No. 3

Trans World Airlines, Inc., Douglas DC-9, N 1063T and a Tann Company Beechcraft Baron B-55, N 6127V, collided approximately 25 NM northeast of the Dayton Municipal Airport, Dayton, Ohio, U.S.A., on 9 March 1967. Report, not dated, File No.1-0002, released by the National Transportation Safety Board, Department of Transportation, U.S.A.

1.- Investigation

1.1 History of the flight

Flight 553 was a scheduled domestic passenger flight from New York to Chicago, Illinois, with en-route stops at Harrisburg, Pittsburgh, Pennsylvania, and Dayton, Ohio. The flight departed Pittsburgh for Dayton at 1125 hours Eastern Standard Time on an IFR flight plan and was operated under radar surveillance for the duration of the flight.

As the flight approached the Dayton terminal area it was cleared to descend from FL 200, its cruising altitude, to 5 000 ft, and a transfer of radar control from Indianapolis Air Route Traffic Control Centre (ARTCC) to the Dayton Radar Approach Control facility (RAPCON) was made when the flight was approximately 8 miles northeast of the Urbana Intersection on Victor Airway 12 North. The Dayton RAPCON approach controller established radio contact with the flight at 1152:36 hours. The flight was again cleared to 5 000 ft, instructed to take a heading of 240° for a vector to the final approach course (ILS) and to report leaving 6 000 ft.

At 1153:22 hours, the controller cleared the flight to descend to and maintain 3 000 ft and turn left to a heading of 230°. This was correctly acknowledged by the pilot-in-command at 1153:28 hours.

Immediately after the issuance of this clearance the controller observed for the first time an unidentified radar target ahead and slightly to the right of the flight and issued at 1153:32 hours the following traffic advisory: "TWA five fifty three, roger, and traffic at twelve thirty, one mile, southbound, slow moving."

This was acknowledged by the pilot-in-command at 1153:36 hours.

Approximately 14 seconds later, the flight and the unidentified radar target merged, separated, changed shape on the radar screen and then disappeared. At 1154:02 hours the controller advised the flight that it was clear of traffic but no reply was received. Subsequent efforts to establish contact with the flight were unsuccessful.

The unidentified radar return was from a Beechcraft Baron B-55 on a company business flight, en route from Detroit, Michigan, to Springfield, Ohio. The aircraft had departed Detroit City Airport at 1101 hours on a special VFR clearance to leave the control zone 5 miles from the airport. No flight plan was filed, nor was one required. Approximately two minutes after take-off, the pilot reported on top of the smoke and haze and then left the Detroit tower frequency. No record of any further communication with any FAA

communication facility or air traffic control facility could be found that related to the Beechcraft, nor was such communication required. The operator of Springfield Aviation Inc., at the Springfield Airport, testified that at approximately 1154 hours the pilot of the Beechcraft established radio contact with his office and requested a courtesy car. During this conversation the pilot stated that he would be landing shortly. There was no record of any subsequent radio contact with the aircraft.

The aircraft collided at 1153:50 hours, in bright daylight, approximately 25 NM northeast of the Dayton Municipal Airport at an altitude of about 4 525 ft AMSL, and both aircraft crashed.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	4 (DC-9) 1 (B-55)	21 (DC-9)	
Non-fatal			
None			

1.3 Damage to aircraft

The Beechcraft disintegrated in flight at the time of the collision. The DC-9 was destroyed by the collision, ground impact and post-impact fire.

1.4 Other damage

None.

1.5 Crew information

The pilot-in-command of the DC-9, aged 39, held an airline transport pilot's certificate with type ratings for the Lockheed Constellation, B-720/707, DC-9 and commercial privileges, aeroplane single-engine land. His last first-class medical certificate was issued on 20 December 1966 with no waivers or limitations. He completed initial DC-9 pilot-in-command's training on 1 November 1966, DC-9 line qualification on 14 November 1966 and had his last line check on 23 February 1967. He had flown a total of 9 832 hours, including 193 hours in DC-9 aircraft, of which 136 hours were flown in the last 90 days. His rest period prior to this trip was 31 hours and he had not flown in the 24 hours preceding the trip.

The co-pilot, aged 29, held a commercial pilot's certificate with aeroplane single and multi-engine land and instrument ratings. His last first-class medical certificate was issued on 9 January 1967 with no waivers or limitations. He completed DC-9 co-pilot training on 3 February 1967 and completed his line qualification on 12 February 1967. The flight which terminated in the accident was his second scheduled flight as a co-pilot in DC-9. He had flown a total of 1 560 hours including 15 hours in DC-9 aircraft.

Also aboard were two flight attendants.

The pilot of the Beechcraft Baron B-55, aged 54, held a private pilot certificate with aeroplane single and multi-engine land and instrument ratings. His third-class medical certificate, dated 13 July 1966, specified that he shall wear correcting glasses while flying. The FAA reported that the limitation on his certificate was not required and was incorrectly affixed to that certificate. He had flown a total of 4 074 hours up to 2 March 1967, including 575 hours in Beechcraft Model B-55 aircraft, of which 493 hours were in the aircraft involved in the accident. He had recorded 274 hours in the preceding year and 37 hours in the preceding 90 days.

1.6 Aircraft information

Both aircraft were properly certificated and their maintenance records indicated that they had been maintained in accordance with existing requirements.

The weight and centre of gravity of each aircraft were calculated to be within their respective limits.

The DC-9 was serviced with Jet A turbine fuel and the Beechcraft was serviced with 100 octane gasoline.

1.7 Meteorological information

The 1200 hours weather reported by various stations in the vicinity of the accident site was high thin scattered clouds, visibility 6 - 7 miles in haze, temperature 23 - 35°F with southwesterly winds at 8 - 10 kt. The 0700 hours Dayton radiosonde recorded very moist unstable air from the surface to nearly 2 500 ft AMSL, a 6°C temperature inversion from approximately 2 500 ft to 3 000 ft AMSL, with relatively dry stable air above approximately 2 500 ft AMSL. The freezing level was at the surface.

The crew of Flight 553 was provided with the current weather information pertaining to their flight at each point of departure. Updated information was available to them en route through the FAA and company communication systems.

