Docket No. SA-118 File No. 852-46

CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: November 1, 1946 Released: November 6, 1946

PAN AMERICAN AIRWAYS - WILLIMANTIC, CONNECTICUT, June 18, 1946

The Accident

A Pan American Airways' Lockheed Constellation, designated as Trip 100, en route from New York, N. Y., to London, England, was landed at Windham Airport, Willimantic, Connecticut, at 1700*, June 18, 1946, with wheels retracted, following a fire in No. 4 engine and subsequent loss of the engine during flight. No injuries were sustained by any of the occupants as a result of either the fire in flight or the emergency landing.

History of the Flight

Pan American Airways' Trip 100 departed La Guardia Field, New York at 1601, June 18, 1946, en route to London, England, with stops scheduled at Gander, Newfoundland, and Shannon, Ireland. Under an instrument Air Traffic Control clearance, the flight climbed on course to an altitude of 15,000 feet and reported reaching that altitude at 1633. The flight reported over Hartford, Connecticut, at 1637, and until that time had been completely routine.

At 1651, the fire warning bell sounded and the light for No. 4 engine came on indicating a fire in that nacelle. The emergency engine fire procedure was immediately initiated in the following sequence: The throttle fully retarded, the mixture control moved to idle cut-off, the propeller feathered and the emergency fuel and oil shut-off valve moved to the "off"

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*All times referred to in this report are Eastern Standard and based on the 24-hour clock.

position. Immediately thereafter, the engine fire extinguisher control was moved to the No. 4 engine position, and the first bottle of CO_2 was emptied into the nacelle in an attempt to extinguish the fire. Although the flames were momentarily retarded, they soon burst out again, and a second bottle of CO_2 was emptied into the nacelle with similar results. The auxiliary CO_2 bottle was used as a final resort but, as with the previous attempts, the fire was not permanently extinguished.

Having already passed Hartford, Connecticut, the captain was aware that weather conditions in its vicinity were satisfactory for an emergency landing. Inasmuch as the flight was, at the time of the fire, above a thin stratus overcast, and since the captain was not aware of the weather conditions at nearby fields, he decided to return to Hartford rather than attempt to locate airport which may have been slightly closer but the weather at which may have caused a greater delay. In order to return to Hartford as rapidly as possible, the captain descended with power and at a very high indicated airspeed which ultimately reached 300 mph. Because the aircraft was continuing to accelerate, the captain partially extended the flaps and reduced the airspeed to approximately 250 mph.

During the high speed descent, the flight crew observed the propeller on No. 4 engine turn slowly despite the fact that it was fully feathered. Flames were pouring from the top inboard louvers of that engine nacelle and were increasing in intensity during the descent. At an altitude of approximately 7,000 feet, about four minutes after the fire warning bell sounded, the No. 4 engine suddenly swung downward and fell free from the wing. Fluids continued to pour from the broken lines streaming behind the nacelle with an appearance which somewhat resembled smoke. Some flames were observed in the wing near the leading edge on the inboard side of the No. 4 engine position after the engine fell from the aircraft. Shortly thereafter, the aircraft entered an overcast and continued through the stratus clouds en route to Hartford.

At approximately 3,000 feet, the aircraft broke out beneath the overcast, and at that time no fire within the wing was visible to any of the crew members. The captain sighted Windham Airport at Willimantic, Connecticut, and being uncertain of the damage incurred as a result of the fire, he decided to land at that field rather than prolong the flight to Hartford. In attempting to lower the landing gear, it was observed that the hydraulic system was inoperative as a result of breakage of hydraulic lines in the No. 4 engine nacelle. Rather than lose any more time than necessary, the captain decided against attempting to actuate the emergency gear extension system and landed as soon as he was able to establish an upwind approach. The landing was accomplished to the northeast with partial flaps since no additional flaps could be extended subsequent to the loss of No. 4 engine.

The landing on the belly of the fuselage was very expertly accomplished, and little damage to the aircraft structure was sustained as a result. None of the occupants was injured as a result either of the fire in flight or the emergency landing. Immediately after the aircraft came to rest on Windham Airport, all occupants deplaned safely.

Investigation

The aircraft lay on the turf a short distance from the northeast runway, facing the northeast. With the exception of the damage resulting from the fire in the No. 4 engine nacelle, bent propellers on the three remaining engines and minor wrinkles on No. 2 and No. 3 engine nacelles, little damage to the aircraft was observed. The No. 4 engine and most of the nacelle were missing from the right wing. Evidence was observed of fire of considerable intensity within this nacelle. Fire had extended to the front spar of the right wing and into the leading edge as far inboard as the No. 3 engine nacelle. The fire had burned through a newly installed baffle, the function of which had been to prevent a draft through this section of the leading edge. The heat had been of sufficient intensity to buckle approximately five feet of the upper portion of the leading edge inboard of the No. 4 engine nacelle.

