SA-144 File No.

C I V I L A E R O N A U T I C S B O A R D
SAFETY BUREAU

ACCIDENT INVESTIGATION REPORT

Adopted: Released:

UNITED AIR LINES, INC., - LAGUARDIA FIELD, NEW YORK - MAY 29, 1947

The Accident

A United Air Lines' C-54, NC 30046, Flight 521, crashed while attempting a take-off from LaGuardia Field, New York, at approximately 1905*, May 29, 1947. Of the 48 occupants, 43 were killed, four sustained serious injuries, and one, the pilot, received only minor injuries. The aircraft was demolished by impact and partially consumed by fire.

History of the Flight

United Air Lines' Flight 521 of May 29, 1947, was scheduled to depart from LaGuardia for Cleveland, Ohio, at 1840. Captain Benton Baldwin, the pilot, reported at 1730 in United's dispatch office, consulted the company meteorologist, and studied route weather data. He found that thunderstorm conditions existed which resulted from a cold front and prefrontal squall line, located at the time west of the New York area. The flight plan based on this weather information and prepared by the Captain and his co-pilot, Robert E. Sands, specified instrument flight at 4,000 feet via Newark and Youngstown to Clevelar with Detroit (Willow Run), Michigan, as an alternate.

At the time that Captain Baldwin consulted the company meteorologist, reports issued by both the United States Weather Bureau and the company meteorologist were available forecasting that the prefrontal squall line then west of New York would break over LaGuardia airport at 1900. Captain Baldwin

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

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testified that he had not seen these reports and that he had not been concerned with them inasmuch as his scheduled departure time was 1830*. The flight plan, filed by Captain Baldwin, was perfunctorily approved by an assistant dispatcher without comment.

Servicing and loading of the airplane was delayed, and departure time was set back from 1840 to 1900. At 1850 passengers and crew boarded. According to the weight manifest, the flight's total gross weight was 60, 319 pounds, the document listing 44 passengers, a crew of 4, 1300 gallons of gasoline, and 2,575 pounds of cargo. At 1855 the engines were started, and Flight 521 requested taxi instructions from the tower. Clearance was given to Runway 13, the wind being reported by the tower as south, variable to southeast, 20 miles per hour. After taxiing out, the aircraft was parked approximately 50 feet adjacent to Runway 18, and, according to Captain Baldwin, the engine "run-up" and "take-off check" was then accomplished.

Captain Baldwin held at this point, approximately six to seven minutes. An unexpected difference occurred between him and Airway Traffic Control with reference to his clearance which had to be straightened out before departure. At 1903 the tower delivered the corrected clearance from Airway Traffic Control

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* The scheduled departure time was actually 1840, but this was what Captain Baldwin testified.

** The control tower operator was positive that clearance was originally given to Runway 13 and that only after Runway 18 had been requested by Captain Baldwin, was the ship cleared to Runway 18. Captain Baldwin stated that he was originally cleared to Runway 18. It should be noted that the choice of runways is a responsibility of the pilot. The tower "clears" only on the basis of traffic considerations.

Meanwhile black thunder clouds and lightning were visible west of LaGuardia. The squall line was breaking then over Hell Gate, some two to three miles west of the field. Air crews hurried to land or take off before being overtaken by the approaching storm. Northeast Airlines' Flight 28, a DC-3, took off from Runway 18 at 1901. American's Flight 250, a DC-3, landed a minute later on the same runway. Pan American's Flight 58 was cleared to land, Runway 18, and TWA's Flight 815 was cleared to land following Pan American, Runway 13. Wind was now being reported by the tower south variable to southwest, 22 miles per hour. At 1904, United's Flight 521 advised: "Ready for take-off." The tower operator asked whether the flight wished to wait out the storm on the ground. Captain Baldwin answered: "I'll take off." The tower then advised Captain Baldwin: "Cleared for immediate take-off, or hold; traffic on final approach north of Riker's Island." Flight 521 taxied from its parked position, rolled onto Runway 18, and without pause or hesitation accelerated for take-off. The throttles were advanced. Air speed increased to above 90 miles per hour. Captain Baldwin applied back pressure to the control column, but the "feel" of the controls was "heavy," and the aircraft did not respond. As the aircraft raced toward the boundary of the field, Captain Baldwin decided to discontinue his take-off. About 1,000 feet from the south end of the runway he applied brakes, ordering the co-pilot at the same time to cut the engines. A ground-loop was attempted by heavy application of left brake. The aircraft, however, proceeded to roll straight ahead. Then, with both brakes locked it continued over the remainder of the runway, crashed through the fence at the airport boundary, and half-bounced, half-flew across the Grand Central Parkway. The aircraft finally came to rest immediately east of the Casey Jones School of Aeronautics, a distance of 800 feet from the end of Runway 18 and 1,700