There was no record of any weather briefing being provided to the Beechcraft pilot. However, with the exception of the Detroit area, the weather was reported to be suitable for VFR operation. Pilots of other aircraft operating in the area near the time of the accident reported that the weather was clear, with haze and that the ground was 80 per cent to 90 per cent snow-covered. The top of the haze layer was estimated between 3 000 ft and 5 000 ft. One pilot stated that visibility was restricted looking toward the ground, and other pilots that it was restricted looking toward the sun. Ground witnesses in the area reported the weather as clear with good visibility.

1.8 Aids to navigation

Special flight checks of radar equipment and pertinent navigational aids were performed after the accident.

Flight checks utilizing a DC-3 disclosed that the radar, navigational aids and communications systems in use at the time of the accident were operating in a normal manner and no difficulty was found in detecting the primary radar target of the aircraft or its radar transponder return.

A flight check using a Beechcraft Baron was conducted with the aircraft flying on a direct course from the Findlay VOR to Springfield Airport at 4 550 ft AMSL. This check revealed that primary radar targets from the Beechcraft received in both the Indianapolis ARTCC and the Dayton RAPCON met the criteria specified for operational use. Primary radar returns on the Dayton RAPCON radar scopes were recorded for the Beechcraft from a point approximately 36 miles from the Dayton radar antenna inbound to a point over the accident site, approximately 23 miles northeast of the antenna site. Marginal returns were evident between 36 miles and 30 miles northeast of the antenna. This data was later verified by a series of tests conducted by the FAA using a similar type target aircraft under a number of different time and atmospheric conditions and were confirmed by several Dayton RAPCON controllers who testified that in the area beyond 30 miles northeast of the antenna, primary radar returns from light twin-engined aircraft were sometimes difficult to detect.

Ground checks confirmed satisfactory operation of the radio navigation aids believed to have been used by the two aircraft.

1.9 Communications

There were no reported difficulties with air-ground communications between TWA 553 and the ground facilities. Investigation revealed no record of any communication between the Beechcraft and any ground stations except the Detroit tower and the Springfield Aviation Company. No communication requirement existed in this case because the Beechcraft was operating VFR without a flight plan.

1.10 Aerodrome and ground facilities

Not relevant to this accident.

1.11 Flight recorders

Flight 553 was equipped with a Lockheed 109D flight data recorder and a Fairchild A-100 cockpit voice recorder (CVR) both of which were recovered from the wreckage in readable condition.

The flight data recorder was recovered from the wreckage area with considerable mechanical damage but no fire damage. Examination of the recording medium revealed no evidence of parameter malfunction, abnormalities of traces or styli alignment, or other abnormal functioning between the calculated lift-off time at Pittsburgh and a time 28 minutes and 50 seconds later. Good correlation was established between parameters but all traces beyond the time point of 28 minutes and 50 seconds were considered unreliable due to aberration. The read-out indicated that, at the time of impact with the Beechcraft, the DC-9 was descending through 4 525 ft AMSL, at an indicated air speed of 323 kt, on a heading of 232°. The rate of descent for the 20 seconds prior to impact averaged approximately 3 500 ft/min.

The CVR was recovered in the DC-9 wreckage area with the chassis partially crushed and deformed. There was no evidence of fire or heat damage and the tape was intact. The recording was integrated with the Air Traffic Control information and a time correlated transcription of the last $2\frac{1}{2}$ minutes of the recording was prepared. The total time between the initiation of communication between the flight and Dayton Approach Control at 1152:36 hours and the collision at 1153:50 hours was 1 minute and 14 seconds. The time from the beginning of the traffic advisory at 1153:32 hours until the end of the recording at 1153:50 hours was 18 seconds. The DC-9's flight path was reconstructed utilizing the flight recorder

readout. The Beechcraft's flight path was chosen based on its probable route from the Findlay VOR to Springfield, Ohio. Since the attitude and speed of the Beechcraft were unknown, the Beech Aircraft Corporation was requested to determine the speed and deck angle of the Beechcraft in level flight, and at a 300 ft/min rate of descent. They were computed to be 194 mph (CAS) at 0.8° negative deck angle and 210 mph (CAS) at 2.1° negative deck angle, respectively. From these data two flight paths were calculated and were plotted as well as the DC-9 flight path on a graph (see Fig. 3-1) after proper wind and temperature corrections. From these ground tracks and headings, the bearing and range of each aircraft from the other were determined. The elevation angle from each aircraft was calculated utilizing the pitch and roll data of the DC-9 and the pitch data for the Beechcraft. The plots were prepared for five-second intervals from 1152:50 through 1153:50 and the points connected to show the approximate path the presented target would have traced on the cockpit windows of each aircraft.

1.12 Wreckage

The wreckage of the two aircraft was found scattered over an area approximately 2.3 miles long and 1.2 mile wide, oriented along a line 230° magnetic. The major portion of the DC-9 was found in one area. The Beechcraft was extensively fragmented, components and fragments, together with some parts of the DC-9, mainly from the nose section, were generally located 4 500 to 9 000 ft northeast of the primary DC-9 impact area.

The DC-9 flight controls surfaces were all accounted for in the main wreckage area. The horizontal trim setting was measured to be 3/4° nose up. There was no evidence of pre-impact malfunction of the flight control systems of the DC-9 or the Beechcraft nor was there evidence of corrosion or fatigue failure found on any DC-9 component.

Portions of the Beechcraft's wing structure were found imbedded in the nose landing gear tire and in the leading edge of the left outboard wing section of the DC-9. There were numerous red paint scuff marks on a number of pieces from the right side of the DC-9 fuselage between stations 110 and 229 and on sections of the left wing upper skin between the forward and rear spar. These scuff marks ran fore and aft and were inclined upward as they progressed aft on vertical or near vertical surfaces such as the side of the fuselage.

Beechcraft fragments were laid out in a two-dimensional mockup and the direction and angles of scuff marks and scratches were measured clockwise relative to the longitudinal axis of the aircraft. These scuff marks and scratches averaged 103°. The vertical component of the scuff marks on the gravity water door of the DC-9 and on the vertical stabilizer of the Beechcraft were found to be approximately 10° and 20° from the horizontal, respectively.

Using these angles, the horizontal and vertical angles between the longitudinal axes of the two aircraft were calculated as being approximately 47° and 10° respectively.

The engines of the DC-9 and the engines and propellers of the Beechcraft were examined, and no evidence of pre-impact malfunction was found.

1.13 Fire

Witnesses in the area of the accident reported that no fire occurred until the DC-9 crashed and exploded. There was no evidence of inflight fire found on the wreckage of either aircraft.