Investigation of the fire pattern disclosed the greatest concentration of fire to have existed along the top inboard area of the No. 4 engine nacelle. Analysis of the nacelle failure indicates that this section of the nacelle structure became weakened by fire and failed. The engine and cowling had swung down tearing away the remaining portion of the nacelle and falling free from the wing. With the separation of the engine from the wing structure, fire had apparently continued in the remaining part of the nacelle for a short period. The steel shroud which had been installed to shield the front spar had been folded over exposing the inboard region to fire. The web in the inboard section buckled and subsequently developed a prominent crack about five inches long, exposing the interior of the integral fuel tank. However, it is apparent that the crack had been produced after the fire in that region was extinguished. Examination disclosed that the fuel level within the tank was considerably below the crack in the web.

The No. 4 engine was located on a farm on which it had fallen, at a point approximately 14 miles east of Windham Airport. It is apparent that several sections of the nacelle had fallen initially, followed in sequence by the main electric junction box, the alcohol tank, the cabin supercharger and drive shaft assembly, and the engine proper. These components were located over an area back along the flight path covering approximately $1\frac{1}{2}$ miles from the point at which the engine came to rest. All engine and accessory components and structural sections were examined thoroughly for indication of fire and/or malfunctioning.

The major portion of all fluid-carrying dural lines, bulkhead fittings and firewall attachments in Zone 2 were consumed by fire, as were almost all dural lines aft of the firewall in Zone 3.* The emergency oil shut-off valve was found near the engine in the closed position. None of the several engine components examined revealed any sign of malfunctioning, although several bore signs of intense heat. An examination of the power section was accomplished but no indication of mechanical failure was disclosed.

A detailed examination of the cabin supercharger drive shaft assembly disclosed a significant combination of failures. Both the inner and outer race of the forward bearing of the drive shaft were mutilated in a manner indicating failure due to inadequate lubrication. Grooves cut into the universal joint disclosed that some of the balls from the shaft bearing had fallen into the joint subsequent to failure of the bearing resulting in extensive mutilation of the universal joint legs. The drive coupling, which is the direct connection between the drive shaft and the engine accessory gear section, was located intact. This unit is designed so as to permit a failure in shear under unusually high torsional load conditions. No indication of excessive shear forces were observed in this unit.

Examination of that part of the hydraulic system within the nacelle revealed no malfunction of the hydraulic pump, however, the high-pressure hose fitting attached to the pump showed definite signs of abrasions on the underside which had undoubtedly occurred prior to impact with the ground. This

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*Zone 1 refers to the power section or that area of the engine nacelle forward of the diaphragm. Zone 2 is the accessory section or that area of the engine nacelle between the diaphragm and the firewall. Zone 3 is the nacelle area aft of the firewall.

