CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: November 22, 1957 Released: November 26, 1957

DOUGLAS AIRCRAFT, INC., DOUGLAS DC-7B, N 821CH, AND U. S. A. F., NORTHROP F-89J, 52-1870A, NEAR SUNLAND, CALIFORNIA, JANUARY 31, 1957

The Accident

At approximately 1118,[1/] January 31, 1957, a Douglas owned and operated DC-7B, N 821CH, and a U.S.A.F. owned and Northrop operated F-89J, 52-1870A, collided at 25,000 feet[2/] over the San Gabriel Mountains about three miles northwest of Sunland, California. The DC-7 crashed on the playground of the Pacoima Junior High School, Pacoima, California, killing three students and injuring 70 others. The four crew members, sole occupants of the aircraft, were killed. The F-89 crashed in the Verdugo Mountains southeast of the collision position, killing the pilot. The radar operator of the F-89, though severely burned, parachuted to safety. Both aircraft were destroyed.

History of the Flights

The DC-7B. On January 31, at 1015, N 821CH took off from runway 3 of the Santa Monica, California, Airport. The aircraft was a new DC-7B being flown for the first time for the purpose of functionally checking the aircraft and its components in flight following production. The flight crew were Douglas Aircraft employees consisting of Pilot William G. Carr; Copilot Archie R. Twitchell; Flight Engineer Waldo B. Adams; and Radio Operator Roy Nakazawa.

The aircraft had been subject to many regular inspections during its manufacture and numerous inspections which were required after production preceding the first flight. Accordingly, it was presumed the DC-7B was in airworthy condition.

Preparations for the flight by its crew were routine. Departure was on a local VFR flight plan filed with the operations office of the company. The plan showed six hours of fuel aboard and that the flight duration was estimated as 2 hours 15 minutes. It also showed the gross takeoff weight of N 821CH was 88,000 pounds, well under the maximum allowable. The load was properly distributed with respect to center of gravity limitations.

1/ All times herein are Pacific standard and based on the 24-hour clock.
2/ Altitudes herein are mean sea level (m. s. l.).

According to routine procedure the flight switched to the Douglas company radio frequency after takeoff and made periodic progress reports. At 1030 the crew reported over the Catalina intersection, 9,000 feet, routine, and thereafter, at 1106, over Ontario, 25,000 feet, routine.

The F-89J. At 1050 that morning, the Northrop operated F-89J, 52-1870A, took off from runway 25 of the Palmdale, California, Airport, accompanied by another F-89J, 53-2516A. The flight of 52-1870A was one of a series of functional flight checks following the completion of IRAN (inspection and repair as necessary), an overhaul project performed under contract by Northrop Aircraft for the United States Air Force. The specific flight was in accordance with provisions of the contract and its purpose was to check the radar fire control systems of both of the all-weather interceptors. The two-member flight crew of 52-1870A consisted of Pilot Roland E. Owen and Radar Operator Curtiss A. Adams, both employees of Northrop.

Preparations for the operation were routine and departure was in accordance with a local VFR flight plan filed with the flight department of the company. The plan indicated the estimated duration of the operation as one hour with sufficient fuel aboard for approximately 1 hour and 45 minutes, considering afterburner time, altitude, and power settings for the mission.

The F-89's took off individually, using afterburners, with a separation interval of 20 seconds. In a wide starboard orbit the pilots utilized radar in a "snake climb" to 25,000 feet. At that altitude, a predetermined scissoring flight pattern was utilized which positioned the F-89's, without ground radar control, for simulated all-weather interceptor attacks on each other, during which the operation of airborne radar equipment could be checked. Radio transmissions, on company frequency, were recorded by ground facilities. These were routine commands between the pilots as they executed the radar check pattern and intercepts.

At 1118 activity in the Douglas radio room was interrupted by an emergency transmission from N 821OH. The voices were recognized by radio personnel familiar with the crew members. Pilot Carr first transmitted, "Uncontrollable." Copilot Twitchell then said, "We're a midair collision - midair collision, 10 How (aircraft identification using phonetic How for H) we are going in - uncontrollable - uncontrollable - we are . . . we've had it boy - poor jet too - told you we should take chutes - say goodbye to everybody." Radio Operator Nakazawa's voice was recognized and he concluded the tragic message with, "We are spinning in the valley." This final transmission from the flight is presented because it contained important information relative to the accident investigation. It not only establishes the midair collision but also indicates the DC-7 was rendered uncontrollable. It further indicates that Mr. Twitchell at least recognized the aircraft with which they collided as a jet. Further, the DC-7 spun during its descent to the ground.

Weather conditions in the area at the time of the accident were reported by the Weather Bureau as clear, visibility 50 miles. Winds aloft at 25,000 were approximately 30 knots from 320 degrees.

Investigation

A committee, headed by Board investigators, was designated to obtain all pertinent information available from eyewitnesses to the collision. Among others, the most important objectives of the group were to obtain the place and altitude of the collision, the headings and movements of the aircraft prior to collision, the portions of the aircraft involved in the inflight impact, and the manner in which the aircraft descended to the ground. Pursuant to these objectives it was learned that more than 140 persons had seen some phase of the accident, most, however, only that portion which followed the impact. About 115 of the known witnesses were personally interviewed and 106 formal statements were obtained from the total. From the interviews and statements several representative witnesses were selected to testify concerning their observations at the Board's public hearing. The selections were made considering the aeronautical experience and background of the persons, the positions from which their observations were made, and how much of the accident they saw. Only a few saw the important phase prior to impact. All stated that clear weather conditions prevailed.

