objective a Board investigating group made a detailed study of the Boeing 377 systems to determine possible malfunctions which could lead to the generation of carbon monoxide. These were considered with probable variations in the pattern of airflow throughout the fuselage. This study disclosed that high levels of carbon monoxide could be generated and distributed unevenly throughout the fuselage in several ways. However, it was impossible to relate the elevation of carbon monoxide found in bodies with the seating arrangement and, consequently, with the source of the carbon monoxide.

Medical tests have continued from the time of the accident to the present to verify the initial findings relative to carbon monoxide concentrations in certain of the bodies. These tests, conducted independently by different federal agencies, verified the concentrations as found initially but raised doubt as to the suitability of any test method because of the decomposed state of the bodies. Additional studies are presently being performed which may answer the question regarding reliability of carbon monoxide results in cases of post-mortem decomposition, but as yet this question is unsolved.

Five recovered wrist watches were examined by a competent watch maker to establish an approximate time of impact. Of these, two had been stopped by impact at 26 and 27 minutes past the hour, respectively. Two were automatic winding, shockproof and waterproof, and one of these was still running, showing the correct time when recovered. The other was full of water and had

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stopped at 35 minutes past the hour. Since the "waterproof" case was intact and showed no physical damage, it was concluded that it ran for some time before being stopped by water seeping in. The remaining watch, which had a nonwaterproof case, had stopped at 28 minutes past the hour and had water inside. This was considered to be the probable cause of stoppage. Considering the waterproof integrity of the case of the watch showing 35 minutes past the hour and eliminating the one still running, a probable time impact was established as 27 minutes past the hour. Since the aircraft had reported at 0104 and did not report, as scheduled, at 0134, the time of the crash is concluded to have been 0127.

An inspection was made of all company maintenance records of N 90944. This included records of the aircraft structure, powerplants, and all accessories. A detailed study of these records, which were adequate and in good order, showed that all airworthiness directives had been complied with and that no known discrepancies existed at the time the aircraft was dispatched on this flight.

The aircraft, a Boeing 377, was manufactured by the Boeing Airplane Company on August 19, 1949. Pan American acquired it on September 28, 1950, and it had been operated in air carrier service since that date. It had been progressively maintained and was currently certificated.^{4/}

The aircraft was equipped with four Pratt & Whitney model 4360B-6 engines.

Propellers installed on these engines were Hamilton Standard model No. 34E60-349, blade model 7015B-2. The propeller domes had incorporated the recently developed speed sensitive pitch lock to minimize uncontrolled engine overspeeds. The blades were solid aluminum. All blades and hubs of each propeller had been overhauled and maintained as complete units since new. Records of the carrier's fleet of Boeing 377's in the Pacific-Alaska Division were examined and revealed that no propeller structural failures had occurred since the adoption of this model propeller.^{5/} None of the propellers on this particular aircraft had been involved in any overspeeding incident. Each engine was equipped with a General Electric model CH10 turbosupercharger. These provided pressurized air for the cabin air conditioning system as well as air for engine supercharging.

On September 19, 1957, when N 90944 was on a trip from Honolulu to San Francisco, the crew heard a loud noise. It was described as similar to dropping the navigation stool on the flight deck. The captain made a check of the lower nose CO₂ bottles and the forward cargo compartment, accessible through a floor hatch in the cockpit. The antennas were checked through the octant and everything was found normal. This incident was written up on the flight engineer's log (Discrepancy Report) and, in addition, suspecting a tire blowout, a tire check was requested by the captain prior to landing at

^{4/} Progressive maintenance is a system whereby overhauls of aircraft are divided into segments so that complete overhaul is not required at one time.

^{5/} However, military services have experienced engine nose section difficulties attributed to the use of the solid aluminum propeller which is considerably heavier than the model previously used.

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San Francisco. This was accomplished by extending the gear and requesting a visual check by tower personnel. No tire damage was observed and a normal landing was made.

Since this incident was written up as a discrepancy, it required an inspection which was signed off with the following action by a company inspector, "Inspected aircraft and found no damage outside." Inasmuch as this indicated no interior inspection of the aircraft, Board investigators further questioned the company inspector who signed off the discrepancy. His statement of action taken follows: "Inspected lower nose and forward cargo compartment, also exterior of aircraft. Found you could duplicate loud noise by stepping hard on door between cockpit and cargo. Also loud bang could be duplicated by dropping forward toilet lid. Nothing abnormal found."