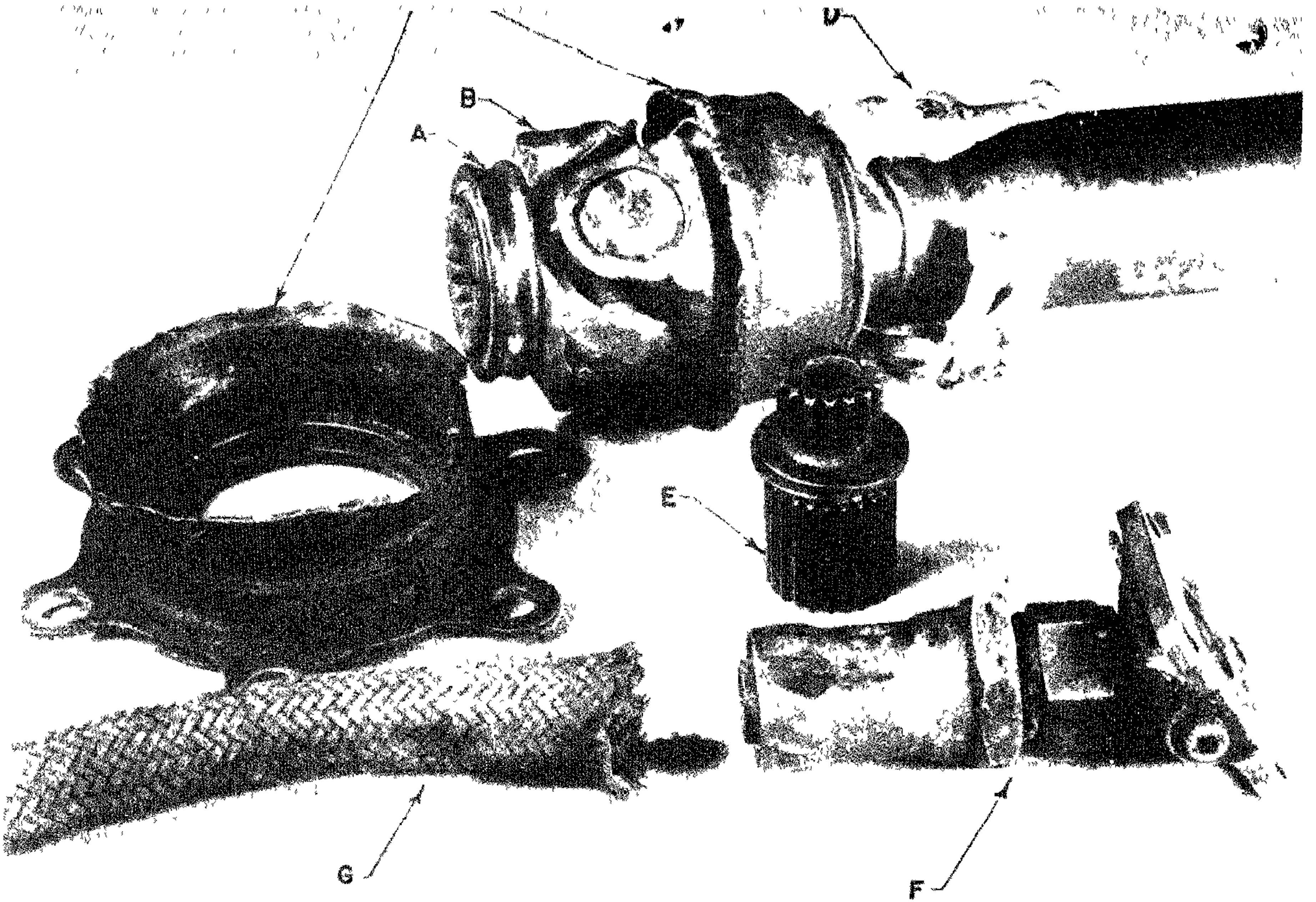

Figure 1. An enlarged view of the dissassembly of the engine end of the cabin supercharger drive shaft and the hydraulic out-line fitting indicating the nature of the failure. A. Shaft bearing B. Universal joint, C. Universal joint housing; D. Aluminum spring-shield; E. Drive coupling shear section; F. Hydraulic out-fitting; G. Hydraulic line (rubber covering consumed exposing steel braid).

fitting is located approximately 3/8" above the forward end of the cabin supercharger drive shaft. The cabin supercharger drive shaft universal joint housing, which is attached to the engine gear box, had fractured circumferentially at the mid-section, and the rear half of the housing had moved rearward and was lodged over the spring assembly expander. Its ragged edge bore indications of having struck adjacent objects and was rolled inward in such a manner as to indicate considerable force of contact while rotating.

The shut-off valves for the fuel and oil systems are located at the firewall in Zone 3. A fire confined to Zone 1 or 2 and of sufficient intensity to consume gasoline or oil lines in those zones would not be fed additional fuel other than that contained in the lines if the shut-off valves were actuated. However, such protection is not afforded Zone 3. Moreover, both the fuel and oil shut-off valves may be actuated only after the propeller is feathered which leaves all such lines forward of the firewall filled with inflammable fluids of sufficient quantity to aggravate the fire severely in the event they were consumed sufficiently to permit leakage.

Inspection of the firewall disclosed the fact that all dural flanges and hose fittings attached to the firewall and directly within the flame path were consumed by fire. It therefore became apparent that while the firewall itself may have provided relatively good protection for Zone 3 from any fire which originated in Zone 2, when the dural fittings were burned or melted out, the effectiveness of the firewall was seriously limited and fire was able to penetrate into Zone 3 at several points.

An air filter unit had been included originally in this aircraft and had been installed on the aft side of the firewall within an integral firewall air duct the dimensions of which were approximately 8" by 10". The duct extended almost vertically to 1-3/4" from the top of the nacelle. Prior to the accident, the filter had been removed from the system exposing the duct to Zone 2. The opening left when the filter unit was removed had not been covered. This was contrary to the manufacturer's instructions. Consequently, the firewall was not capable of completely preventing penetration of possible fire from Zone 2 into Zone 3.

In the absence of a steel plate covering for the duct, the fire which broke out in Zone 2 passed with little difficulty into Zone 3 and, because of the lack of fire extinguishing equipment in this area, the fuel carrying lines were quickly consumed and the fire developed to uncontrollable proportions.

This model aircraft was equipped with fire detectors in Zones 1, 2 and 3, as well as in the induction system. Two separate fire detection circuits were installed in each nacelle and each circuit was provided with a separate warning light in the cockpit. One of these circuits included the engine induction system and the other circuit included the three nacelle zones. In this instance, the flight crew observed that the warning light which indicates a fire in one of the three zones in No. 4 nacelle came on. Inasmuch as the induction system light did not come on, the flight crew assumed that no fire had occurred in this area. The fire extinguishing system is so installed that approximately 70 percent of the CO_2 is directed to Zone 1, 23 percent to Zone 2 and 7 percent to the induction system. No agent is supplied to Zone 3. Should an engine nacelle fire penetrate to or originate in Zone 3, no means of extinguishment are available to the flight crew. Furthermore, the entire system is designed in such a manner that, regardless of the location of the fire, the distribution of the extinguishing agent is apportioned in the same ratio. In the subject accident, although three separate bottles of CO_2 had been discharged into the nacelle, none of the agent proved effective in extinguishing the fire in Zone 2 or 3.