Of the witnesses who saw the aircraft before inflight impact a few were oriented or, by the nature of their work, were fully cognizant of directions. The preponderance of these witnesses stated that the DC-7 was on a heading of nearly due west and the F-89 was on a heading of nearly due east a few seconds before impact. They stated that the DC-7 seemed to be flying in a straight and level attitude. The F-89 was also described by most as flying straight and level; however, a few thought it was turning left. None described any movements indicating either aircraft made evasive maneuvers to avoid the collision. They, however, stated that because of the altitudes, variously estimated above 20,000 feet, it would have been difficult, if not impossible, to see any such movements. Neither aircraft was making a contrail which would have marked its flight path.

Nearly all witnesses stated a smoke cloud appeared in evidence of the inflight impact and this was followed by a sound, resembling a clap of thunder. These were the factors directing the attention of most witnesses to the accident.

Eyewitnesses said that the DC-7 continued on a westerly heading for a short interval, then rolled to its left. As this occurred a plan view was afforded and several people noted that a portion of the left wing was sheared off. They also saw a shower of metal pieces near the smoke cloud reflecting the sun. The roll continued and the DC-7 entered an increasingly steep descent. Several witnesses thought that the plane turned about its longitudinal axis during the descent and said that metal pieces continued to break off in the area of the wing fracture. Numerous persons stated there was no fire but that white-gray smoke trailed from the wing fracture. Witnesses close to the crash site noted a general breakup of the aircraft before it struck the ground.

Witnesses stated that the F-89 emerged from the smoke cloud on an easterly heading. It burst into flames which enveloped the aircraft from its midsection rearward. While most witnesses said the aircraft did not spin a few thought that it did. Most stated that the visible portion of the F-89 seemed intact, in that the wings and tip tank-rocket pods were in place. The fall of the F-89 was described as a consistently steep trajectory. Although the preponderance

of witnesses who saw the F-89 before collision said it was headed easterly, many who saw it fall stated the trajectory was southeast. It was estimated that Mr. C. A. Adams, the radar operator, ejected from the aircraft about halfway down the descending arc of the jet.

The pilot of the F-89 that accompanied 52-1870A stated that the radar check flight had been entirely routine until the accident occurred. He stated that he and Mr. Owen had completed several simulated intercepts and that just before the accident each aircraft was being positioned for another. He stated that Mr. Owen's aircraft was to attack and his was to be the target. At this time, according to the pattern, the interceptors were 15-20 miles apart with Owen's aircraft on a heading of 135 degrees and his own on a heading of 45 degrees. He explained that according to the procedure Mr. Owen would next issue a radio command at which time both pilots would execute standard bank 90-degree turns. In the case of Mr. Owen a left turn to a heading of 45 degrees, and in his own case a right turn to a heading of 135 degrees. In this manner, at the completion of the turns, the aircraft would be positioned so that Mr. owen could proceed 90 degrees to the flight path of the target aircraft, commonly called the "attack vector." As the flights converged the radar operator of Mr. Owen's aircraft would locate the target plane on his radar scope and direct his pilot toward the target in a manner which would enable the pilot to simulate a firing pass. The procedure required both aircraft to maintain 380 knots true airspeed. He stated that the purpose of this type interceptor was to seek out an enemy aircraft by use of radar and destroy it in a weather situation which precluded positioning by visual reference. The witness explained that no feature of the radar ever flew the aircraft or took control from the pilot, it being designed to provide information to the pilot to enable him to maneuver into firing position. He explained the "lockon" phase was not a reference to control of the aircraft but meant that the radar was being directed to one specific target to the exclusion of all others.3/ He added that during this phase, target information was presented directly to the pilot on a small radar scope in his cockpit.

The pilot testified that Mr. Owen had given the signal for each pilot to begin his 90-degree turn. This, he recalled, was, "Start making your ninety, now, Jim." He said that he immediately began his turn and would assume, according to regular practice, that Mr. Owen did too. The pilot added that it was standard practice for the attacking pilot to transmit, "Steady on," indicating when the turn was complete. He said that this transmission was not received and subsequent calls to Owen were not answered. The witness said that he could not see the other F-89 at any time during this period and did not know the collision had occurred until notified by ground radio, which had intercepted the message from N 8210H. This occurred approximately one minute after the witness had finished his 90-degree turn. Then, aware of a collision, he could only suspect that 52-1870A was involved.

The radar operator who survived the collision stated that when it occurred he was checking a navigational feature of the radar equipment. The nature of the check required the radar search feature to be off. He said that he was not looking out but was looking at the equipment with his head lowered into a shield, "muff," which excluded most of the outside light. He testified that he did not

3/ An electronic device coupled to the pilot radar scope of F-89, 52-1870A, for the purpose of recording lockons, showed that 52-1870A had completed three. It showed no incompleted passes.

recall hearing the command to make the turns and to his best recollection the F-89 was on a heading of 135 degrees, its true airspeed was 380 knots, and its altitude was 25,000 feet when the impact occurred. The radar operator said the turn could have been started without his knowledge while he was concentrating on receiving the interrogator beacon signal in checking the navigational device. Also, because he was looking into the hood, without outside reference, a turn might not have been noticed. He estimated that he was occupied with the check about 45 seconds. He described the impact as being extremely severe but did not know whether it was a collision or an explosion. He said his cockpit was quickly enveloped in flames and his sole thought was to eject. This he accomplished quickly and with no recollection of the specific details. The witness stated there was no fault with the aircraft operation prior to the accident.