1.14 Survival aspects

This was a non-survivable accident. All persons aboard the two aircraft died of traumatic injuries.

A review of the medical records and the post-mortem examination of all the pilots involved did not reveal any pre-existing disease or impairment.

1.15 Tests and research

Because the accident occurred during daytime in VMC, a special study was conducted to determine the visibility afforded the three pilots involved.

For certification the manufacturer had been required to demonstrate that the cockpit visibility of the DC-9 met the intent of Civil Aeronautics Manual 4B which contained the FAA policies on pilot's compartment visibility requirements. These policies, which provided detailed technical information on recommended methods of complying with the provisions of Part 4B of the Civil Air Regulations on the subject, are for guidance and are not mandatory in nature.

Investigation disclosed that the DC-9 cockpit visibility did not meet the letter of the FAA policy but was approved as meeting the intent of these recommended policies. The recommended maximum post width was 2.5 inches but the posts in the DC-9 were 3-5/8 inches wide as projected to the pilot's eye.

Under conditions of good visibility and atmospheric conditions the threshold of visibility is less than one minute of arc. The determination of the colour of a target requires approximately twice the arc as that required for the threshold of visibility. In detecting a target at a distance of 1 mile or more only the fovea, or central part of the retina of the eye, is used. Peripheral vision comes into play only at close distances where the eye does not have to see or identify definite objects. For example, with peripheral vision, motion and objects can be detected but the object or colour cannot be identified. The conspicuity of a target depends on a number of items including its size, colour, relative motion, and brightness contrast. The characteristics of the atmosphere through which the target is viewed also affect the detectability of the target. Any contamination of the atmosphere such as haze, visible moisture, or smoke would make the target more difficult to detect and would in effect require it to subtend a greater arc in order to be detected.

With regard to the differences in conspicuity of various colours under favourable conditions, international orange has by far the most outstanding conspicuity. Under conditions of decreased visibility and in combination with other colours, the combination of red and white (the colours of the Beechcraft) was not one of the most conspicuous sets.

Under the physical conditions that appear to have existed in this accident, the maximum range of target detection would have been approximately 4 miles. At this range each target would have subtended 1.5 minutes of arc or more when viewed from the other aircraft and each of the crews should have been able to detect the other aircraft if it were presented in the areas of visibility provided by the windows of the cockpits. According to a recent study* the probability of detection for targets which exceed 1.4 minutes of

* Collision Avoidance Visibility, 22 May 1966, Lockheed California Company, Burbank, California.

arc, visual angle, is 100 per cent in clear visibility. Once the pilot's attention has been directed toward a target which has no relative motion, colour would be the thing that would attract the eye and lead to focusing on the target. If relative motion existed it would lead the eye to the target. Given the circumstances presented to the DC-9 crew, they should have detected the Beechcraft within 3 seconds after receiving the warning from ATC, if it was presented in the clear visibility area of the windshield. Assuming a 1/2-second pilot decision time and a 1/3-second pilot motor-response time the crew should have been able to detect the target and initiate a change in their aircraft's direction in not more than 5 seconds, if the target was presented continuously in the clear glass windshield.

Extensive studies of many collision accidents have shown that there was an opportunity, of varying degree, for the pilot or pilots to see the conflicting traffic in sufficient time to take evasive action. In many cases where the pilots have survived, they have testified that they were maintaining a careful lookout but despite it they did not see the other aircraft in time to avoid a collision, or they did not see the other aircraft at all.

Collision studies, including controlled flight tests, have demonstrated that seeing other aircraft in flight is difficult. The degree of such difficulty is variable, with numerous tangible and intangible factors affecting it. The tangible factors include the angular limits of cockpit vision, interfering cockpit structure, and detection range. The latter is influenced by many things, including the colour of the target, background against which the target is displayed, its apparent angular size and shape, atmospheric conditions, and apparent relative motion or lack thereof. In this connexion note that aircraft converging on collision courses provide no apparent relative motion when viewed from each other. Another factor which is allied to relative motion is termed "range rate", or the rate at which the apparent size of a target increases or decreases when the range is closing or opening.

Intangible factors of a physiological nature include the individual's physical condition, degree of fatigue, and training.

Finally, regular and frequent checks of instrumentation both operational and navigational, are required during all phases of flight, particularly during the approach to a terminal area in preparation for landing and the crew has limited opportunity to look out for other traffic.

In the present case the DC-9 crew's attention was concentrated on controlling the airspeed, checking the altitude of the aircraft in relation to the clearance limit of 3 000 ft, preparing to perform the pre-landing checklist, and turning to their assigned headings. All of these items required the attention of at least one of the pilots inside the cockpit for various periods of time. It was estimated that the preparations necessary before reading the checklist would take from 10 to 15 seconds, during which time at least one of the pilots would have had his attention concentrated inside the aircraft.

The lack of verbal comment on the part of either crew member of the DC-9 suggests that neither of them saw the Beechcraft. Observation of routine aircrew operations of air carrier flights has shown that when designated traffic is not observed, crew members shift their positions and institute some form of visual search pattern in an effort to detect the target. There is also, generally, some verbal comment between crew members regarding the detection or failure to detect the target.

At the time of the accident there were no FAA-approved devices or systems available on the commercial market which, if installed on either the DC-9 or the Beech Baron aircraft, would have assured positive separation of the two aircraft.

2.- Analysis and Conclusions

2.1 Analysis

The Beechcraft pilot had carried out frequent flights into the Springfield area and was familiar with the local airway structure. He was qualified and his aircraft was equipped for instrument flight.

The operation of the Beechcraft was carried out in accordance with existing FAA regulations pertaining to the conduct of a VFR flight from point to point. Evidence revealed that, when the collision occurred, the Beechcraft was flying at an altitude of approximately 4 500 ft AMSL in accordance with FAR Part 91.109 for the heading being flown (195° magnetic). There was no requirement for the Beechcraft pilot to contact any FAA air traffic control facility, use his transponder, or display the rotating red beacon with which his aircraft was equipped and it was not believed that imposing any of the above would necessarily resolve the mid-air collision problem.

During the descent from cruising altitude in preparation for landing at Dayton the DC-9 flight crew had to monitor the air traffic control transmissions, carry out aircraft heading and speed changes, accomplish the checklist items and look out for other traffic in the area.