Two "hard" landings had been reported by crews on June 4, 1957, and October 3, 1957, respectively. Following the first, inspection of the aircraft (N 90944) by certificated mechanics included a visual inspection of all outer skins for wrinkles, fuel stains in cell areas, cracks or damage to landing gear, lowering of flaps and inspection of flap area and landing flaps themselves. No visible damage was found. One item in the inspection required in the manual, namely, removal of a surface cover for inspection of the wing spar webs, was omitted; however, the mechanics who performed the inspection were satisfied that there was no damage to the aircraft and accordingly "signed off" the inspection form. The second hard landing was followed by an inspection which was reported verbally by the inspecting mechanic, to the captain of the flight, as complete. This verbal report was accepted by the captain since in his opinion the landing was not sufficiently hard to warrant a written report.

N 90944 had made 41 flights during the period September 19 to November 8, 1957, the date of Clipper 944's departure from San Francisco. The pilots on these flights were questioned regarding any unusual noises, turbulence encountered in flight, hard landing, or any other significant occurrences, which were not made a matter of record. Nothing was reported that shed any light on the accident.

The last preflight inspection was started on November 6, 1957, and continued until the date of departure, November 8, 1957. All items required had been checked and signed off by appropriate maintenance personnel.

During the course of the investigation, and in view of the circumstances of the disappearance of the aircraft and the absence of living witnesses or crew members, an extensive investigation of personal activities and backgrounds of crew, passengers, and company ground personnel of the San Francisco base of PAWA was made by CAR and other governmental agency personnel. This investigation included personal interviews with all personnel who might have had access to the aircraft for any reason while the aircraft was on the ground on its last stopover at San Francisco from November 6, 1957, to November 8, 1957, and involved some 98 persons. This phase of the investigation disclosed that the aircraft received normal preparation for the flight and disclosed nothing relative to the character or behavior of any person that might point to sabotage in connection with the loss of the aircraft.

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Subsequent to the public hearing, the Board conducted an investigation of specific maintenance and overhaul practices and occurrences at the carrier's San Francisco base. The purpose of this investigation was to obtain information by which maintenance adequacy of the carrier's Boeing 377 aircraft and powerplants could be evaluated; consequently, a part of the investigation related directly to these aircraft.

A number of irregularities in maintenance procedures and/or practices were noted. However, because the airplane was lost at sea with no message giving any clue as to the nature of the emergency and because there was no direct application of these irregularities to 944, it is obviously impossible to associate them with, or disassociate them from, the accident.

The subjects of emergency procedures, and crew training and competency therein, were investigated. It was established that the company's emergency training curricula, including ditching, fire fighting and smoke evacuation procedures, were adequate and that all crew members of N 90944 had successfully completed the required training.

Analysis

It is obvious from the investigation portion of this report that an analysis to arrive at the probable cause of the accident is seriously handicapped by the scarcity of physical evidence. However, the following seems logical.

If a large-scale fire had occurred in the cabin, cockpit, baggage compartment, or lounge area, some evidence of such fire would most probable be present in the recovered pieces. Since none was found, it is reasonable to conclude that a large-scale fire did not occur in any of these areas. There was no physical evidence to indicate the occurrence of a powerplant or localized fuselage fire nor was there any evidence to indicate that there was no such fire. Although a powerplant or localized fuselage fire would not immediately destroy the structural integrity of the aircraft, both the indicated lack of directional control and absence of any distress message could well be associated with this kind of emergency. Such fire could generate considerable quantities of smoke which might present serious difficulties to the crew. However, equipment is provided to combat such an emergency and the crew is trained in its use. Fire damage that was observed on the floating debris was confined to those surfaces which were above the waterline. Obviously, this damage could have been caused only by a surface fire following impact.

Clipper 944 made five routine hourly position reports after its departure from San Francisco, the last one 21 minutes prior to impact with the water. After the last routine position transmission, the aircraft descended from 10,000 feet going away from Ocean Station "November" which it had passed some 35 minutes before.

As has been stated, the location of impact was computed to be in the vicinity of latitude 29°26'N. and longitude 143°34'W. This is approximately 105 miles west of the last position established for the aircraft and about 30° off course to the right or north. Lack of knowledge of both the time and

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start of descent and precise impact point makes it impossible to determine by analytical means, or otherwise, the airspeed or the descent rate existing during the descent.

