SA-236 File No: 1-0050

CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: December 7, 1951 Released December 12, 1951

UNITED AIR LINES, INC., —FORT COLLINS, COLORADO, JUNE 30, 1951

THE ACCIDENT

United Air Lines' Flight 610, a Douglas DC-6, N-37543, crashed 18 miles west-southwest of Fort Collins, Colorado, and 29 miles west of the centerline of Airway Amber 3, at approximately 0200,[1] June 30, 1951 All of the occupants were killed and the aircraft was demolished

HISTORY OF THE FLIGHT

Flight 610 of June 29, 1951, originated in San Francisco, California, and was scheduled to Chicago, Illinois, with en route stops, among which were Oakland, California, Salt Lake City, Utah, and Denver, Colorado The crew consisted of Captain J R Appleby, First Officer H G Tower, Flight Engineer A T Petrovitch, and Stewardesses C J Raymond and F M Smith The flight departed San Francisco on schedule at 1915 and after stopping at Oakland proceeded to Salt Lake City, arriving there at 2324 It departed Salt Lake City at 0011, June 30, 1951, 26 minutes behind schedule due to the reloading of bulky cargo At the time of departure the aircraft weighed 78,597 pounds, which was within the certificated gross take-off weight of 79,380 pounds, the load was properly distributed with respect to the center of gravity There were five crew members, forty-four adult passengers and one infant on board The approved flight clearance indicated an IFR flight, via Red Airway 49, Green Airway 3, and Amber Airway 3, to Denver at a cruising altitude of 15,000 feet, with Omaha, Nebraska, designated as the alternate airport

The flight proceeded in a routine manner and at 0104 reported over Rock Springs, Wyoming, at 15,000 feet, estimating its arrival over Cheyenne, Wyoming, at 0147 and over Denver at 0207 [2] Forty-three minutes later, at 0147, the flight reported having passed the Silver Crown fan marker (located 12 miles west of Cheyenne) and requested a lower altitude Accordingly, a new clearance was immediately issued—"ARTC clears United 610 to DuPont intersection,[3] descend to 8500 feet immediately after passing Cheyenne, maintain 8500 feet, no delay expected, contact approach control over Dacono "[4] This clearance was acknowledged and the flight reported that it was over Cheyenne at 0147, at 15,000 feet and was now starting to descend The Denver altimeter setting was then given the flight as being 30 19 inches Nine minutes later, at 0156, the flight reported reaching its assigned altitude of 8,500 feet No further communication was received from the flight

At 0200, the Denver Control Tower requested the company radio operator to advise the flight to call approach control Repeated calls were made without an answer It was later determined that Flight 610 had crashed on a mountain 18 miles west-southwest of Fort Collins, Colorado

INVESTIGATION

Investigation disclosed from the direction of the swath cut through the trees that the aircraft struck the side of Crystal Mountain while flying with its left wing low and on an approximate magnetic heading of 210 degrees The altitude at the point of impact was found to be 8,540 feet MSL After initial contact with the trees the aircraft continued to travel approximately sixty feet, at which point it struck the ground From here it

[1] All times noted herein are Mountain Standard and based on the 24-hour clock

[2] All radio communications from the flight while en route from Salt Lake City to Denver were transmitted to the company radio operator at Denver and relayed to Denver Air Route Traffic Control

[3] The intersection of the west course of the Denver VAR range with the north course of the Denver low frequency range

[4] Dacono is a fan marker located approximately 15 miles north of the DuPont intersection

traveled in a straight line 225 feet, then bounced into the air again, and came to rest 465 feet farther on The aircraft was demolished, and aircraft parts and assemblies were strewn over a 1,400-foot area [5] Localized fires occurred after impact

An examination of the wreckage revealed that at the time of impact the landing gear and flaps were retracted During this examination nothing was found to indicate that there was any structural failure of the aircraft or its components prior to impact Numerous pieces of mail, paper, cabin insulation and other light materials were found north-northeast of the point of impact along the flight path a distance of two miles from the scene of the accident All of the debris was heavily spotted with engine oil and several pieces showed evidence of burning, indicating that at the time of impact an explosion occurred which blew this material aloft and that it was carried away by the eddying wind currents Identical material which was also spotted with engine oil was found at the scene of the accident