A part of the accident investigation was devoted to determining as accurately as possible the geographic location over which the collision occurred. While eyewitness' statements were being obtained, it was learned that a movie crew, on location, had accidently photographed the explosion cloud while shooting a western movie scene. To facilitate retakes, and for other purposes, a feature of the camera used permitted putting exposed film in the camera and aligning it precisely with features on the film. Thus it was possible to insert a frame of film bearing the explosion cloud in the camera, place the camera in its original position, and align the topographic details on the film with the same details on the lens image. After determining the elevation of the terrain (750 feet), the height of the camera, and other details, sightings were made using a surveyor's transit. Assuming the collision occurred at approximately 25,000 feet, it was calculated the accident occurred 5,000 feet northeast of the Hansen Dam Spillway located between Pacoima and Sunland, California. Because the distance between the camera and the accident was over 30 miles the film, even when blown up to its maximum, did not show either aircraft or any detail of the collision.

During this phase of the investigation it was also learned that a surveyor, at work, had seen the collision. The witness stated that the next day he repositioned his transit and made bearings on the position of the explosion cloud position as he recalled it. Again assuming the collision was at 25,000 feet, results showed the accident took place over a position about 12,500 feet northeast of the Hansen Dam Spillway.

From the results of both of these investigatory actions, together with considerable eyewitness testimony, it was determined that the accident occurred over an area northeast of the Hansen Dam Spillway, which is sparsely populated.

Following the midair collision, the DC-7 continued on a westerly heading for approximately four miles where it crashed on the grounds of the Pacoima Junior High School and an adjoining church.

Wreckage distribution and the manner in which various components struck the ground made it clearly evident that the DC-7 sustained structural failure of its basic airframe during descent. A considerable number of major pieces from the tail surfaces and aft fuselage were recovered along a two-mile path ending just east of the principal wreckage area. For the most part pieces of the aft fuselage were closer to the principal area, showing this portion of the aircraft failed after the tail section. Portions of fuselage forward of the

wing and just aft of the wing were located on the church property, indicating disintegration in this area prior to the initial ground impact.

The major portion of the DC-7 fell on the school property and on impact it broke up into numerous pieces, many of which were additionally damaged or destroyed by intense ground fires. Distinct craters were made by each of the four powerplants and the main wing center fuselage unit. The wide separation between the craters compared to the normal distance between the components as installed on the aircraft showed these units had also separated from their supporting structure before ground impact. Characteristics of the craters, and the way debris was thrown out of them, showed clearly the units which made them were moving westerly.

Following the inflight impact the F-89 fell southeastward for nearly 2-1/2 miles where it crashed on a narrow ridge in the rugged terrain of the Verdugo Mountains. Evidence showed the aircraft struck the ground relatively flat with a high sink velocity but little forward motion. The impact and an accompanying explosion caused extensive disintegration of the aircraft. An intense ground fire also completely or partially consumed many of the wreckage pieces.

During the structural investigation every effort was expended to determine, independent of eyewitness information, if there had been an inflight collision between the aircraft and, if so, the manner in which it occurred. After the many scattered wreckage pieces were found, identified, and their locations documented, they were transported to one location. There, the problems were approached by mockup, reconstruction, layout, and isolation of pieces bearing collision evidence. This work disclosed and isolated areas of damage which, by their nature, conclusively prove that a midair collision did occur. Results of this work also provided the material for determining the physical relationship of the aircraft to each other at the instant of impact.

One of the most significant areas involved in the inflight contact was the left wing of the DC-7, between stations 530 and 613. This area had been severely fragmented by impact forces with the largest single piece found about 18 by 12 inches in size. This piece and many others from the wing area were severely torn, crushed, and curled. They also bore scratches and smudges associated with the collision contact. Some of these pieces were recovered from ground positions below the previously described collision area considering the drift effect from winds aloft.

Outboard of station 613 to the wing tip, a span of about 8-1/2 feet, the wing panel was recovered in one piece. This component was recovered in the Sunland area and was in a relatively undamaged condition. At the fractured inboard end of this piece the stringers and spar sections were crushed and deformed rearward. On the bottom surface skin in the fracture area, scratches running aft and inboard were noted. Others were evident adjacent to the fracture with a few light smudges and scratches on the upper leading edge skin. Corresponding scratches were noted near the inboard end of a portion of aileron normally positioned on the wing in this area.

The average angle of the fracture, measured at the inboard end of this severed wing panel, was three degrees from a perpendicular to the centerline of the center wing spar. The aft end of the separation plane was farther inboard than its leading edge.

At station 530 the leading edge wing skin was deformed rearward. There, additional scratches and black-gray smudges were noted. Between station 530 and the wing root there was no evidence of collision except minor deformation and a few grayish smudges at station 397 on the upper leading edge wing surface. Spectographic and microchemical tests identified these gray smears as paint, identical with samples taken from the F-89 horizontal stabilizer.