A fairly flat angle of impact is indicated by the nature of damage to the recovered material, its location within the aircraft, and by the lack of severe mutilation of bodies. The part of the aircraft from which the recovered wreckage came indicated breakage of the fuselage at about the same locations as has occurred on previous survivable ditchings of the same model aircraft. These circumstances suggest a nearly survivable ditching may have been accomplished. From this it would logically follow that some control may have been available at the time of water impact. Exercise of such control would tend to rule out crew incapacitation. However, two pertinent conclusions regarding the final portion of the flight are evident. Consideration of the distance flown from the last reported position to the impact point, and of the time required to traverse that distance shows that the flight did not turn back toward Ocean Station "November." Also, the ditching to the north of the planned route indicates that appreciable lateral distance, not on course and away from the ocean station, was traversed after the start of the emergency.

It is difficult to understand why the captain would have elected to continue away from "November" had he been able to do otherwise. Weather was not a factor and it is not believed that the shipping lanes to the north offered any inducement to turn in that direction. Conversely "November," a fixed ocean station equipped with radio homing and radar devices and rescue equipment, was in close proximity with trained personnel readily available.

The condition of the sea at the time and place of the ditching is not known precisely, but it should not have been appreciably different from that existing at the weather vessel 105 miles to the east. That vessel's official observation at 0000, one hour and 27 minutes before the ditching, included: waves from 300° at a frequency of 11 - 13 seconds with a mean maximum height of 8 feet. Surface winds were southwest 11 knots. These conditions would produce a usable sea surface for ditching. One airline captain en route near the place and close to the time of the ditching stated that seldom had he seen the sea conditions more favorable for ditching. Due consideration of all these factors leads to the belief that either loss of directional control or crew incapacitation was the possible cause of the aircraft proceeding away from "November" after the start of the emergency.

There is a record of previous emergencies involving Boeing 377 aircraft which were accompanied by serious directional control difficulties. Emergencies referred to, except one, followed complete separation of a powerplant from the aircraft. The one exception occurred following takeoff with the cowl flaps fully open. Common to all of these occurrences was heavy buffeting in flight and in the case of powerplant separation, great difficulty in simultaneously maintaining altitude and directional control. Such occurrences bear a striking resemblance to what appears very likely to have occurred to 944.

Buffeting, which can be sufficiently violent as to cause concern for the structural integrity of the aircraft, is most likely caused by disrupted air flow over the empennage. Disrupted air flow, in turn, usually results from

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some occurrence which disturbs the smooth outer shell of the aircraft, such as an object passing through the fuselage; an explosion in an engine nacelle, wing leading edge, or the fuselage; or an engine being wrenched from the aircraft. A fuselage explosion has been discounted. Though not indicated factually or historically in any manner with respect to the propellers in use, failure of a propeller blade or portion thereof, or separation of an entire propeller by engine failure or nacelle explosion either from explosive fumes or turbosupercharger failure, are the most likely cause of the kind of damage being considered. These possibilities and their consequences are also suggestive of what may have happened to N 90944.

Lack of any known message from the aircraft after start of the emergency may be related to fuselage external and/or internal damage which broke antennas and/or caused major damage to the electrical distribution system. In view of conclusions elsewhere in the analysis, crew incapacitation is a definite possibility.

Since pathological study indicated the possibility of carbon monoxide in the cabin prior to impact, the most likely sources thereof must be considered. CO is generated in most any type of a fire (electrical, combustible fluids and solids) or by the thermal decomposition of many substances. A large fire within the fuselage is not compatible with the condition of the recovered wreckage so a smouldering fire would appear to be more likely. Such a fire would cause considerable smoke in the cabin, in addition to the carbon monoxide, and contribute to the off-course location of the crash but should have been controlled by the emergency fire fighting equipment carried on board unless the fire had ignited some material like nitrate film. Such a fire should not have created the need for an immediate ditching unless the smoke accompanying it was excessive and irritating and the fire was uncontrollable.