The damaged engines and propellers were examined and these indicated that all four engines were developing considerable power when the impact occurred All engine instruments were so severely damaged that their readings were of no value

A study of the aircraft's maintenance records indicated that the aircraft was airworthy when departing San Francisco

Much of the radio navigational equipment and some of the flight instruments were recovered These were taken to Denver for study and analysis The resulting investigation indicated that prior to the crash no fire existed in any of the electronic or electrical equipment, and that all of the aircraft's communications and navigational equipment was apparently functioning in a normal manner Conditions of propagation during the times involved were conducive of good radio reception All ground radio stations in the area were functioning normally, as evidenced by subsequent flight checks and a study of each station's records The aircraft was heading 210 degrees magnetic, plus or minus a few degrees, at the time of impact

This last fact is further substantiated by the condition of the directional instruments when recovered In the cockpit were four heading indication instruments There were two magnetic or master direction indicators operated by a flux gate compass system, one each for the pilot and copilot These were both jammed at a reading of about 210 degrees The magnetic compass and the directional gyro were also found to be reading approximately 210 degrees Furthermore, as a part of the radio navigational equipment there were two ADF (automatic direction finding) receivers The dual indicator azimuth scale of the copilot's ADF must be rotated manually and when used to determine a bearing it is set to agree with the magnetic heading of the aircraft This instrument was found jammed at a reading of approximately 202 degrees

On each side of the control pedestal of the DC-6 are panels containing six audio selector toggle switches The two switches nearest the captain actuate the voice and range control positions of that pilot's ADF, the two middle switches actuate the same controls on the VHF navigation receiver, and the two furthermost from the captain actuate identical controls on the copilot's ADF These switches are in such a position that they cannot be easily seen by either pilot and to use them at night without the use of lights it is customary to feel for them All switches are of uniform size and are equally spaced on the panel Although cockpit lights and a small flashlight are available to the captain, it is normal practice to use a minimum of cockpit lighting to avoid glare

The magnetic course to Denver from Cheyenne is 168 degrees The audio signals of the Denver low frequency range for this course are heard as an "A" on the left side and an "N" on the right side At Denver there is another range, namely a VAR (Visual Aural Range), the north course of which nearly parallels the north course of the low frequency range The audio signals of this course when flying toward Denver are heard as an "N" on the left or east side, and as an "A" on the right or west side The similarity of the tone of the signals emitted by both ranges makes it difficult to differentiate between them The identification signal "DEN" is identical for both stations

[5] Appendix A Wreckage Distribution Chart

As a part of the investigation, an exploratory flight was made in a similar type aircraft to determine the credibility of the probable flight path of the subject aircraft between Cheyenne and the scene of the crash [6] In an effort to duplicate the assumed track of Flight 610, the test flight crossed the Cheyenne range station from the northwest at 15,000 feet, and a shallow descending right turn was started toward a heading of 210 degrees magnetic Two minutes were required to arrive at this heading Continuing on this heading, a descent of 700 to 1,000 feet per minute was maintained at an indicated air speed of 245 miles per hour Descent from 15,000 to 8,500 feet MSL required seven minutes Four minutes later the flight arrived over the scene of the accident after climbing slightly to clear the ridge Thirteen minutes were required to fly from Cheyenne to the scene of the accident This time, added to the time the aircraft reported crossing Cheyenne, closely approximates the assumed time of the crash

Recorded radio contacts with Flight 610 disclosed that between Salt Lake City and Cheyenne it was flown in accordance with the flight clearance

Captain Appleby had been employed by United Air Lines, Inc since November 1, 1940, and had accumulated a total of 9,990 flying hours in DC-3 equipment Prior to April 1951 he had flown many hours as captain in DC-3 aircraft between Salt Lake City and Denver In April he attended the company's DC-6 school, where he received 15 50 hours of transition training Following the DC-6 training he received 9 20 hours of training on DC-4 type aircraft This latter training was necessary, since Captain Appleby was being assigned as captain on a route designated as San Francisco-East, involving both DC-6 and DC-4 aircraft Up to and including June 30, 1951, he had flown 29 hours as first officer and 61 hours as captain of DC-6 aircraft The records also indicated that he had made 11 one-way trips in and out of Denver as captain in this type aircraft