Evidence revealed that radio transmissions during the descent were made by the pilot-in-command and it was therefore believed that the co-pilot was probably flying the aircraft. The high-speed warning clacker immediately followed by the landing gear warning horn sounds, identified on the CVR tape, would indicate that the co-pilot was making power adjustments as well as heading changes in response to vectors issued by the ATC controller. The pilot-in-command would probably have been monitoring these heading and power changes in addition to offering certain instructional comments to the co-pilot.

The company operating procedure is for the pilot flying the aircraft to go over the checklist silently before requesting the other pilot to read the list aloud. The co-pilot's comment "ready on the checklist," issued just prior to the collision, could have been such a request. It can be assumed, therefore, that sometime during the descent the co-pilot had made a complete check of the cockpit, including positioning of certain switches, and was requesting the pilot-in-command to read the preliminary landing checklist.

The testimony of the radar controllers from the Dayton RAPCON, and the flight test results, indicated that the area of radar coverage beyond 30 miles from their antenna in the vicinity north to northeast of the Rosewood VOR was an area in which light twin-engine aircraft may not provide a good primary radar return at low altitudes. A direct route from Detroit to the Springfield Airport would take the Beechcraft through this area. However, the tests indicated that this area of marginal returns did not exist within 7 miles of the accident site. Therefore, considering the speed of the Beechcraft, it could have been proceeding through an area of adequate primary radar coverage for approximately 2.5 minutes prior to the collision (from 1151:30 hours to 1153:50 hours). The Board noted, however, that it was not possible to duplicate exactly the conditions that existed on the date of the accident, particularly with regard to tuning of the radar and reproducing

atmospheric conditions, both of which have significant effects on the detection of aircraft targets. Taking into account the inconclusiveness of these tests and the other information in the record regarding the absence of targets in the area of the DC-9 at the time the handoff was accomplished, the Board had no reason to disbelieve the controller's statement when he said he gave the DC-9 crew the conflicting traffic as soon as he saw it on the radar scope.

Under the existing circumstances the controller was required to provide traffic information to the flight and would not normally provide a radar vector to keep the targets separated unless the pilot requested such service. In that case radar vectors would have been provided subject to time available and/or existing workload. Although there were 7 seconds available, the DC-9 crew did not request an avoiding vector and under the circumstances there was no reason for them to have done so. Even if the crew had immediately requested such a vector there would not have been sufficient time for the controller to provide effective vectoring service.

Part 91.85, FAR, restricts an arriving aircraft operating below 10 000 ft MSL within 30 nautical miles of the airport of intended landing to a maximum indicated airspeed of 250 kt. The flight recorder read-out indicated that the DC-9 was operating at a speed of 323 kt at the time of the collision, approximately 25 nautical miles from the point of intended landing. The excess speed contributed to the accident in that it reduced the available time for the crew of either aircraft to see and avoid the other or for the controller to take appropriate action. Furthermore, based on the CVR transcription, the DC-9 crew was devoting some of its attention to speed control, clearance response, manoeuvring for the approach, and the pre-landing checklist, shortly before the traffic advisory was issued. This activity could direct both DC-9 pilots' attention inside the cockpit, reducing the effectiveness of any visual search for potentially conflicting traffic.

The DC-9 crew acknowledged receipt of the traffic advisory transmission by "Roger". It is believed that sound safety practice warrants an immediate response from the crew involved as to their visual sighting or failure to sight the target indicated by the controller. A more informative response would be an immediate "Roger, no contact" or "Roger, have him in sight". This would alert the controller to the necessity to continue following the traffic and take further action if the need arose.

From the presentation in Figure 3-2 and 3-3 it is apparent that, between times 1152:50 hours and 1153:35 hours and again from 1153:45 to 1153:50, the Beechcraft was in such a position as to be visible to the DC-9 pilot-in-command in the centre windshield, but partially obscured to the co-pilot's view by the windshield post to the right hand side of his front windshield, assuming that both pilots were in the normal position in their seats. Had either or both of them moved their heads forward to the alert position, they would have enhanced their ability to detect the target presented by the Beechcraft.

Figure 3-4 depicts the position of the DC-9 in relation to the left side cockpit cabin window of the Beechcraft. It was in a position to be seen by the Beechcraft pilot, should he have looked to his left between 92° and 108° and between 6° to 14° up. However, his attention was predominantly focused in the direction of his flight path as the primary responsibility of all pilots operating under VFR conditions is to assure that they have a clear flight path and to avoid other traffic in that airspace. The present-day "see and be seen" concept is based on all flight crews maintaining a lookout for other aircraft when they are operating under VFR flight conditions. This applied to the crew of the DC-9 who, although they were operating on an IFR flight plan, were in VFR conditions

and were required to maintain their own lookout for other traffic in their flight path. In addition, the DC-9 crew received an accurate traffic advisory from the RAPCON controller concerning the conflicting traffic, an advantage not afforded to the Beechcraft pilot.

The right-of-way rules are specific on two counts in this instance. The rule governing traffic gave the right-of-way to the Beechcraft who was on the right, as did the rule regarding an overtaken aircraft being given the right-of-way. In both instances the Beechcraft had the right-of-way and the DC-9 crew was required to alter course. Nothing is implied here to indicate that, had the Beechcraft pilot seen the DC-9, he should stubbornly maintain course expecting the DC-9 to take the necessary evasive action. All indications are that the Beechcraft pilot did not see the DC-9.

Based on the lack of intra-cockpit conversation concerning the traffic given to the DC-9 crew and the lack of evasive manoeuvres on the part of the DC-9, it was concluded that the DC-9 crew did not observe the Beechcraft.

While there were certainly a number of conditions which might have hindered the visual detection of the Beechcraft from the DC-9, such as haze, the lessened contrast between the red and white Beechcraft and the partially snow-covered ground, and the small size of the target, the DC-9 crew should have been able to detect the Beechcraft in time to avoid the collision.

In view of the evidence the Board concluded that, although each aircraft was in a position to see and be seen by the other at a distance of approximately 4 miles, each of the involved aircrews failed to see and avoid the other. The DC-9 was the overtaking, converging aircraft and thus in the better position to afford the pilots an opportunity to observe and avoid the Beechcraft. Therefore, primary responsibility for avoiding traffic within its flight path rested with the DC-9 crew.