Discussion

Although the flight crew followed the procedures for combating power plant fires in a satisfactory manner and utilized the fire extinguishing equipment as completely as possible, there is no doubt that the fact that No. 4 engine fell from the aircraft at the moment it did proved to be the most effective single factor in removing the danger to the wing structure. Immediately prior to tearing loose from the wing, the nacelle contained every evidence that the fire was increasing in intensity; that there was no hope of the fire "burning itself out"; and that no further corrective action on the part of the crew was practicable. Had the engine nacelle remained intact for a longer period of time, it is certain that the fire would have weakened the wing structure sufficiently to cause failure of a major wing component or combination of components. There is, furthermore, reason to believe that the fire would have spread into the No. 3 engine nacelle had not the major source of the fire been eliminated when the engine tore loose. The damage to the spar indicates forcibly the narrow margin under which the aircraft was operating at the moment the engine was dropped and very little additional heat would have been required to ignite the fuel within the integral tanks.

The fact that almost all the fluid-carrying dural lines in Zones 2 and 3 were partially consumed by fire indicates the necessity for materials of greater heat-resistant qualities in those lines carrying inflammable fluids. Regardless of whether shut-off valves are incorporated in the respective systems, the aggregate capacity of all gasoline, oil, alcohol, and hydraulic fluid lines furnishes a source of fuel for nacelle fires which may develop a fire of severe proportions. In the event the feathering action is not complete and the propeller windmills while the fire extinguishing procedures are being executed, the contents of the oil sump may continue to drain into the area of fire if the lines in this region are consumed. The lines aft of the firewall presented an even greater hazard in this respect inasmuch as the action of the shut-off valves did not prevent the continued flow of inflammable fluids through fractured or fire-consumed lines.

It is apparent that the contents of the fluid-carrying lines contributed to some extent to the fire in this instance. Because the shut-off valves cannot be actuated prior to completion of the feathering action, the lines retain full capacity of their respective fluids. It does not appear impracticable to so design the system that these lines be emptied of their contents prior to feathering but after the ignition switches have been shut off. While the fire-resistance of empty lines may be less than those lines which carry fluids, they nevertheless present less of a hazard in engine nacelle fires.

The effectiveness of the firewall appears to be of paramount importance in consideration of fires as occurred in this instance and the evidence indicates conclusively that the effectiveness of the firewall was seriously impaired as a result of the burned and melted flanges attached to the firewall. Fire penetration into Zone 3 was possible through the large openings left in the firewall when these dural flanges were burned out. It appears unreasonable to incorporate in the firewall fittings and attachments of such composition as will substantially reduce its effectiveness particularly in view of the fact that materials are available which will provide a fire-resistance almost equivalent to that of the firewall itself. The omission of the steel plate over the opening left when the air filter had been removed from the firewall was clearly an oversight* and the rapidity with which the fire increased to severe proportions can primarily be attributed to this factor. Unless an engine nacelle fire can be effectively isolated, extinguishment techniques are rendered extremely difficult.

Evidence of severe heat on the baffle between engines No. 3 and No. 4, on the wing structure adjacent to the nacelle, including the front spar and on the steel shroud protecting that portion of the spar directly behind No. 4 engine, indicates clearly the need for additional protection of the aircraft structure from engine nacelle fires. The greatest single danger from such fires lies in the potential damage to the wing structure, and it was apparent that the fire was in no sense confined to the nacelle in this instance. Although the steel shroud mentioned above proved a valuable shield for the front spar, similar protection should be provided the remainder of the critical wing structure lying in the probable flame path of a nacelle fire.

Examination of the cabin super charger drive shaft universal joint housing and the adjacent hydraulic fluid line and fitting reveals the probable origin of the fire. The forward bearing of the drive shaft failed as a result of lack of lubrication. Failure of this bearing caused the universal joint to whip violently and beat against the inner surface of the universal joint housing. The housing eventually fractured circumferentially and the rear portion became free to rotate with the shaft and to move rearward. As a result of the violent whipping action which followed the failure of the bearing, the

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*CAR 04.6640 The firewall shall completely isolate the engine compartment and shall have all necessary openings fitted with close-fitting grommets or bushings. (Part 04, as amended to November 1, 1943)