First Officer Tower, who was assigned as Captain Appleby's copilot, had accumulated 5,848 flying hours, of which 1,526 were on DC-6 aircraft and 917 on DC-4's Both pilots were well acquainted with the terrain which lies to the right of the route between Cheyenne and Denver

On the night of June 29-30, a weak upslope flow of air existed on the east slope of the Rocky Mountains in southeastern Wyoming and northeastern Colorado This resulted in cloud layers ranging generally from 8,000 to 17,000 feet Previously, a general shower and thundershower condition existed in the area but by the night of June 29-30 only scattered light showers remained in southeastern Wyoming and no thundershowers existed nearer than the eastern border of Colorado There was a solid layer of clouds south of Cheyenne with base 8,000 and top 12,000 No turbulence or icing of significance was indicated for that area For this area winds aloft between 8,000 and 10,000 feet were northerly and under 10 miles per hour This was substantially as forecast

ANALYSIS

Numerous theories were explored in an effort to determine why the pilot, after crossing Cheyenne, possibly assumed a heading of 210 degrees magnetic and then held this heading until the aircraft crashed into the mountain One plausible theory is that after the aircraft passed over the Cheyenne range station the Denver low frequency range was tuned for aural directional guidance to Denver At the same time the Denver VAR range was tuned in for the purpose of identifying the DuPont intersection, the point to which the flight was cleared This intersection is the point where the west course of the Denver VAR range crosses the north course of the Denver low frequency range

In order to isolate the low frequency range receiver to aid in its aural reception, the captain may have meant to eliminate the aural signals of the VAR range receiver by depressing the toggle switches (voice and range) which are mounted on the audio selector control panel located near the captain's right knee As previously stated, in a darkened cockpit the lights must be turned up in order to see these switches and read their positions, however, instead of doing this it is often the practice to feel for them

It is therefore possible that the captain may have inadvertently depressed the wrong switches, the second and third switches from

[6] Appendix B Chart showing the probable flight path of Flight 610 including radio ranges used for approach to Denver

the left, thinking he had depressed the third and fourth (or middle two) switches This would silence the range signals of the captain's low frequency receiver and also silence the voice feature of the VAR receiver, but would permit the VAR range signals to be audible As previously stated, the identification signals and tonal qualities of both ranges are identical

After the aircraft passed over the Cheyenne range station, the normal procedure would be the execution of a standard rate right turn to a heading, probably not exceeding 210 degrees, which would intercept the north course of the Denver low frequency range With the above-mentioned configuration of radio tuning, the "A" signal is on the left (east) side of the north course of the Denver low frequency range Also, the signal "A" is on the right (west) side of the north course of the Denver VAR range

It can be seen that on approach to Denver from the north, a right turn to attempt to fly the "on course" of the low frequency range while listening to the "A" (right) side of the VAR range would take the aircraft deeper into the "A" quadrant of the VAR range and thus an "on course" signal would never be heard

As previously noted, the records indicate that Captain Appleby had flown the route involved many times in DC-3 aircraft and that he had made eleven one-way flights to and from Denver as captain in DC-6's Since the DC-6 aircraft is much faster than the DC-3 the difference in air speed may not have been properly considered resulting in the heading toward the mountains being maintained longer than should have been However, no logical explanation can be found for the length of time the aircraft was held on a heading which the crew should have known would lead to the mountains west of the airway

Another possible theory was considered which was subsequently established by a flight test conducted by the CAA After passing Cheyenne, the CAA pilot tuned his ADF to the Denver low frequency range and turned that receiver's selector switch to the compass position In tuning the Denver frequency of 379 kilocycles he purposely detuned the receiver on the high side This detuning allowed the receiver to be affected by the range signal of Fort Bridger, Wyoming (located approximately 304 miles west-northwest of Denver), the frequency of which is 382 kilocycles As a result the ADF compass needle indicated an average bearing of 225 degrees on the azimuth scale but with the needle "hunting" plus and minus 20 degrees With the ADF switch in the compass position and with fine tuning it was possible to receive a faint "A" signal and a "DEN" identification However, it should be noted that when the Denver low frequency range was properly tuned the signals were clear and distinct Therefore, if the United Air Lines' captain had inadvertently detuned his ADF, as described above, and was following such a heading thinking the needle indicated the direction of the Denver range station, he would have been flying toward the mountains