The operation of high speed aircraft with accelerated closure rates, frequent and necessary diversion of attention to cockpit duties, and current conspicuity problems, places a difficult burden upon flight crews; nevertheless, maximum vigilance must be maintained in terminal areas when operating in a "see and be seen" environment. The aid provided flight crews by ATC in the form of radar traffic advisories is critical to safe operations in this environment. To provide the protection required, the system must lend every effort to provide advisories of conflicting traffic as soon as possible. To this end, the most reliable equipment available must be utilized and controllers must be continually vigilant for targets which may appear to be on converging courses.

2.2 Conclusions

(a) Findings

Both aircraft were properly certificated and airworthy at the time of their last take-off.

Both flight crews were properly certificated and qualified to conduct the flights.

The weather was suitable for VFR operation in the accident area.

The sun was in such a position as not to affect the detectability of either aircraft by the crew of the other.

There was no evidence of any malfunction of either aircraft or any component thereof before the collision occurred.

The Beechcraft Baron was operating on a VFR flight without flight plan and none was required. Its radar transponder was not being utilized nor was it required. It was flying on a magnetic heading of approximately 195° and at an altitude of approximately 4 500 ft AMSL.

The Beechcraft pilot was not in radio contact with any FAA controlling facility and no such contact was required, but he was in radio contact with the Springfield Airport just prior to the collision.

There was no way the Beechcraft Baron pilot could have been warned of the fact that his intended flight path would intersect that of the DC-9.

The DC-9 was operating on an IFR flight plan under radar control of the FAA throughout the flight. Its radar transponder was operating and being observed by the Dayton RAPCON controller. The rotating beacon, actuated by the flight recorder switch, was operating at the time of the collision. It was descending to 3 000 ft on a heading of approximately 232° in accordance with instructions from FAA controllers for an approach and landing at Dayton, Ohio. The rate of descent for the 20 seconds prior to impact averaged 3 500 ft/min at an indicated airspeed of 323 kt.

The RAPCON controller advised the DC-9 crew of the presence of a slow speed target at 12:30, 1 mile. This warning was acknowledged approximately 14 seconds before the collision.

The CVR indicated that the DC-9 crew never detected the traffic reported to them even though it was displayed in the clear glass areas of the windshields before the traffic advisory was issued.

The DC-9 crew was in a better position than the Beechcraft pilot to see and avoid the other aircraft. Approximately 5 seconds should have been sufficient to detect the target and initiate a change in direction of the DC-9. The aircraft response time would have been approximately 3 seconds.

There is no evidence of any attempted evasive action by either crew.

The Beechcraft appeared on the radar scope at the Dayton RAPCON as a primary target and the controller reported the target to the DC-9 crew as soon as he determined the aircraft were on conflicting courses.

The Dayton RAPCON radar has an area where poor primary radar returns are occasionally received from light twin-engine aircraft and the Beechcraft passed near or through this area prior to being observed by the controller. There was an area of good primary radar return between the accident site and a point approximately 7 miles north.

Flight checks indicate the Dayton RAPCON radar was suitable for performance of its function as an aid of air traffic control in accordance with existing criteria.

The collision occurred at an altitude of approximately 4 525 ft AMSL.

The time of the collision was 1153:50 hours.

The descending DC-9, overtaking and converging from the left, struck the level Beechcraft from the left rear quarter. The collision angle between longitudinal axes of the two aircraft was approximately 47° in the horizontal plane and 10° down in the vertical plane.

The collision destroyed the Beechcraft by causing it to disintegrate, and the pilot was killed instantly. Portions of the Beechcraft penetrated the forward fuselage section of the DC-9 and destroyed the integrity of the DC-9 flight control system. The DC-9 entered a descending left turn, crashed and burned.

Under existing right-of-way rules, the right-of-way belonged to the Beechcraft pilot.

The Beechcraft pilot, while flying in an area of increased traffic potential, did not use his radio or transponder to make his presence known to the air traffic controllers; however, he was not required to do so.

(b) Cause or
Probable cause(s)

The Board determined that the probable cause of this accident was the failure of the DC-9 crew to see and avoid the Beechcraft. Contributing to this cause were physiological and environmental conditions and the excessive speed of the DC-9 which reduced visual detection capabilities under an air traffic control system which was not designed or equipped to separate a mixture of controlled and uncontrolled traffic.

3.- Recommendations

The situation as it now exists is one in which ATC cannot assure an appropriate level of safety between "known" and "unknown" traffic operations, nor can the pilots of high-speed modern aircraft safely operate these aircraft in accordance with "see and be seen" VFR right-of-way rules in the short period of time available to them for detection and corrective action.

One answer to this perplexing problem might lie in a programme whereby larger segments of the navigable airspace be designated as positive control areas to include terminal areas. Operation in positive control airspace normally requires that: the aircraft operate under IFR at a specific flight level assigned by ATC; the aircraft be equipped and instrumented for IFR; the pilot must be rated for instrument operation; and the aircraft must have an operational transponder and two-way radio. It may well be that in those areas where the radar coverage is adequate for designation as a positive control area this type of operation could prevent recurrence of an accident of this type. Such a programme would not be without impact on many of the airspace users and would be subject to many limitations including economic considerations.

Recognizing that almost any approach to the problem of ensuring greater safety for present-day flight operations is one in which the cost will usually be objectionable to some, the Board was of the opinion that the development of a practical Collision Avoidance System (CAS), suitable for use on the majority of aircraft, would provide a great contribution to flight safety. Such a system would detect a potential collision hazard, call the pilot's attention to the hazard, and display the evasive action required by the pilot in order to avoid a collision. The system should be automatic and intended to be utilized when

operating under both IFR and VFR weather conditions. A CAS would serve to supplement the ATC system by increasing flexibility, and also return a measure of control to the cockpit. Since the ATC system is basically a co-operative system, the CAS would therefore tend to restore balance to a system which has in the past been moving progressively in the direction of control from the ground to a point fast approaching the limits of effectiveness. It is still in the experimental development state, however.

4.- Action taken

Subsequent to the accident the FAA took the following action aimed at prevention of similar accidents:

On 15 August 1967, the FAA issued Advisory Circular No. 90-32 titled Air Traffic Control and General Operations, Radar Capabilities and Limitations. The stated purpose of this Circular was to . . . "advise the aviation community of the inherent capabilities and limitations of radar systems and the effect of these factors on the service provided by air traffic control facilities". This Circular discussed the capabilities and limitations of the air traffic control radar and concluded that radar is highly beneficial to the control and separation of IFR air traffic, but some aircraft may not be seen. This fact, together with the increasing amount of traffic which is flying while not radar-identified and under control of ATC facilities, decreases the capability of a controller to cope with every contingency which may arise and occasionally precludes his capability to provide traffic advisory services. After separation between controlled traffic has been ensured, the controller may then direct his attention to providing additional services such as radar advisories to visual flight rules aircraft. The pilot who requires these services will substantially assist the controller, and himself, by immediately advising the controller of the exact nature of his request, weather conditions, type of aircraft, route and type of flight plan, altitude, magnetic heading, as well as by understanding ATC radar and controller limitations.