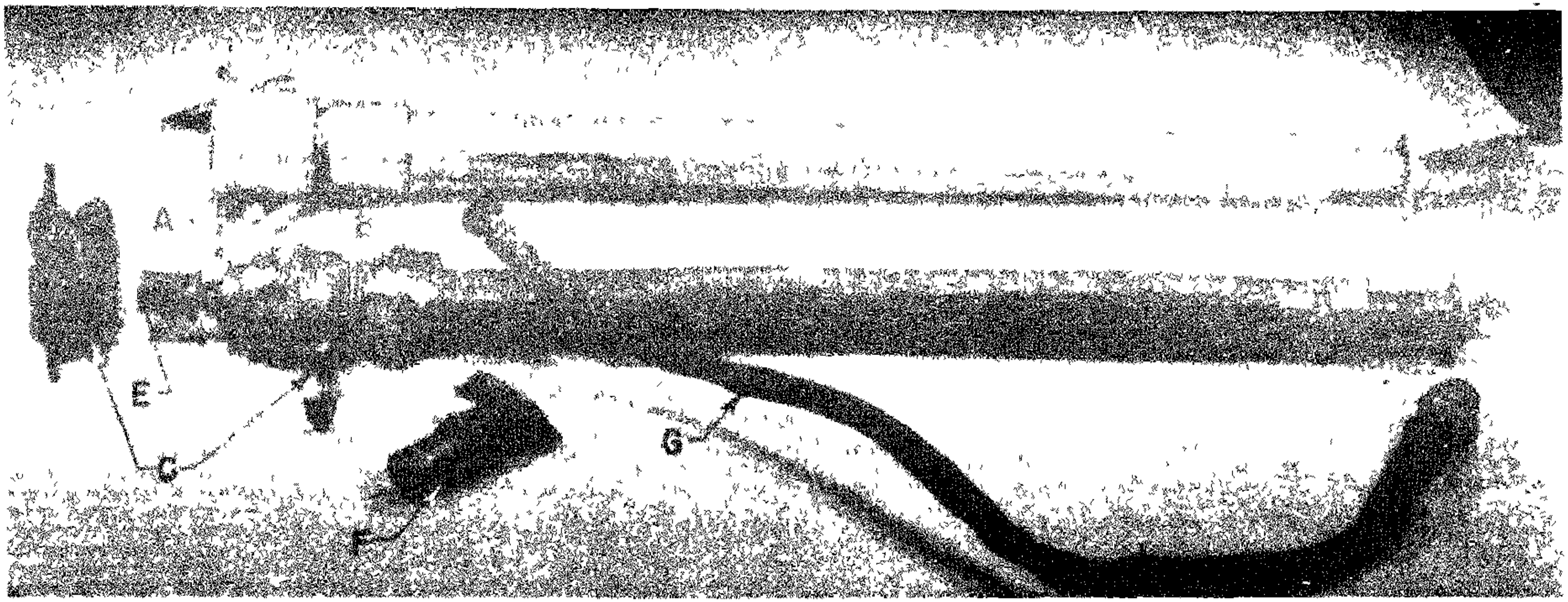

Figure 2. The cabin supercharger drive shaft assembly installed in NC 88858 is shown beside a new unit. The drive coupling shear section (E) is shown partially installed.

The shaft bearing failed due to lack of lubrication and the inner race (A) became separated from the outer race. This resulted in violent contact between the universal joint (B) and the universal joint housing (C). The housing eventually fractured circumferentially and the shaft was permitted to vibrate while rotating. The fractured edge of the universal joint housing (C) still on the shaft contacted the hydraulic out-fitting (F) breaking the seal and causing a spray of hydraulic fluid throughout the area.

The drive coupling shear section (E) was so constructed as to permit a failure in shear under such circumstances. This unit, however, did not shear in this instance and the failure occurred in the universal joint housing instead.

Item D indicates the aluminum spring-shield.

Item G indicates the hydraulic line with the rubber covering consumed exposing the steel braid.

supercharger drive shaft and housing came in contact with the hydraulic line fitting with considerable force causing leakage of hydraulic fluid. Inasmuch as this line is under a pressure of at least 1,500 pounds per square inch, the fluid was evidently released forcefully in a fine spray. The cause of the ignition of the hydraulic fluid was not positively determined, however, block tests were conducted on the supercharger drive shaft by Lockheed Aircraft Corporation in which such a situation was simulated, and it was determined that this condition resulted in a shower of sparks accompanied by considerable heat. These tests revealed, furthermore, that the heat developed in burning out the supercharger drive shaft bearing and fracturing the guard left the universal joint red-hot. The failure of the universal bearing, therefore, was capable of causing leakage of the hydraulic fluid and of producing the heat necessary to ignite it.

Shearing of the drive shaft coupling would have prevented the damage which resulted from failure of the forward bearing by permitting the drive shaft to stop. It is not known whether the torsional loads for which the unit was designed exceeded those encountered in this instance. However, failure of the shear section had averted serious damage in other occasions in which the supercharger drive shaft bearing had failed in this model aircraft. Because of the difficulty of designing a shear unit adequate for all possible load conditions resulting from failures in the drive shaft assembly, consideration should be given the installation of a more satisfactory means whereby the shaft may be disconnected from the engine accessory gear section.