The above-mentioned theories are based on the premise that the pilot tuned to the Denver ranges after passing Cheyenne However, the Cheyenne low frequency range provides an excellent airway course to the south, meeting the north course of the Denver low frequency range Had the Cheyenne low frequency audio facility been utilized to a point approximately halfway to Denver and had the Denver range then been properly tuned, no difficulty would have been experienced in receiving correct ADF indications and clear aural range signals

The Denver VAR range was commissioned January 1, 1946 This facility was installed with the approval of the aviation industry, as is the case in any addition or major change in all radio aids to air navigation Although for five years this range has operated in close proximity to the Denver low frequency range and although both ranges utilize the same "DEN" identification signal, there have been no known recorded complaints from airmen that difficulty or confusion resulted

However, in the interest of safety and in order to avoid any possible error in identifying these ranges, the CAA has placed the code letter "V" before the "DEN" identification signal of the VAR range This additional signal should avoid any possible mistake in confusing the two ranges

Also, as a result of this accident, United Air Lines has effected a change in the audio selector panels which contain the six selector switches on all their DC-6 aircraft This was accomplished by lengthening

the middle two toggle switches which select the VAR and other VHF radio navigational receivers, and was done to help avoid any possible mistake by the crew in switch selection

Subsequent to the investigation and public hearing relative to this accident, the Civil Aeronautics Board was informed by United that it has reviewed its entire flight operations administration This review indicates, among other things, that greater importance should be placed upon indoctrination and training of flight personnel, with particular emphasis on maintenance of route and equipment qualification It is understood that the program is at this time in the process of development and that United will make it a continuous effort

FINDINGS

On the basis of all available evidence the Board finds that

1 The carrier, the aircraft, and the crew were properly certificated

2 The gross weight of the aircraft was within approved limits, and the load was properly distributed with respect to the center of gravity

3 There was no malfunctioning of the aircraft or any of its components prior to impact

4 Although instrument flight conditions existed at the time of the accident, no abnormal weather was encountered by the flight

5 The flight crossed the Cheyenne range station at 15,000 feet and then executed a right turn to a heading of 210 degrees magnetic, descending to 8,500 feet

6 The 210 degrees magnetic heading was maintained until the aircraft struck the mountain

PROBABLE CAUSE

The Board determines that the probable cause of this accident was that, after passing Cheyenne, the flight for reasons undetermined failed to follow the prescribed route to Denver and continued beyond the boundary of the airway on a course which resulted in the aircraft striking mountainous terrain

BY THE CIVIL AERONAUTICS BOARD

/s/ DONALD W. NYROP
/s/ OSWALD RYAN
/s/ JOSH LEE
/s/ JOSEPH P ADAMS
/s/ CHAN GURNEY

—38767

Supplemental Data

INVESTIGATION AND HEARING

The Civil Aeronautics Board received notification of the accident at 0444 MST, June 30, 1951, from the Civil Aeronautics Communications at Kansas City An investigation was immediately initiated in accordance with the provisions of Section 702 (a)(2) of the Civil Aeronautics Act of 1938, as amended A public hearing was held in connection with the investigation of this accident at Denver, Colorado, on July 19-20, 1951

AIR CARRIER

United Air Lines, Inc , is a Delaware corporation The company is engaged in the transportation of persons, property and mail, under certificates of public convenience and necessity issued by the Civil Aeronautics Board It also possesses a regular operating certificate issued by the Civil Aeronautics Administration for the routes involved

FLIGHT PERSONNEL

Captain J R Appleby, age 32, was employed by United Air Lines, Inc , November 1, 1940 He had accumulated 10,565 flying hours, of which 106 were on DC-6 type equipment He held a valid airline transport pilot rating His last instrument check was accomplished on April 30, 1951, and route check April 28, 1951 He satisfactorily passed his last CAA physical examination February 14, 1951

First Officer H G Tower, age 35, was employed by United Air Lines, Inc , September 7, 1945 He had accumulated a total of 5,848 flying hours, of which 1,526 were on DC-6 type equipment He held a valid airline transport pilot rating