With respect to the F-89, it was learned it had fallen to the ground intact except for components which separated because of the inflight collision damage. This damage was obviously so extensive that continued control was impossible. Further, characteristics of fire damage showed the aircraft was afire during its descent to the ground.

Of equal importance to the structural objectives was the F-89 fuselage nose section rearward to about station 125. This area had sustained severe inflight strike damage causing much of it to separate in flight as two large pieces and many fragments. One large section consisted of the upper panel structure above the nose section side doors from station 12.688 rearward to station 105. Below this panel structure an area the length of the panel and about 15 inches wide was gouged out. This area measured four degrees to the longitudinal axis of the aircraft with the aft end higher than the forward end. A portion of the front nose circular ring was still in place at station 12 on the large nose piece. The ring was fractured 22-1/2 inches from the top centerline on the right side and 10 inches from the top centerline on the left side. Measurements were made over the peripheral distance.

The second large piece from the nose section was from the area below the nose section side door between stations 12.688 and 105, or roughly the structure below the bottom edge of the gouged-out area. Similar to the upper nose section piece, this component bore inflight impact evidence, had been torn off in flight, and was recovered away from the main wreckage area of the F-89. The bottom portion of the fractured circular nose section ring at station 12 was attached to this large lower panel section. A line joining the edges of the fractures of this ring on the lower section made an angle of about 29 degrees with a waterline plane, the right side being lower than the left.

From the damage described and mockup reconstruction it was clearly evident that an object, about 15 inches deep, had passed through the F-89 nose compartment from front to rear at an approximate angle of 29 degrees. The object passed through the fibreglass radome, the nose frame at station 12, and through all intermediate frames and bulkheads, rearward to and including station 105.

The F-89 radome was recovered in two large pieces. The separation line on these two pieces corresponded approximately to the fractures in the circular nose section ring. The larger radome piece bore scratches in its black exterior paint and it was evident that they were made by a rivot line on the object which penetrated the entire nose section.

During the structural investigation considerable other inflight impact and collision sequence evidence was found. Most, however, was cumulative in the principal areas already described or it was so inconsistent with the clearly established pattern that the damage was considered secondary.

It was also possible during the layouts, the reconstruction, and isolation work to examine the individual pieces of wreckage which were not involved in the inflight impact but which separated from the DC-7 before the ground impact. The characteristics of the various fractures clearly showed that the general breakup of the DC-7 before ground impact was the result of airloads beyond the design or required strength of the airframe. Such loads were undoubtedly imposed during unusual attitudes of the airplane in its fall. This general disintegration, according to wreckage distribution, occurred shortly before ground impact and started with the empennage of the aircraft.

An equally exhaustive effort was expended in examining the engines of both aircraft and, in the case of the DC-7, its engines and propellers. The objective was to determine whether or not any inflight failure or operating difficulties of these components contributed in any way to the cause of the midair collision.

As indicated, the four DC-7 powerplants separated from the aircraft before ground impact as a result of excessive airloads. The units were severely damaged by this impact and were principally recovered from the widely separated craters in the schoolyard. In each case the propeller assemblies, nose, supercharger, and rear accessory cases were broken from their respective power sections. All cylinders were broken loose from their power section. Numerous components from these assemblies were scattered forward of the craters for distances as great as 250 feet. There was no evidence on the engines of inflight contacts.

Following a preliminary examination at the wreckage site, the powerplants were removed to suitable facilities for disassembly and detailed examination. This showed the various gear trains, bearings, and shafting of the engines had been normally lubricated prior to impact and that there was no evidence of failure or operational distress. Boroscopic examination of the cylinders revealed no indication of combustion irregularities. The articulating assemblies of the engine showed no evidence of operating distress and the oil pumps and screens were free of foreign material. While all of the engine accessories were recovered, ground impact damage precluded them from being functionally checked.

The DC-7 propellers remained tight on their shafts; however, each assembly, as indicated, was broken from its engine. The propeller blades exhibited various degrees of camber and face-side bending. Careful examination of the propeller blades, especially of the Nos. 1 and 2 engines, showed clearly they were not involved in the inflight collision.

Examination of the propeller pitch-changing mechanisms disclosed the stop rings properly indexed for a blade range of 94-1/2 degrees positive, full feathering, and minus 14 degrees, reverse. Impact markings on the spider shims and shim plates revealed a propeller blade angle at ground impact averaging 58.5 degrees. Because of the inflight disintegration of the aircraft and separation of the powerplants, as well as possible throttle manipulation during the descent, little significance can be attached to this evidence with respect to power or airspeed at the instant of collision.

The turbo-jet engines of the F-89 were recovered in the main wreckage of the aircraft. Both were heavily damaged by ground impact and fire after impact.

Some portions of the engines were hurled 4,000-5,000 feet from the crash site. The inlet and accessory sections of both engines were broken off and consumed by fire. The first three stages of the left engine compressor and the first stage of the right engine compressor were broken away. Variable bending and lack of damage to some blades in the same stages were indications that the damage was the result of impact with the ground. The combustion cans, although deformed, showed no indication of overheat. Crossover tubes were normal. Both turbine assemblies were intact but displaced rearward. The aft sides of the turbine wheels were freshly scored, indicating rotation when the wheels were forced rearward.