Because of the extremely high pressures at which hydraulic fluid is conducted through engine nacelles and the relatively high inflammability of currently used petroleum base fluids, hydraulic lines present a particularly significant hazard. The evidence obtained from the investigation of this

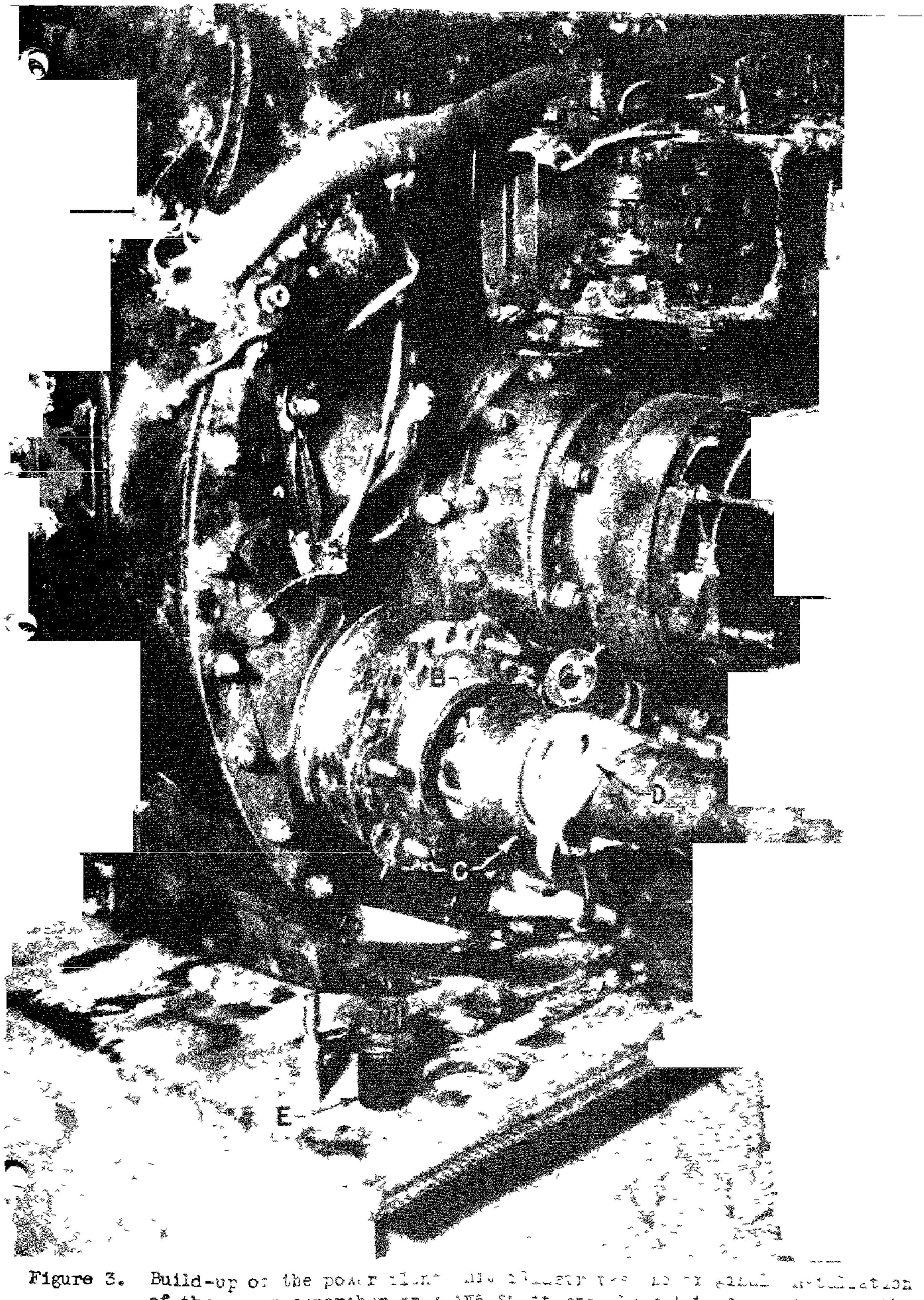

Figure 3. Build-up of the power plant also illustrates the [illegible] installation of the cabin supercharger drive shaft and the relative [illegible] of the hydraulic out-fitting.

accident indicates that a leakage in a hydraulic line or fitting often results in a fine spray of hydraulic fluid being forced into the nacelle under extremely high pressures. The explosive manner in which such a spray of hydraulic fluid ignites has been effectively demonstrated in Lockheed laboratory tests conducted since this accident. It is therefore urgent that fluids of lesser combustibility be developed for use in modern aircraft as soon as possible. At least two such products have been developed to date but the primary obstacle to the immediate use of such fluids is the lack of service test data as to their usability within hydraulic systems incorporated in aircraft currently in service.