The FAA has adopted a rule establishing that all aircraft flying below 10 000 ft AMSL, will be limited to a maximum speed of 250 kt effective 15 December 1967. The rule was promulgated to ". . . provide a more realistic 'see and avoid' environment in the airspace below 10 000 ft mean sea level (MSL) where traffic congestion is greatest . . ."

It is recognized that speed control is only part of the answer to the collision threat, and the Administrator is presently studying the feasibility of climb and descent corridors for use by high performance aircraft at major air terminals.

ICAO Note: The following documents may be of interest:

1. Midair Collision in U.S. Civil Aviation - 1968. A Special Accident Prevention Study. National Transportation Safety Board
2. Near Midair Collision Report of 1968. Air Traffic and Flight Standards Technical Report. Federal Aviation Administration
3. Report of Proceedings of the National Transportation Safety Board Into the Midair Collision Problem (4 - 10 November 1969)
   Report Number: NTSB-AAS-70-2

ICAO Ref.: AIG/003/67

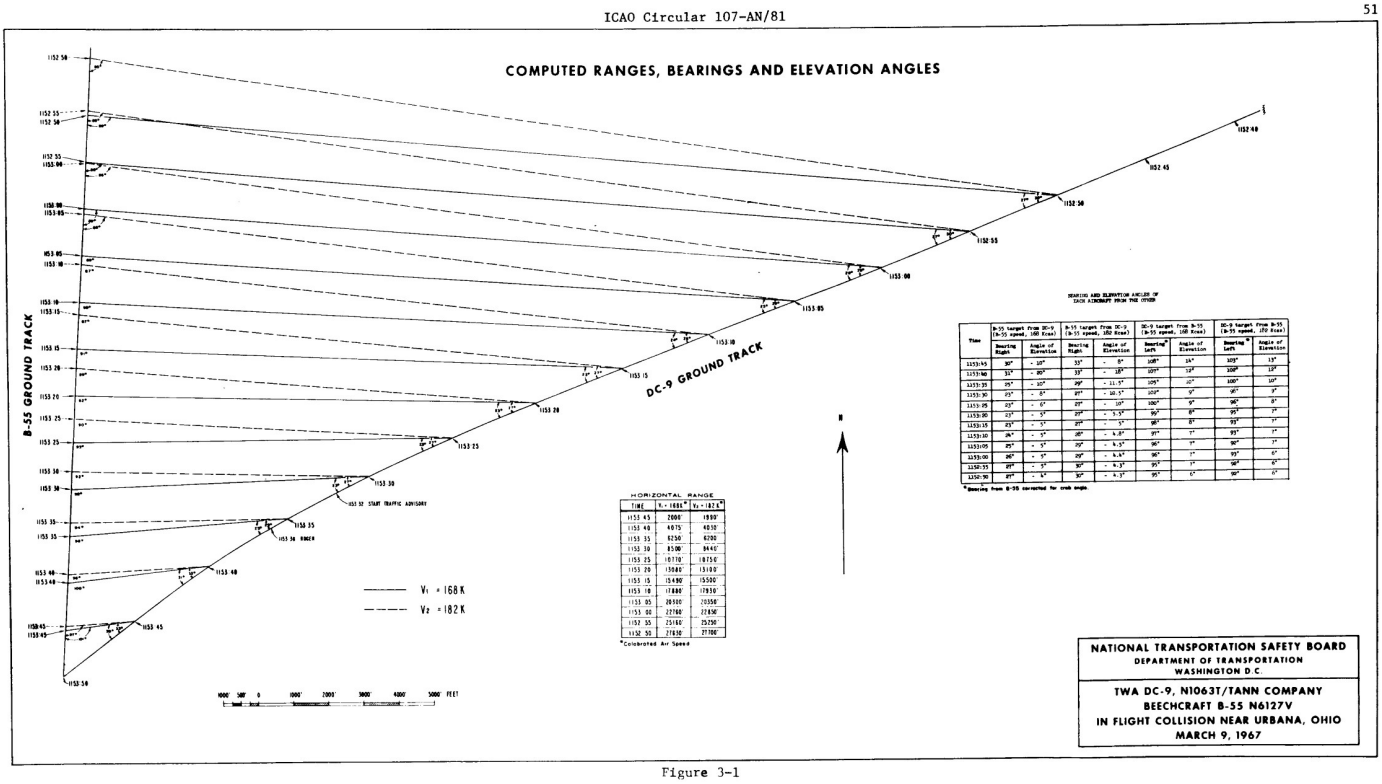
COMPUTED RANGES, BEARINGS AND ELEVATION ANGLES
B-55 GROUND TRACK
DC-9 GROUND TRACK
V1 = 168K
V2 = 182K
N
1000' 500' 0 1000' 2000' 3000' 4000' 5000' FEET
HORIZONTAL RANGE
*Calibrated Air Speed
NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C.
TWA DC-9, N1063T/TANN COMPANY
BEECHCRAFT B-55 N6127V
IN FLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9, 1967