From the investigation of the powerplants of the DC-7 and the engines of the F-89 there was no evidence found to indicate that a malfunction or failure of any of these units was a factor in the accident.

Because of some misunderstanding during the accident investigation, the Board believes it is in the public interest to explain the status of the DC-7, the nature of its first flight, and the requirements and restrictions associated with the operation. These subjects were fully explored during the public inquiry through witnesses representing the Douglas Company and the Civil Aeronautics Administration (CAA).

From inception of an air-carrier-type aircraft to commercial production of the model many months, or years, of design, evaluation, and tests are required. During this period after the model is produced it is an experimental aircraft and may be flown only under an experimental certificate issued in accordance with Civil Air Regulations by the CAA. This strictly limits operation of the aircraft in the interest of safety. During this period the model must exhibit, through every manner and type of test, its strength, safety, performance, and quality, and meet or exceed the standards required by appropriate Civil Air Regulations. On completion of this work, if the airworthiness is proved the model is awarded a type certificate and may be duplicated in exact kind and quality for commercial sale. N 8210H was such a duplicate, one of over 300 already manufactured and in use in commercial aviation.

The manufacture of such aircraft under type certification is closely supervised by CAA personnel. This is a form of quality control and accomplished by inspection and tests performed regularly and frequently throughout manufacture. When production is complete numerous additional checks are accomplished by the manufacturer, and in the case of N 8210H nearly 15 hours ground time were accumulated on the powerplants during this work.

Before a formal airworthiness certificate is issued for the individual aircraft, Civil Air Regulations require that a functional inflight check be accomplished. This is principally a flight to gather information from which, if necessary, final and minor adjustments on the aircraft and its components can be made. Accordingly, N 8210H was being flown for this purpose when the subject accident occurred.

The functional check flight is made under a special flight authorization certificate issued by the CAA and it also is restrictive. Among other limitations, the aircraft must be flown in visual flight rule weather conditions, without passengers and, except for landing and takeoff, the operation must be over sparsely populated areas.

The F-89 was produced in a similar manner; however, the standards and specifications of a military plane are governed by the military establishment and not by Civil Air Regulations.

The IRAN project, in the case of the F-89, was principally a complete overhaul of the aircraft. This in no manner changed the basic proven airworthiness of the aircraft; however, such projects may modernize some of its components, especially those relating to its weapons systems.

Northrop records showed that after the overhaul work was completed with respect to 52-1870A, the aircraft had been flown six times for various checks of the work performed. The subject flight was to be a final check by the Northrop Company before turning the aircraft back to the U.S.A.F. It was for the purpose of checking the radar portion of the weapons systems of the aircraft and thus was a functional check flight.

In accordance with Air Force regulations pertaining to the Air Force flying activity at Palmdale, which were mutually agreed upon and part of the Northrop operating procedures, the F-89 flights were not to be made over congested areas except during landings and takeoffs. Also, the flights were to be conducted within an area generally bounded by San Diego, northwest to Santa Barbara, northeast to Bakersfield, and southeast to El Centro. As a standard Air Force requirement this area was designated and published as a local flying area; however, such did not set it apart for the exclusive use of the company. As a matter of fact, the same area is used in the flying operations of the numerous aircraft manufacturers located in the Los Angeles vicinity. Witnesses stated the joint use of this airspace was common knowledge. They also said it was heavily used by the aircraft of the manufacturers, the military, and commercial traffic serving the large metropolitan area. Further, the space was limited by restricted areas bordering the aforementioned local flying airspace on the east and west sides. The accident occurred within this local flying area.

It will be recalled that both flights were operated under local VFR flight plans. Accordingly, the avoidance of other aircraft was a direct responsibility of the pilots of both aircraft. Civil Air Regulations, Part 60, Section 60.12 (c), clearly place this responsibility on all pilots, regardless of the type aircraft. Rules for avoidance and right-of-way are also spelled out in these regulations, Section 60.14 (a) through (c) and Section 60.15.

Because of this pilot responsibility it was considered important to determine what, if any, effect the operational nature of the flights had on the ability of the pilots to carry it out. Specifically, it was important to learn whether or not the operational nature of the flights required an unusual amount of pilot cockpit preoccupation. Witnesses, well qualified through actual experience in performance of the flights, were questioned with respect to this subject.

A Douglas representative described the production flight check from its beginning to end, stating that each was very similar and followed a definite pattern. He stated the purpose was a thorough operational check of the aircraft, its powerplants, and its equipment involving flight at various power settings, aircraft configurations, all at various altitudes. The witness testified that flight check sheets are carried aboard the flights and the items

are accomplished in the sequence of their arrangement on the sheets. He also said that as the flight progressed and the items were accomplished the results were recorded. This duty, he said, was exclusively a responsibility of the flight engineer. He also said the manipulation and setting of controls, except flight controls, was principally done by the flight engineer. He concluded that there was no greater pilot cockpit preoccupation in this type of operation than in any other.

During the investigation these flight check sheets were recovered from the wreckage of N 8210H. It was noted that many of the items had been completed and in sequence. The end of the completed items indicated that when the collision occurred the aircraft was being flown at 25,000 feet and at about 330 knots true airspeed, for the purpose of checking carburetor operation at maximum cruise power. A study of the writing showed clearly it was in the handwriting of Mr. W. B. Adams, the flight engineer.