THE AIRCRAFT

N-37543, a Douglas DC-6 aircraft, manufactured April 1950, had a total of 3,784 flying hours, and was currently certificated by the Civil Aeronautics Administration It was equipped with four Pratt and Whitnev, Model CA15 engines, and the propellers were Hamilton Standard hydromatic full feathering type

CHART II – DISTRIBUTION OF WRECKAGE
UNITED AIR LINES ACCIDENT
DC-6 N37543 AT CRYSTAL MOUNTAIN
NEAR FORT COLLINS COLORADO JUNE 30 1951

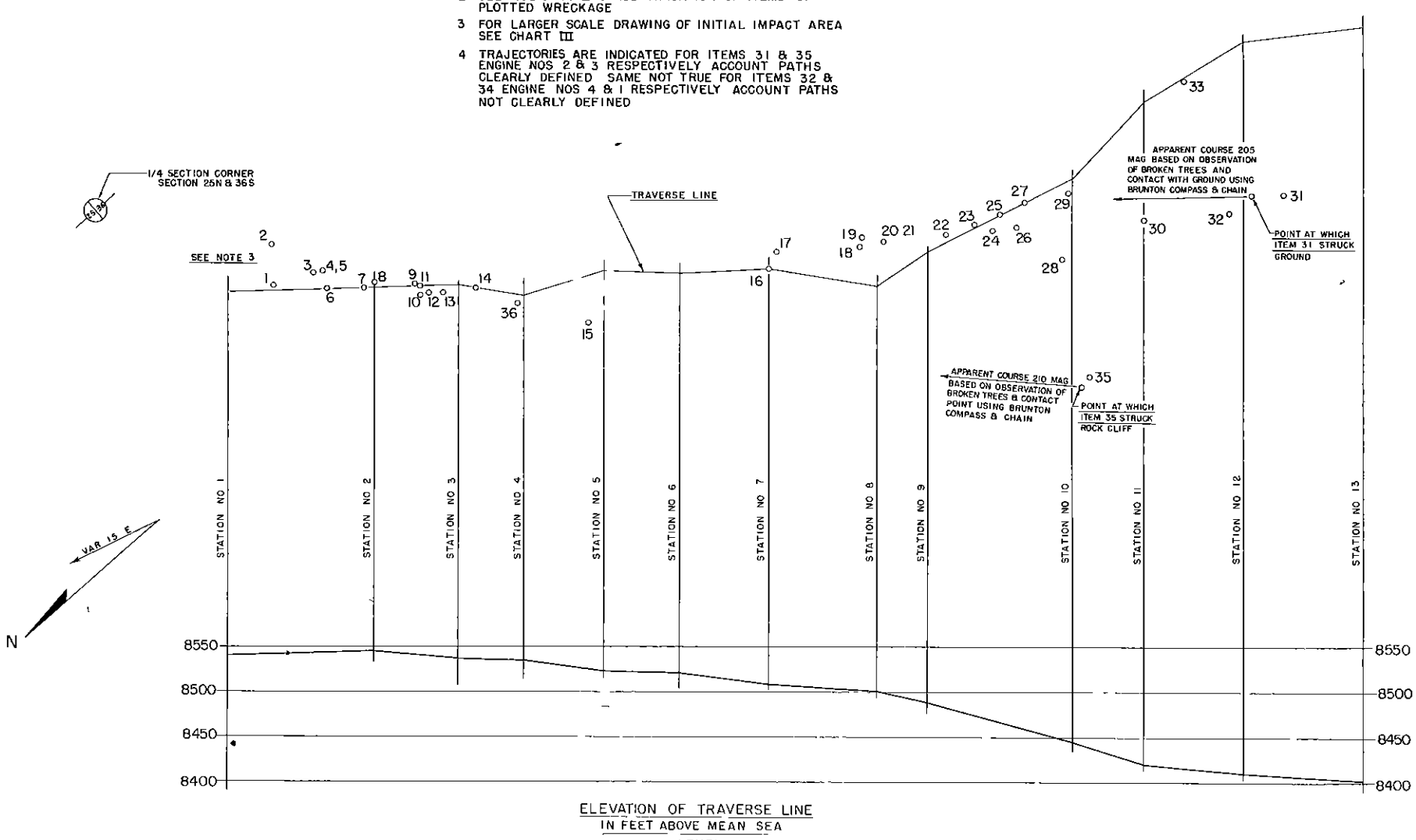
NOTES

1 SCALE 1 40

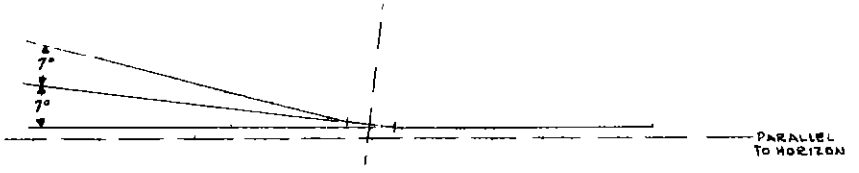
2 SEE CODE CHART II FOR IDENTIFICATION OF ITEMS OF PLOTTED WRECKAGE

3 FOR LARGER SCALE DRAWING OF INITIAL IMPACT AREA SEE CHART III

4 TRAJECTORIES ARE INDICATED FOR ITEMS 31 & 35 ENGINE NOS 2 & 3 RESPECTIVELY ACCOUNT PATHS CLEARLY DEFINED SAME NOT TRUE FOR ITEMS 32 & 34 ENGINE NOS 4 & 1 RESPECTIVELY ACCOUNT PATHS NOT CLEARLY DEFINED