A more probable source of CO would be an unusual occurrence in a power package which could have initiated a chain of events leading to the introduction of carbon monoxide into the fuselage. Such an unusual occurrence could be a failure which would release part of a propeller blade or the entire propeller, or a failed turbosupercharger disk. It is likely that such an occurrence would be accompanied by serious flight control problems and possibly fire. If a propelled object, such as a propeller, came through the fuselage it could easily start a fire, knock out some radio equipment, make emergency smoke evacuation procedures ineffective, and destroy the crew's emergency oxygen supply. Such an occurrence fits the known circumstances better than any of the other possibilities.

A third type of CO source which also fits most of the known circumstances is the malicious introduction of pure CO into the cabin and preferably the flight deck. CO unaccompanied by smoke would not be recognized by the crew and occupants and symptomatic quantities could be absorbed by the crew before they realized it. Under these circumstances complete incapacitation of the crew would result and the aircraft could have been flown into the water.

Several techniques have been used in the past to make quantitative determination of carbon monoxide in bodies of accident victims. Because of the violence associated with certain types of aircraft accidents the applicability of the results of some techniques and methods had been subject to question.

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The results were even more questionable when the bodies had passed through certain stages of putrefaction. Since the beginning of the Board's investigation of this accident the Armed Forces Institute of Pathology has devoted considerable time to verifying the suitability of the various testing methods available. Further, and more important, a new technique was evolved which adapted the use of gas chromatography to the determination of carbon monoxide levels in the blood of accident victims. This new technique was demonstrated to be both specific and applicable for use on the bodies which were not exposed to advanced post-mortem decomposition.

In a recent Navy accident, which involved multiple casualties and similar exposure to warm sea water, two of the eight immediately lethal fatalities demonstrated elevated CO values. In that accident there was no inflight fire, but a post-impact surface fire did occur. This casts some doubt on the nearly established conclusion that carbon monoxide is not a byproduct of advanced stages of post-mortem decomposition. This question may take a considerable amount of time to resolve. The Board's report is being released, nevertheless, in the absence of a satisfactorily established cause.

The Board is deeply indebted to the Armed Forces Institute of Pathology for its valuable assistance in the investigation of this accident and its research which continues and has already made a significant contribution to the field of aviation medicine and airplane accident investigation.

The maintenance history of 944, as obtained from the records, was, in the main, normal and there was nothing that could be related directly to the accident. However, in view of the incomplete hard-landing check at San Francisco, and the somewhat cursory check following the report of a "loud noise" in flight, also at San Francisco, maintenance and the airworthiness of the aircraft cannot be accepted as being normal in all respects.

The omission of the main spar inspection during the hard-landing check eliminated an important and what is probably the most onerous and time-consuming step of the procedure. This omission is considered to be significant and indicates that in this instance at least expediency rather than thoroughness prevailed. It can only be concluded that the "loud-noise" check was at best cursory. The Board's investigation of specific maintenance practices at San Francisco established these practices as not being entirely isolated cases. However, the Board did find at the time of this investigation that the carrier was in the process of reviewing and, where necessary, revising their maintenance manual and procedures. This effort also included a realignment of some personnel assignments and responsibilities. Furthermore, the results of maintenance investigation were called to the attention of the CAA, by memorandum dated March 19, 1958, with a recommendation that PAVA maintenance practices be reassessed. The CAA has advised that suitable corrective measures have been taken.

There was no evidence of a bomb-type explosion within the fuselage. Had a large-scale bomb explosion occurred in the fuselage (cabin, cockpit, baggage compartments, and/or lounge), evidence of this would undoubtedly have been found on some of the recovered wreckage material as well as on the bodies.

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Findings

On the basis of all available evidence the Board finds that:

1. The crew, aircraft, and carrier were currently certificated.
2. The flight was properly planned and dispatched.
3. The gross weight of the aircraft at the time of takeoff was 147,000 pounds, the maximum allowable.
4. Progress of the flight and position reports were normal and routine for more than half of the planned flight distance.
5. Shortly after the last routine report an emergency of undetermined nature occurred.
6. This was followed by a descent from 10,000 feet.
7. No emergency message was received from the aircraft.
8. Some preparation for ditching was accomplished.
9. The aircraft broke up on impact.
10. A surface fire then occurred.
11. Weather was not a factor.
12. Exposure of the crew to carbon monoxide was indicated but incapacitation could not be definitely established.
13. No evidence of foul play or sabotage was found.
14. Irregularities of maintenance practices and/or procedures disclosed during the investigation could not be linked to the accident.