It is significant that under the conditions of this accident the evidence discloses little apparent effect of the CO_2 on the fire. Although the flames were retarded momentarily following the initial discharge of CO_2, they immediately broke out again with even greater intensity. The following two discharges evidently had no effect. It is difficult to determine accurately whether the discharge was inadequate to extinguish the fire at all, or whether the substance which was burning was being released under such circumstances that it became immediately reignited. However, it was demonstrated in subsequent tests that while the universal joint was being burned sufficient heat was developed to continue the combustion of the hydraulic fluid as readily as oxygen became available. It is important nevertheless to consider that the lightness of the CO_2 would facilitate dissipation in the airflow through the nacelle, and that the effectiveness of CO_2 is well known to be inferior to that of methyl bromide and monochlorbrommethane as a fire-extinguishing agent. In view of the fact that the acceptability of these agents to air carrier aircraft has not been determined completely, there is undoubtedly a need for more intensive research into the applicability of superior agents to aircraft fire extinguishing systems.

It is believed, furthermore, that the absence of discharge nozzles into Zone 3 deprived that region of the fire protection it needed in this instance. It appears illogical that a detection device should be incorporated in that zone to warn the pilot of the existence of a fire when no means are available to him of extinguishing such a fire. All research data available prior to the time of the accident, however, indicated that the distribution of the fire extinguishing nozzles incorporated in this power plant was accomplished in accordance with the best information available to the aviation industry. The advent of power plants of the size and operating in the temperature range of the type engines involved poses problems which require a reevaluation of the safety techniques developed on the basis of earlier power plants. Foremost among these certainly are those techniques designed to prevent or control engine nacelle fires.

Findings

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

1. The Company, aircraft and crew were properly certificated for the flight.

2. That portion of the flight to a point abreast Providence, Rhode Island, had been entirely routine with nothing unusual having been observed.

3. After the aircraft had been in flight approximately 40 minutes, the supercharger drive shaft bearing failed due to inadequate lubrication; the universal joint housing attached to the engine gear box fractured in its midsection and struck the hose-fitting on the outlet line from the hydraulic pump sufficiently to cause a leakage of hydraulic fluid into Zone 2.

4. Failure of the forward ball bearing of the supercharger drive shaft and subsequent failure of the universal joint housing generated sufficient heat to ignite the hydraulic fluid.

5. The drive shaft shear coupling failed to shear in this instance and no means were available to disconnect the supercharger drive shaft from the engine accessory gear section.

6. The engine fire warning bell sounded and the fire warning light came on indicating fire in one of the three zones of the No. 4 engine nacelle. No fire was indicated in the induction system.

7. The flight crew observed flames coming from the top inboard louvers of the No. 4 engine nacelle.

8. Normal emergency fire procedures were executed by the crew and all three bottles of CO_2 were discharged into the engine nacelle.

9. The first discharge of CO_2 retarded the fire momentarily but the subsequent two discharges had no apparent effect upon the fire.

10. The fire consumed almost all fluid carrying lines in Zone 2 and increased rapidly in intensity.

11. After penetrating the firewall through the uncovered air filter duct, the fire partially consumed most of the fluid carrying lines in Zone 3.

12. No fire extinguishing discharge nozzles were located in Zone 3 although one fire detection unit had been installed in that area.

13. Having burned for approximately four minutes, the fire weakened the nacelle structure sufficiently to cause it to tear loose from the wing and fall free.

14. Some fire persisted in the wing for a short while after the engine nacelle fell from the aircraft.

15. While the fire was in progress, the captain descended at high speed, returning towards Hartford, Connecticut, with intentions of landing at the airport located near that city.

16. The aircraft entered a thin stratus overcast at approximately 4,000 feet and broke out beneath the clouds at 3,000 feet.

17. After breaking out beneath the overcast, no fire was visible to any of the crew members.

18. Upon sighting Windham Airport, Willimantic, Connecticut, after establishing visual contact, the captain elected to land at that field.

19. Inasmuch as the hydraulic system was inoperative, a landing was made with the landing gear retracted and with the flaps partially extended.

20. No injury to any of the occupants was sustained as a result of either the fire in flight or the emergency landing.

Probable Cause

The Board determines that the probable cause of this accident was fire in the No. 4 engine nacelle due to fracture of the universal joint housing of the supercharger drive shaft, breakage of the adjacent hydraulic line, and subsequent ignition of the leaking hydraulic fluid.

Conclusion

As a result of the investigation of this accident the Board concludes that:

1. The major wing structure in the vicinity of the engine nacelle was not adequately protected from possible engine nacelle fire in 049 aircraft.

2. Dural and other alloys of aluminum are not sufficiently resistant to heat to warrant their use in lines conducting inflammable fluids within the engine nacelle.

3. Having been located at the firewall, the shut-off valves afforded

no protection from possible drainage of highly inflammable fluids through fractured or fire-consumed lines in Zone 3.