ELEVATION OF TRAVERSE LINE
IN FEET ABOVE MEAN SEA LEVEL

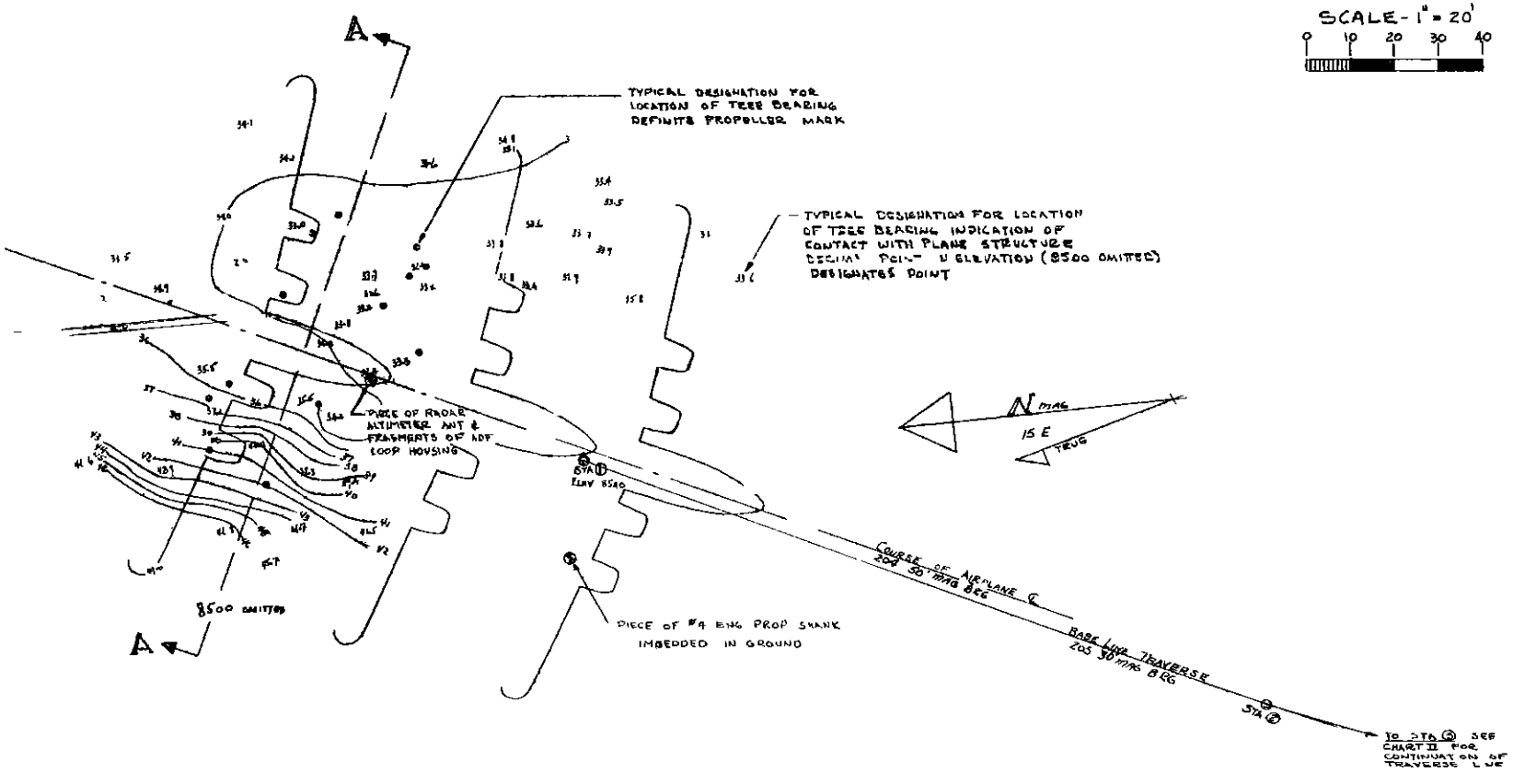


SECT A-A
ROTATED APPROX 70° ℄
SECTION REPRESENTS LOWER SURFACE OF DC 6 AIRPLANE FROM WING TIP TO WING TIP AND ITS DISPLACEMENT FROM A LINE PARALLEL TO HORIZON AS DETERMINED FROM BROKEN TREE TOPS

CHART III-INITIAL IMPACT AREA

UNITED AIR LINES ACCIDENT
DC-6 N37543 AT CRYSTAL MOUNTAIN
NEAR FORT COLLINS, COLORADO, JUNE 30, 1951

SCALE-1" = 20'
0 10 20 30 40



CODE CHART II - WRECKAGE DISTRIBUTION
N-37543, Near Crystal Mountain, June 30, 1951