Witnesses experienced in the F-89 radar check flight operation stated it required precision flying and that accuracy of headings and altitudes was required within narrow tolerances. Because of this the simulated intercepts were usually flown using autopilot. Witnesses familiar with Mr. Owen's technique believed he would have been using it continuously during the radar pattern and simulated intercepts which would include the turn preceding the attack vector. The radar operator could not tell from his cockpit. The witnesses testified that using the autopilot provided the precision necessary and greatly reduced the pilot's concentration within the cockpit. Testimony indicated that during the turn preceding the attack vector the pilot had only to monitor the turn. During this time there was nothing connected with the radar equipment to occupy his attention. Greatest cockpit concentration on the pilot's part would be later during the lockon phase of the intercept which follows completion of the turn to the attack vector and after the search phase has been accomplished. Witnesses concluded that during the positioning turn Mr. Owen would be free to look out for other aircraft. As previously stated, the responsibility to look out for other aircraft was in no manner reduced by the designation of a local flying area.

Analysis

The several areas of primary collision damage and markings furnished the foundation for a successful analytical study of how the inflight collision sequence occurred and the relative attitudes of the aircraft at impact.

Initial contact occurred when the leading edge of the left wing of the DC-7 between stations 530 and 613 made contact with the fibreglass radome of the F-89. As the two aircraft passed, the left wing of the DC-7 and nose section of the F-89 progressively penetrated one another until the left wing outboard of station 530 was sheared off and the nose section rearward to station 125 was destroyed. Impact markings made during this sequence showed clearly that the aircraft were rolled 36 degrees to the left with respect to each other.

As the split second sequence continued the left horizontal stabilizer of the F-89 brushed across the upper surface of the DC-7 left wing at station 397 leaving paint smudges in that area. The relative angle in the roll plane between the aircraft and location of the stabilizer brush marks showed the F-89 would clear the No. 1 propeller arc of the DC-7, thus accounting for the absence of propeller cuts and blade damage. The aircraft then passed one another and

from all the available evidence there were no other primary contacts between them. Damage received by the F-89 clearly showed it would have been rendered uncontrollable. In the case of the DC-7 it is doubtful that effective control would have existed, the latter substantiated by the final transmission from its crew, "Uncontrollable."

The relative angle between the aircraft in the pitch plane must be deduced from the impact markings and the existing angles of attack of the aircraft when the marks were made. Impact damage was all predominately rearward and slightly inboard on the DC-7 with little or no upward or downward indications. On the F-89 the damage was rearward with a four-degree upward angle. With respect to airspeeds, a principal consideration in determining angles of attack, ample evidence indicates that the true airspeed of the F-89 was 380 knots and, though less conclusive, it is quite probable that the true airspeed of the DC-7 was 330 knots. Considering this evidence, it is very reasonable to conclude that both aircraft, relatively, were level in the pitch plane.

The impact angle in the yaw plane is perhaps the most important factor of the collision orientation because it is most indicative of the converging flight paths before impact. This angle is based on considerations of airspeeds and the fracture angle of the cut on the left wing of the DC-7, which was measured as three degrees inboard from front to rear. Accepting the airspeeds mentioned and the angle of the cut, the resultant angle of convergence was about five degrees from head-on.

As previously indicated, the correlation of physical damage, collision marks, and impact angles relate one aircraft to the other but not with respect to the ground. It is therefore necessary to deduce the orientation with respect to the ground through other means. While direction of flight at impact may often be indicated by the direction of wreckage scatter, in the subject accident this was not definitive. Thus, orientation of the aircraft with respect to the ground and the direction of flight of the aircraft at impact are necessarily based on the observations of eyewitnesses and some circumstantial evidence.

The preponderance of eyewitnesses, some aeronautically qualified and cognizant of direction, believed that the DC-7 was heading about due west and the F-89 was heading approximately due east when they collided. While it is possible that some error may exist in these collision headings because of the difficulty of such estimates from ground positions, it is noteworthy that only substantial errors would have an appreciable effect on the results based on them. Recalling it was Pilot Owen's intention to turn left from 135 degrees to 45 degrees using a 30-degree bank, and accepting the collision headings as substantially correct, it is entirely reasonable to conclude that the F-89 was banked to its left about 30 degrees with respect to the ground when the impact occurred. This conclusion would thus place the DC-7 flying straight and level, or nearly so, when the two aircraft collided.

In summary, based on all the available evidence, it is the judgment of the Board that this collision occurred nearly head-on while the DC-7 was flying straight and level, or nearly so, on an approximate westerly heading. It is believed that it occurred while Pilot Owen was executing a level left turn from 135 degrees toward an anticipated heading of 45 degrees and that his aircraft was banked approximately 30 degrees. It is also clearly evident that the accident took place in clear weather conditions at 25,000 feet over a noncongested area between one and two miles northeast of the Hansen Dam Spillway.

The small difference between the standard bank of 30 degrees and the 36-degree impact angle in the roll axis cannot be positively explained. It is possible, however, that this six-degree difference is indicative of the start of an evasive maneuver. From the transmission by Mr. Twitchell, "Poor jet too," it is known that he saw the F-89. Because the collision sequence occurred in about 1/100 of a second he could not have recognized the aircraft as a jet at that time and must have done so before impact. It is possible, therefore, he saw the jet in time to react and start a left bank which had progressed six degrees but which was insufficient to avoid the collision.