Probable Cause

The Board has insufficient tangible evidence at this time to determine the cause of the accident. Further research and investigation is in process concerning the significance of evidence of carbon monoxide in body tissue of the aircraft occupants.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE
 /s/ CHAN GURNEY
 /s/ HARMAR D. DEBNEY
 /s/ G. JOSEPH MINETTI
 /s/ LOUIS J. HECTOR

S U P P L E M E N T A L D A T AInvestigation and Hearing

The Civil Aeronautics Board was notified of the unreported aircraft at approximately 0200, November 9, 1957. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A hearing, ordered by the Board, was held in San Francisco, California, on January 15 and 16, 1958.

Air Carrier

Pan American World Airways, Inc., is a New York corporation with its main offices in New York. Headquarters for the Pacific-Alaska Division are at San Francisco International Airport. The corporation operates as an air carrier under a certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration. These certificates authorize the carrier to engage in air transportation between various points in the United States and foreign countries, including the route involved in this instance.

Flight Personnel

Captain Gordon H. Brown, in command of Clipper 944, was 40 years of age and had been employed by Pan American since May 1, 1942. His record shows that he had been progressively advanced within the company and during his 15 years of experience he had made many over-ocean flights. Of his total flight time of 11,314:55 hours, he had accumulated 674:50 hours in Boeing 377 aircraft. Captain Brown was based at San Francisco and had been flying the Pan American Pacific-Alaska Division since November 28, 1956. Company records show that all required airman certificates and ratings on the Boeing 377 were currently effective on the day of the accident. In addition, he had satisfactorily completed all PAWA ground training requirements, including periodic pilot refresher emergency equipment on the B-377 and wet-ditching drill on August 2, 1957. He had had a rest period of approximately 11 days. Captain Brown held a class one medical certificate dated May 1, 1957.

First Officer William P. Wygant was 37 years of age and had been employed by Pan American World Airways since September 24, 1946. He had a total of 7,355:57 flying hours, of which 4,018:58 had been in B-377 aircraft. He was currently certificated by the CAA and had also completed all special courses including emergency equipment in the B-377 and the wet-drill for ditching.

Second Officer William H. Fortenberry, pilot-navigator for Clipper 944, had been employed by PAWA since August 27, 1951. He had a total of 2,683:10 hours, of which 1,552 were in the B-377. All of Mr. Fortenberry's certificates and ratings were currently effective and he had had a rest period of over 19 days prior to his departure on November 8. Like both captain and first officer, he had satisfactorily completed all required regular and special courses, including emergency and ditching courses.