4. Because the shut-off valve mechanism cannot be actuated until after the propeller is feathered, the fuel and oil lines throughout the engine nacelle retain their respective fluids after feathering has been accomplished. The presence of such fluids within the nacelle presents a definite fire hazard.

5. The effectiveness of the firewall was seriously limited by inadequate sealing and by the use of dural fittings.

6. The design and location of the cabin supercharger drive shaft installed in the 049 until the time of this accident presented a distinct fire hazard because of its susceptibility to poor lubrication and its proximity to the hydraulic lines.

7. Petroleum base products presently in use as hydraulic fluids are excessively inflammable particularly in view of the fact that materials of lesser combustibility have already been developed. Service test has not been accomplished on any of such fluids.

8. The carbon dioxide fire extinguishing system was not adequate to extinguish the fire in Zone 2 sufficiently to permit the flight crew to remove the fuel source and the cause of ignition.

9. The distribution of the fire extinguishing agent throughout the nacelle was inadequate for some fires. No extinguishing agent was provided in Zone 3.

BY THE CIVIL AERONAUTICS BOARD

/s/ J. M. Landis

/s/ Oswald Ryan

/s/ Harllee Branch

/s/ Josh Lee

/s/ Clarence M. Young

APPENDIX

Intensive research was accomplished by the Safety Bureau into this and other recent accidents involving fire in air carrier aircraft in order that the most effective action possible may be taken. Coordination was accomplished with all agencies concerned in the preparation of an amendment to those parts of the Civil Air Regulations pertaining to air transport aircraft and operations. In view of the vulnerability of Zone 3 to possible engine nacelle fires and the potential danger which exists in damage incurred by the critical wing structure in the vicinity of the engine nacelles, the Civil Aeronautics Board promulgated additional regulations designed to isolate more completely Zones 1 and 2 by increasing the effectiveness of the firewall in aircraft in the air transport category, to improve the systems of fire detection and extinguishment in both the fuselage and engine nacelles, and to increase the fire resistant qualities of engine nacelle components and aircraft structure. These regulations become effective November 1, 1946.

The manufacturer had foreseen some of the implications of engine nacelle fires in the Model 049 aircraft. For instance, the steel shroud protecting the main spar directly behind the nacelle and the Zone 3 engine fire detection unit had been added although no such protection had been provided other aircraft models currently in air carrier service nor were any requirements in existence which rendered such installations mandatory. This accident discloses, however, that the fire protection in the 049 engine nacelle was not totally adequate and that further attention was required to correct deficiencies in fire preventive equipment. The remedies being effected as a result of this investigation will not be confined to this particular model aircraft but will be extended wherever necessary to include all aircraft in air carrier service.

SUPPLEMENTAL DATA

Investigation

The Civil Aeronautics Board was notified of the accident at 1745, June 18, 1946, and an investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. Air Safety Investigators of the Board's New York Office arrived at the scene of the accident at 1130 the following day, and were later assisted in the investigation by other members of the Safety Bureau Staff. A public hearing was ordered by the Board and was held at New York, N. Y., June 28, 1946.

Air Carrier

Pan American Airways, incorporated under the laws of Delaware, and having established its headquarters at New York, N. Y., was operated under a Certificate of Public Convenience and Necessity and an Air Carrier Operating Certificate, both issued pursuant to the provisions of the Civil Aeronautics Act of 1938, as amended. These certificates authorized Pan American Airways to transport persons, property and mail between New York, USA, and London, England.

Flight Personnel

Captain Samuel H. Miller, age 29, of White Plains, New York, was pilot of the aircraft. Until the date of the accident, he had accumulated a total of 6,000 hours flying time, of which 226 hours were obtained in Lockheed 049 aircraft. First Officer Woodrow L. Lawson, age 28, of Beechhurst, N. Y., was co-pilot. He had accumulated a total of 1,800 hours flying time until the date of the accident, of which 20 hours were obtained in Lockheed 049 aircraft. John J. Howell, Second Officer, Perry W. Mumford, Third Officer, Charles R. Kaufman, Engineer Officer, Gerald W. Fay, Assistant

Engineer Officer, Ralph S. Gibson, Radio Officer, Frederick Gusman, Assistant Radio Officer, John F. De Rudder, Purser, and Beatrice M. Avenia, Stewardess, comprised the remainder of the crew. All flight crew personnel were properly certificated or otherwise qualified for their respective duties.

Aircraft

NC 68858, a Lockheed 049, Constellation, was manufactured in April, 1946, and had until the date of the accident accumulated a total of 387 hours flying time. Four Wright Duplex 739 C-18BA-2 engines were installed, each rated at 2,200 horsepower. The engines were equipped with Hamilton Standard propellers. Each engine had accumulated a total of 387 hours service since installation during manufacture. At the time of take-off from LaGuardia Field, the total weight of the aircraft was within its maximum gross load limits, and the load was distributed with respect to its center of gravity within approved limits.