Figure 3-1

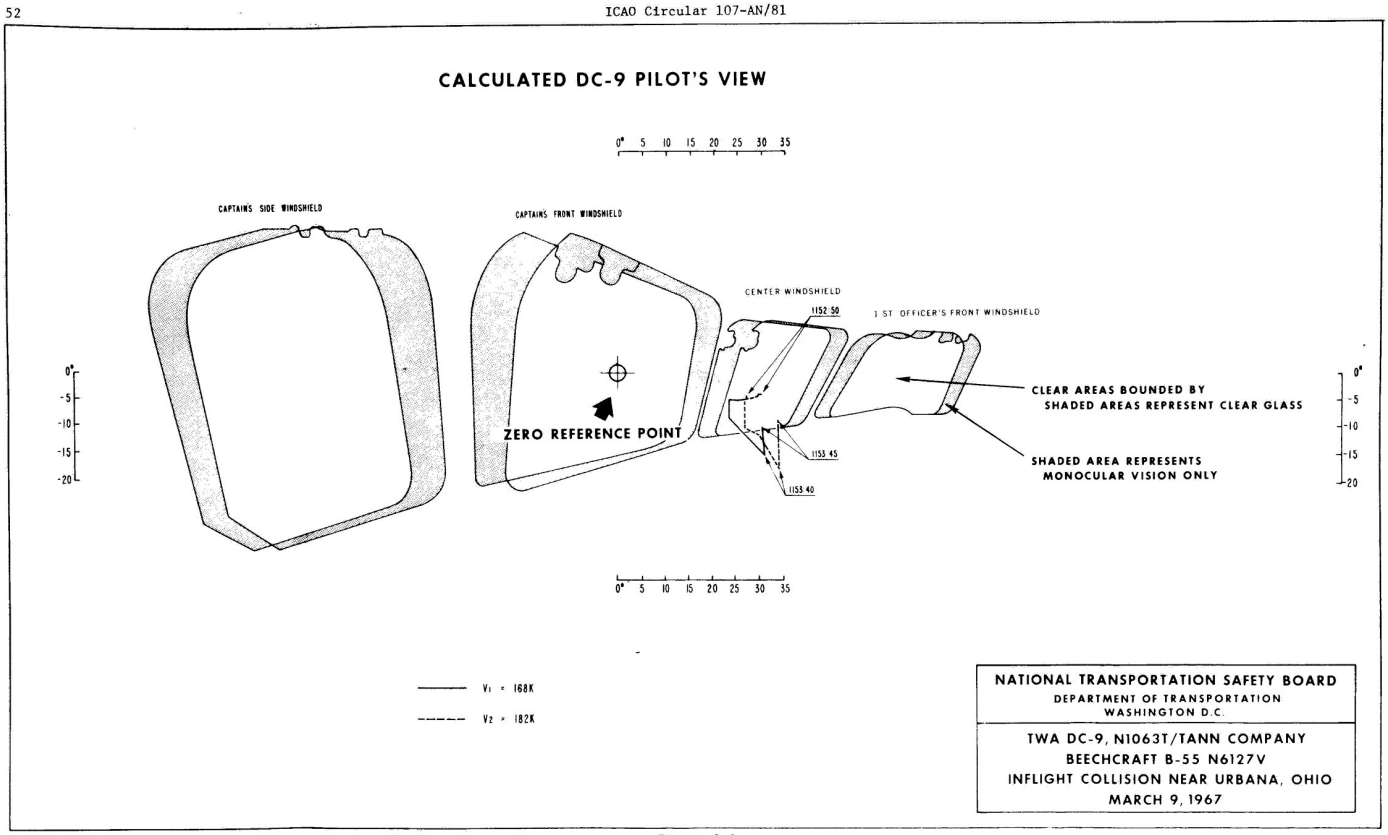
CALCULATED DC-9 PILOT'S VIEW
0° 5 10 15 20 25 30 35
CAPTAINS SIDE WINDSHIELD
CAPTAINS FRONT WINDSHIELD
CENTER WINDSHIELD
1ST OFFICER'S FRONT WINDSHIELD
1152.50
1153.45
1153.40
ZERO REFERENCE POINT
0°
-5
-10
-15
-20
CLEAR AREAS BOUNDED BY
SHADED AREAS REPRESENT CLEAR GLASS
SHADED AREA REPRESENTS
MONOCULAR VISION ONLY
V1 = 168K
V2 = 182K
NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C.
TWA DC-9, N1063T/TANN COMPANY
BEECHCRAFT B-55 N6127V
INFLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9, 1967

Figure 3-2

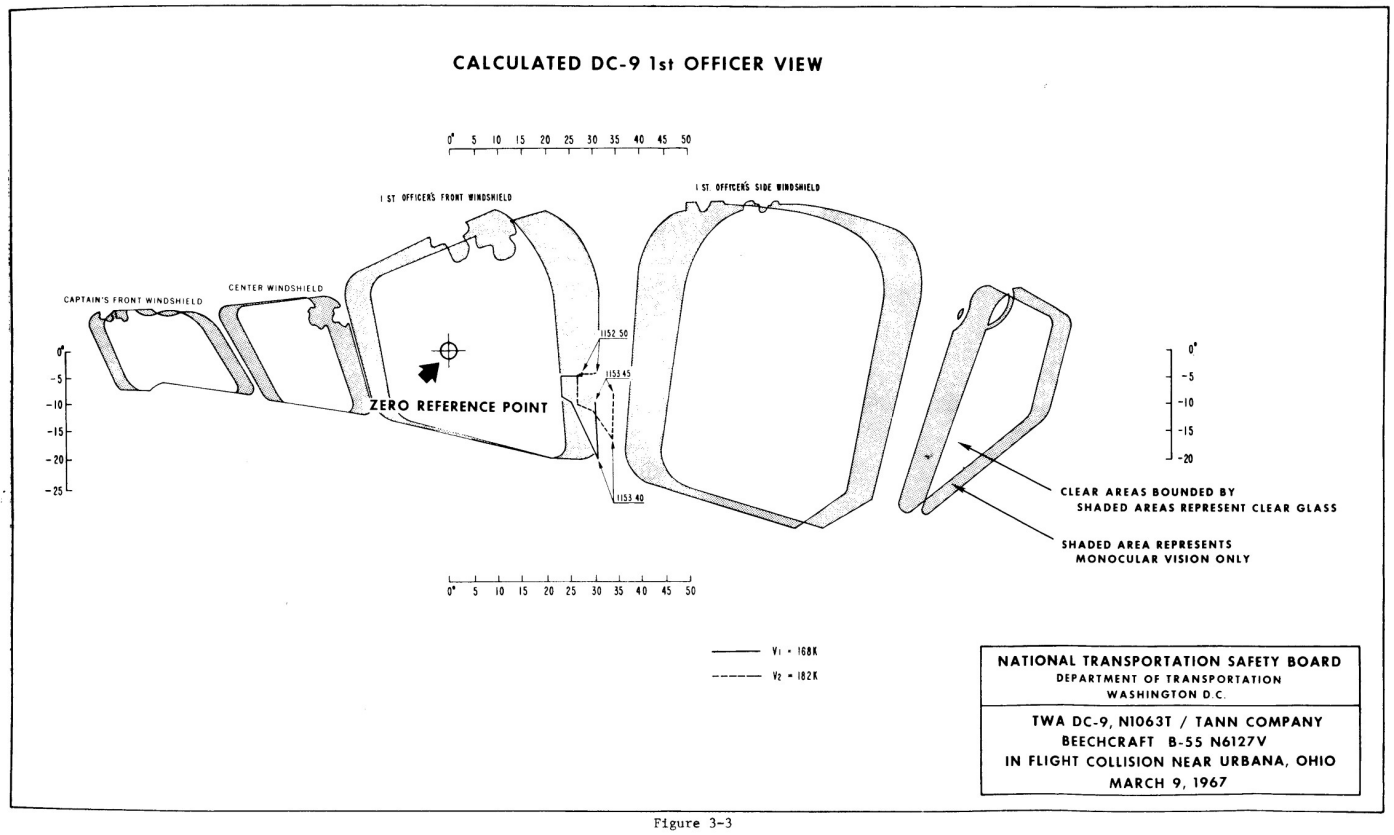
CALCULATED DC-9 1st OFFICER VIEW
0° 5 10 15 20 25 30 35 40 45 50
1 ST OFFICER'S FRONT WINDSHIELD
1 ST OFFICER'S SIDE WINDSHIELD
CAPTAIN'S FRONT WINDSHIELD
CENTER WINDSHIELD
ZERO REFERENCE POINT
1152.50
1153.45
1153.40
0°
-5
-10
-15
-20
-25
CLEAR AREAS BOUNDED BY SHADED AREAS REPRESENT CLEAR GLASS
SHADED AREA REPRESENTS MONOCULAR VISION ONLY
V1 = 168K
V2 = 182K
NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C.
TWA DC-9, N1063T / TANN COMPANY
BEECHCRAFT B-55 N6127V
IN FLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9, 1967