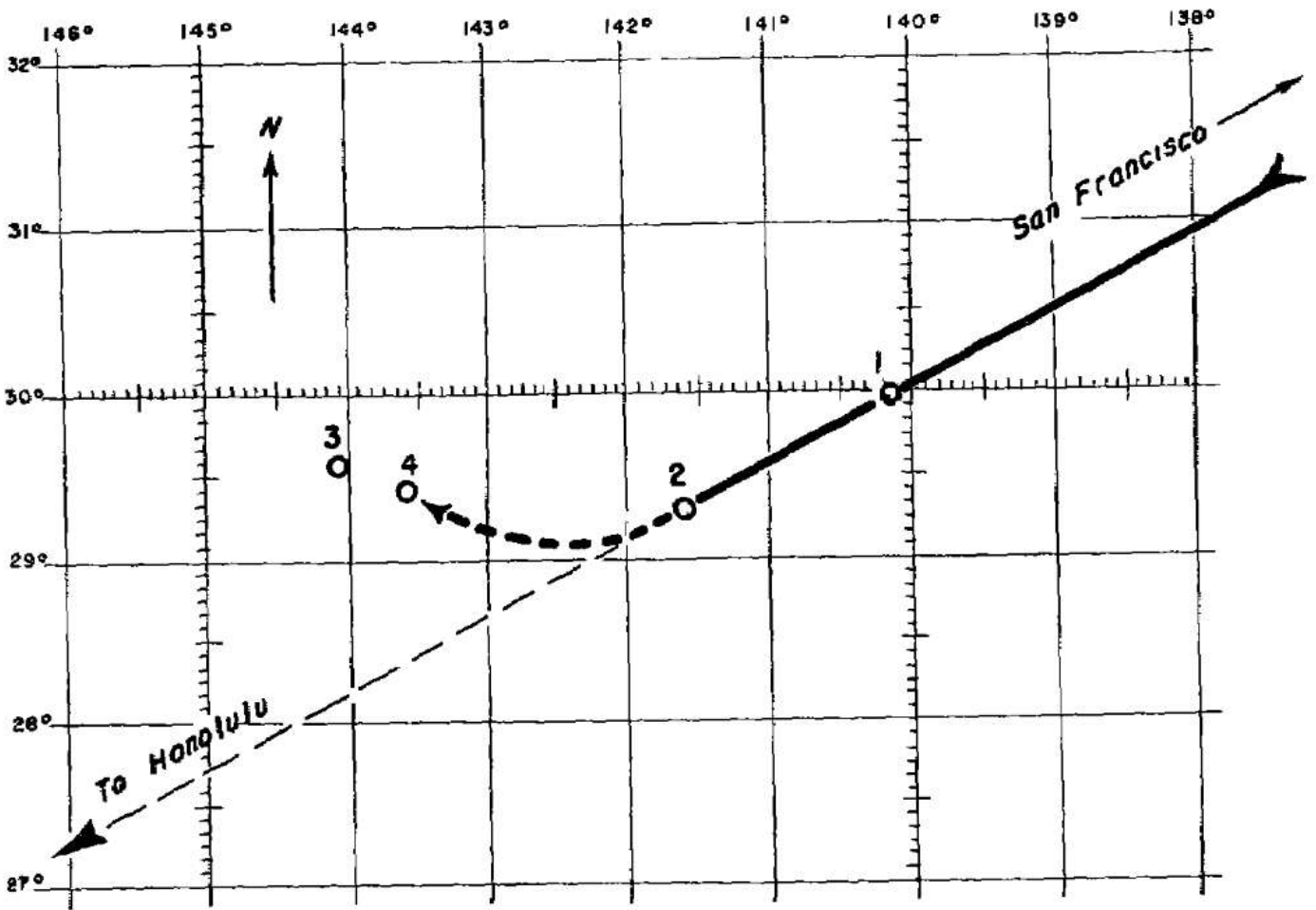
Flight Engineer Albert F. Pinataro, age 26, had been with PAWA since July 11, 1955. Prior to employment with the company he had completed an air-

craft maintenance course (9 months) at Glendale, California, Junior College and an aircraft and engine course (9 months) at Los Angeles City Aircraft School. CAA certificates and ratings were currently effective and included those of flight engineer, aircraft and engine, aircraft and engine instruments, and radio telephone. His total flight time was 1,596:21 hours, all in Boeing 377 aircraft. Engineer Pinataro had 160 hours rest period prior to his duty assignment on Clipper 944 on November 8.

Cabin attendants assigned to the crew complement consisted of John E. King, Flight service supervisor; Oliver E. Crosthwaite, purser; Marie L. McGrath and Yvonne L. Alexander, stewardesses. All of these personnel had been employed by PAA for several years and an examination of company records showed all of them had completed company training courses in B-377 emergency equipment and ditching procedures.

The Aircraft

N 90944, a Boeing model 377, serial number 15960, was owned and operated by Pan American World Airways and was currently certificated by the Civil Aeronautics Administration. The aircraft had accumulated 23,690:58 flying hours. It was equipped with four Pratt and Whitney R4360-R26 engines. No. 1 engine had a total time of 13,804 hours, and 282 hours since overhaul; No. 2 engine a total of 16,317 hours, and 1,208 hours since overhaul; No. 3 engine a total of 16,961 hours, and 1,249 hours since overhaul; and No. 4 engine a total of 13,459 hours, and 153 hours since overhaul. The aircraft, engines, and propellers had been maintained as prescribed and were within their time limitations.



- 1 Weather Vessel Approximately midway between San Francisco and Honolulu
(29° 59' N - 140° 8' W)
 - 2 Last reported position of 944
(29° 20' N - 141° 35' W)
 - 3 Wreckage and bodies
(29° 36' N - 144° 3' W)
 - 4 Probable impact
(29° 26' N - 143° 34' W)
- SCALE
0 50 100
NAUTICAL MILES

Known path
 Probable path
 Planned path

ATTACHMENT A
PAWA — N 90944
November 9, 1957

USCOMM-DC-25160