In order to evaluate the all-important question of whether or not the crews could have seen and avoided the collision, an analytical study of the opportunities was made. The aforementioned collision factors were applied, with others, such as closure speed, visual range, and angular position of the conflicting aircraft on the other's windshield. It must be realized that some of these latter factors are the products of numerous tangible and intangible considerations.

The maximum distance that an aircraft can be seen depends upon its angular presentation, its color contrast with the existing background as affected by the degree of illumination, and the atmospheric conditions of visibility including altitude effect. These factors are highly variable and different in each actual situation, and small amounts less than optimum in the conditions result in an appreciable reduction of the maximum distance that an aircraft can be seen. Also, it is known that the head-on or near head-on flight paths are the most unfavorable situations for sighting other aircraft because of the relatively small frontal profile presented during such closure.

Realizing the intangible nature of the maximum sighting distance, the Board carefully considered each factor, together with published material on the subject, and selected 3.5 miles as its best estimate in the subject situation.

Accepting this distance and applying it to the flight path portion of the analytical study, the F-89 would enter visual range about five degrees to the right of zero reference on the DC-7 windshield. Movement during closure would be slowly from right to left until just before impact. At visual range the DC-7 would be positioned 22 degrees to the left of zero reference on the F-89 windshield. Considering the banked attitude of the F-89, this initial position would be on the canopy glass off the armorglass windshield. Movement of the DC-7 during closure would be slowly diagonally downward from left to right until just before impact.

Considering the probable flight path of each aircraft to collision, the visual range, and the true airspeeds of the aircraft, computations show the closure speed between them was about 700 knots. The calculated time from visual range to collision was about 15 seconds.

While a conflicting aircraft is within visual range it must first be detected by the pilot, then an avoidance decision must be made and, finally, the aircraft must respond to and carry out the avoidance maneuver. Each of these factors requires an element of time, the total of which must be sufficient for a successful collision avoidance.

Detection of another aircraft is probably the greatest time-consuming factor, being restricted by physiological limitations of the human eye. The eye will best detect an object when it is within the focal field of vision, some 2-3 degrees wide. With sufficient motion the object may be detected within the peripheral field, a few degrees outside the focal area. To compensate for these restrictions the pilot must employ scanning to search the broad areas of potential collision to detect other aircraft. Thus a reasonable opportunity to avoid collision must include a reasonable time for detection.

Following detection, the pilot must then evaluate the situation and determine if collision courses exist and, if so, decide on the proper evasive maneuver. The time required for such decision may vary considerably, according to the situation. For example, it may be hard to determine whether or not a conflicting aircraft is approaching or moving away. It may also be difficult to decide which way a turning aircraft is progressing and where its projected flight path will take it from its sighted position. This is especially difficult when the conflicting aircraft and the aircraft from which it is viewed are being flown at high speed.

Aircraft response, especially for the large transport type, is less than immediate. Although with boosted controls the attitude of the aircraft may be altered rapidly, several seconds are required before the direction of flight is sufficiently changed to avoid collision.

Considering these collision avoidance elements and all the available evidence, it appears that only the minimum time opportunity existed for the pilots to have carried out the basic elements of collision avoidance. It is clear that only if the pilots sighted the other's conflicting aircraft early in the period when it was visible and took immediate evasive action could the collision have been avoided. Thus, it is the considered opinion of the Board that, while visual separation could have been effected in the time available, because of the near head-on closure and the high rate of closure at high altitude the pilots were confronted with unusually great problems of visual separation.

The accident, which appears to have occurred under almost the most adverse conditions insofar as the time opportunity for the pilots to see and avoid is concerned, raises the question whether the long established "see and be seen" philosophy applicable to VFR flight is adequate in uncontrolled operations. It is clear that, under certain conditions of speed and angle of convergence, very little time opportunity exists for pilots to observe the other aircraft and take avoidance action. As aircraft speeds and traffic density increase, this problem will be aggravated. While this problem is serious, and growing more so, it is not sufficient cause to discard the see and be seen rule. Alternatives to this fundamental rule in VFR operations either do not exist as yet or are so extreme that they would penalize the expeditious flow of traffic to the point where aircraft operations in general would be stifled. For instance, the practical consequences of immediate implementation of full positive control for such operations regardless of weather would be the grounding of a large percentage of current aircraft operations. Therefore, until technological advances are made which will insure separation of aircraft without reliance on the vigilance of the pilot, the Board will continue to rely on the see and be seen policy with whatever refinements circumstances and the state of the art permit. In this

connection, the Board calls attention to certain regulatory amendments already adopted and others in preparation which serve to refine the see and be seen rule in the light of high-speed, high-performance aircraft operations. In this group are the pilot vigilance and restrictions on flight testing rules; the VFR minimums within control zones for flights with traffic clearance, and speed control and communication rules in high density air traffic zones; the high altitude quadrantal rules; and the rules establishing the continental control area.