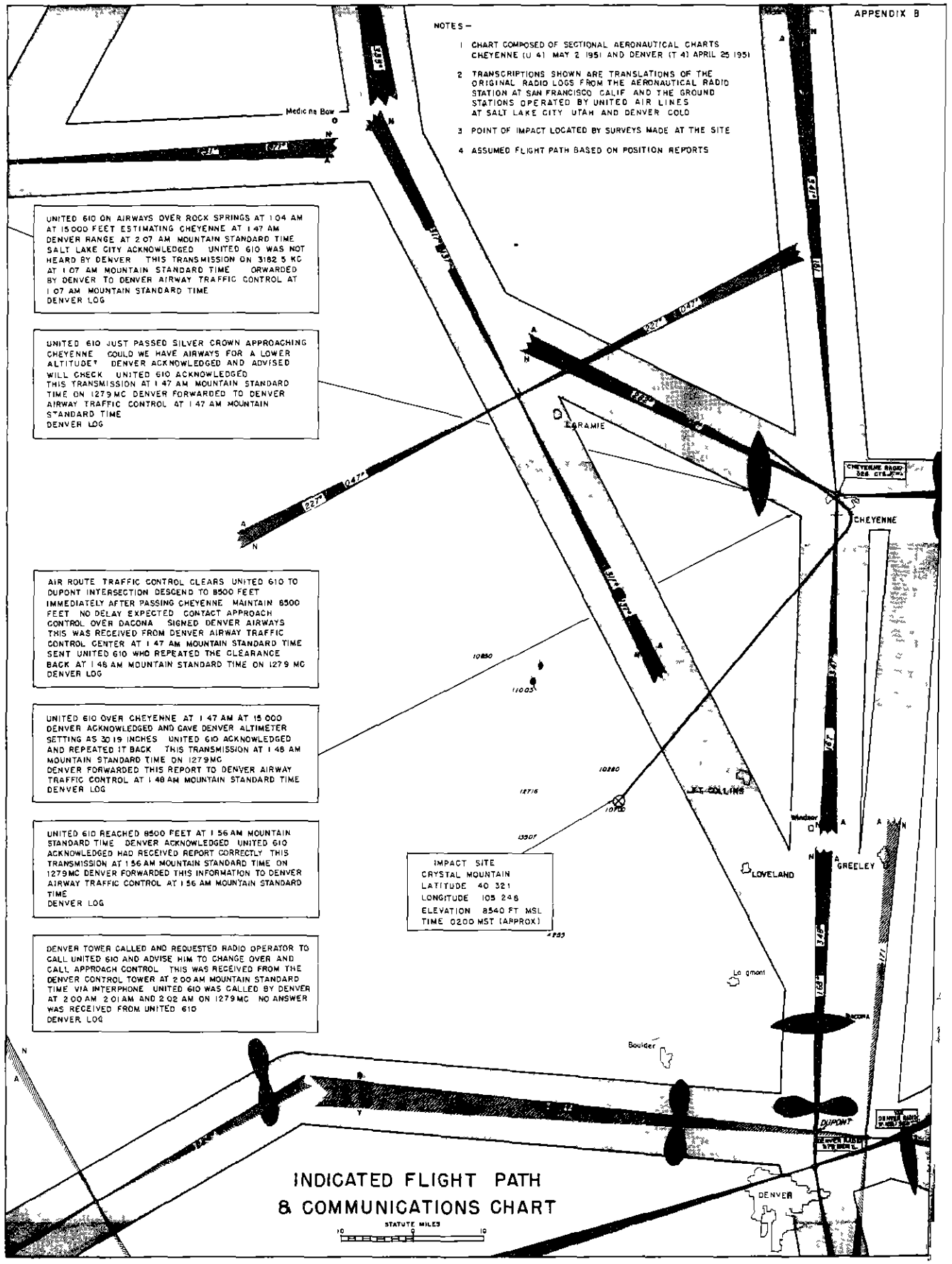
Item Description

1 - L. H. Stab. and Elevator.
2 - L. H. Aileron including flying tab.
3 - Tail cone.
4 - R. H. Aileron and bell crank.
5 - L. H. outer wing panel (5 feet).
6 - Outer wing panel (12 feet).
7 - R. H. Aileron (8 feet) adj. to operating bell crank.
8 - R. H. stab. and elevator complete.
9 - One-half elevator torque tube, gust lock and bell crank.
10 - L. H. aileron.
11 - Tail bulkhead.
12 - L.H. upper wing skin including center spar cap & fus. attach fitting 8' long.
13 - Portion of wing tank area.
14 - Rear spar top cap adjacent to fuselage.
15 - R. H. side fuselage - first 2 cabin windows and wing illumination light.
16 - Wing center section and flap. R. H. + 5 feet outer panel.
17 - R. H. flap (8 feet) inboard end.
18 - Top R. H. side of fuselage (20 feet)
19 - Bottom of rudder (5 feet).
20 - Top of rudder including flying tab.
21 - L. wing upper skin from fuselage fillet outboard to #2 nacelle bet. front and center spar.
22 - Rear cargo compartment aft bulkhead.
23 - 4x9 foot piece of fuselage skin under L. H. fillet.
24 - L. H. stabilizer tip.
25 - Fuselage belly (50 feet long) including main junction box, control pedestal, wiring, control cables, circuit breaker panel, cockpit equipment, belly pits, cabin flooring, radio, instruments
26 - Nose gear assembly - complete.
27 - Aft fuselage section including vertical stabilizer and all interior cabin and lounge furnishings. Includes area bet. first frame forward of cabin door aft to and including vertical stabilizer.
28 - Main gear strut including one wheel and tire.
29 - #2 nacelle structure.
30 - L. H. wing center section from #2 nacelle and to outboard end of flap. (Flap fully retracted.)
31 - Engine. (Pos. #2)
32 - Engine. (Pos. #4)
33 - Main landing gear - strut broken 26" above axle and complete with brakes, wheels, tires.
34 - Engine. (Pos. #1)
35 - Engine. (Pos. #3)
36 - Prop hub #164885 with blade shanks. Piece of blade shank found near plane table fits here.

Survey made by:

Frank Taylor - CAB
Joe Paden - DACO
Carl Eck - ALPA
A. M. Salmon - UAL

Structures Committee



INDICATED FLIGHT PATH & COMMUNICATIONS CHART