Figure 3-3

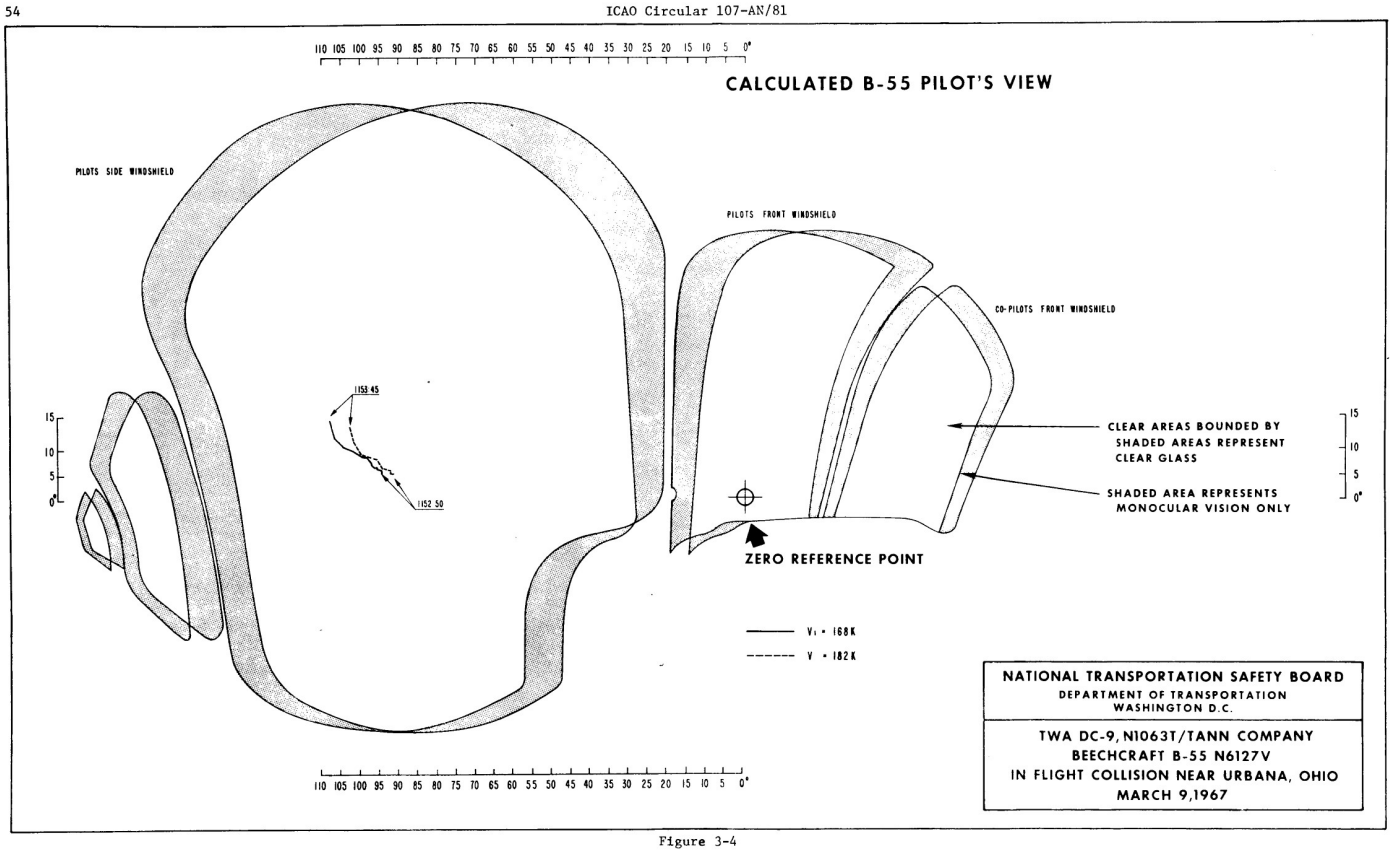
110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0°
CALCULATED B-55 PILOT'S VIEW
PILOTS SIDE WINDSHIELD
PILOTS FRONT WINDSHIELD
CO-PILOTS FRONT WINDSHIELD
1153 45
1152 50
15
10
5
0°
CLEAR AREAS BOUNDED BY SHADED AREAS REPRESENT CLEAR GLASS
SHADED AREA REPRESENTS MONOCULAR VISION ONLY
ZERO REFERENCE POINT
V₁ = 168K
V = 182K
NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON D.C.
TWA DC-9, N1063T/TANN COMPANY
BEECHCRAFT B-55 N6127V
IN FLIGHT COLLISION NEAR URBANA, OHIO
MARCH 9,1967

Figure 3-4