In view of the foregoing, the Board must call to the attention of all persons engaged in the operation of high speed aircraft that the closure rates of such aircraft in normal operations impose obligations for vigilance on the part of operating crews which are of extreme urgency. We are faced with no immediate alternative but to seek the redoubling of effort on the part of management and operating crews to prevent any avoidable diversion or preoccupation which would tend to compromise the ability of pilots to see and avoid other aircraft. It has not been possible in this instance to determine specifically what had prevented the crews of either aircraft from taking timely action; however, we conclude that the avoidance of collision by visual means was not beyond the physical capabilities of the pilots involved provided full attention was given to collision avoidance. Accordingly, reliance must continue to be placed upon pilots of aircraft engaged in similar operations to provide for separation under visual flight rules. To this end, however, the Board will continue to review inflight procedures, cockpit design including instrument and equipment layout, aircraft crew complements, and the training and indoctrination of flight crews to insure that the possibility of recurrence of such a collision is minimized.

Findings

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

1. The aircraft and the crews were properly certificated according to the status of the aircraft and nature of the operations.

2. Preparations for the flights were complete and routine.

3. The flights were operated in clear weather conditions and in accordance with the provisions of local VFR flight plans.

4. Under VFR weather conditions and VFR flight plans collision avoidance rested in visual separation, a pilot responsibility.

5. The DC-7 and F-89 collided in flight on approximately west and east headings, respectively. They were at 25,000 feet over a noncongested area between one and two miles northeast of the Hansen Dam Spillway.

6. At impact the F-89 was rolled about 30 degrees left, both aircraft were about level in the pitch plane, and the convergence angle was about five degrees from head-on.

7. Both aircraft fell out of control and the DC-7 crashed in a populated area.

8. From visual range, estimated at 3.5 miles, the closure speed between the two aircraft was 700 knots and over the probable flight paths the time to collision from visual range was about 15 seconds.

9. The nature and purpose of the flights did not prevent all pilots from maintaining a lookout for other aircraft.

10. There was no evidence found to indicate that any malfunction or failure of the aircraft or their components was a factor in the accident.

Probable Cause

The Board determines that the probable cause of this midair collision was the high rate of near head-on closure at high altitude which, together with physiological limitations, resulted in a minimum avoidance opportunity during which the pilots did not see the other's aircraft.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ G. JOSEPH MINETTI

/s/ LOUIS J. HECTOR

SUPPLEMENTAL DATA

Investigation and Hearing

The Civil Aeronautics Board was notified of this accident through its Santa Monica office a few minutes after it occurred. Investigators were promptly dispatched to the scene and an investigation was initiated and conducted in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A public hearing was ordered by the Board and held in the Hollywood Roosevelt Hotel, Hollywood, California, on March 20-21, 1957.

Companies

The Douglas Aircraft Company, Inc., a Delaware corporation, has its principal offices in Santa Monica, California. The company is principally engaged in the manufacture of aircraft.

Northrop Aircraft, Inc., a California corporation, has its principal offices in Beverly Hills, California. The company is principally engaged in the manufacture of aircraft.

Flight Personnel

1. Douglas. Pilot William G. Carr, age 36, was employed by the company on January 14, 1952. He held a valid airman certificate with an airline transport rating and rating for the subject aircraft. He also held numerous other type ratings as well as ratings on airframes and powerplants. Pilot Carr had 11,757 total flying hours, of which 598 were in the DC-7 type. His last medical examination was accomplished November 27, 1956, without waivers.

Copilot Archie R. Twitchell, age 50, was employed by Douglas since February 2, 1955. He held a valid airman certificate with airline transport and DC-7 ratings. The pilot had accumulated 7,115 flying hours, of which 287 were in the DC-7. His last medical examination was accomplished, without waivers, on February 9, 1956.

Flight Engineer Waldo B. Adams, age 43, was employed by Douglas, January 4, 1937. He held a valid airman certificate with flight engineer, airframe, engine, and commercial pilot ratings. Company records showed he had accumulated 2,711 flying hours as a flight engineer, of which 278 were in the DC-7 type aircraft. He had taken his last physical examination on February 22, 1956, and it was accomplished without waivers.

Flight Radio Operator Roy Nakazawa, age 29, was employed by the company May 26, 1952, and held the position of a flight line technician (electronics). Mr. Nakazawa held a second-class radiophone license issued by the Federal Communications Commission on December 11, 1953.

2. Northrop. Pilot Roland E. Owen, age 36, was employed by the company on October 15, 1951. He was the Chief of Production Test at the time of the accident. He held a valid airman certificate with commercial and instrument

ratings. He also held a formal certificate of authority from the United States Air Force to fly the F-89. Pilot Owen had accumulated 2,754 flying hours, of which 1,320 were in jet aircraft and 1,249 were in the F-89 type jet. His last physical examination was accomplished in May 1956, without waivers. His last high-altitude indoctrination was accomplished May 31, 1955, (valid for three years).

Radar Operator Curtiss A. Adams, age 27, was employed October 10, 1951, as an electronic checkout man. His last physical and high-altitude indoctrinations were received in May 1956 and September 1956, respectively.

The Aircraft

The DC-7B, N 8210H, had a total of 1:03 flying time since its manufacture. It was equipped with Wright engines, model 972TC18DA-4, and Hamilton Standard propellers, model 34E60-363, blade model 6921A-8. The engines and propellers had accumulated about 14 hours of ground running time since new.

The F-89 bore manufacturer's serial number 4447 and U. S. A. F. designation 52-1870A. The aircraft had been flown 261 hours since manufacture and 6 hours since IRAN. The F-89 engines were Allison, model J-35A-35. The left and right engines had accumulated 258 hours and 200 hours, respectively, since new.