feet from the point at which brakes were first applied. It was almost immediate enveloped in flames. Only Captain Baldwin was able to escape before emergency fire equipment and rescue arrived. Other surveyors, one of whom later died, were assisted out of the wreckage within a period of 2 to 3 minutes after the crash.

Investigation

Benton Baldwin, age 38, graduated from the Army Air Corps Flying School in October 1933. After two and a half years of service as an Army pilot, he started flying for United Air Lines. From February 1940, to the date of this accident, he flew as a captain for United, except for the period of May 18, 1942, to June 12, 1946, when on active duty with the Army Air Forces. Of his total of 8,703 flying hours, 336 were in C-54 type equipment. Instruction in the C-54 consisted of ground school and 10 hours of flight training, a course offered to company pilots at United's San Francisco Flying School. After completing the course in November 1946, Captain Baldwin was considered qualified by the company to fly as pilot on regularly scheduled runs in C-54 airplanes. He was also certificated by the Civil Aeronautics Administration for a 1,050 to 10,800 horsepower rating.

Robert Sands, age 28, holder of commercial pilot certificate No. 308303, was the first officer for the flight. He was also trained in the U. S. Army Air Forces, and spent four years on active duty with the air forces as a military pilot. He was employed by United September 7, 1945, as a student pilot; and was assigned as a first officer December 4, 1945. Robert Sands accomplished C-54 training for first officers at the United's San Francisco Flying School, November 1946, and was qualified by the company to serve as a first officer in C-54 equipment on regularly scheduled runs. Mr. Sands had a total of 2,323 flying hours, 256 of which were in C-54 type equipment.

Both Captain Baldwin and First Officer Sands had received routine medical examinations. They had no known physical deficiencies, and were in good physical condition for flight duties.

The aircraft, NC 30046, a C-54B-DC, was completely destroyed. The fuselage was crushed by impact, and partially consumed by fire. All seats, with the exception of the hostesses' seats, were found detached from the floor. Fire extinguishers were found not discharged and in the proper racks.

The empennage and the empennage control surfaces sustained very little impact damage though partially consumed by fire. No structural failure or mechanical malfunction was found.

The cockpit was left relatively intact. The floor had been torn as a result of the failure of the nose gear, and the forward upper section of the fuselage was consumed by fire. No reliable evidence was obtained from the position of the controls. Impact tension on the control cables and acceleration forces during the course of the crash may have altered their true position The gust lock reel was located, and the gust lock tape found reeled-in. A sand bag was found between the gust lock handle and the floor of the cockpit. Since this handle could have been raised as a result of cable tension from impact, this position cannot be regarded as indicative of the gust lock being either on or off during the course of the take-off roll.

Two cylinders from each engine were removed. These cylinders and the interior of the power sections were then examined along with the magnetic oil sump plugs, oil strainers, induction systems, and prop governors. As a result of this inspection, and of the investigation to this date, no indication of any mechanical malfunction has been found in any of the power plants.

Nicks, bends and abrasions on propeller blades showed uniform damage to all four propellers. These markings indicated that the propellers were turning at a fairly high speed, but that little more than idle power was being developed at the time the damage occurred.

Both wings were crushed by impact and partially consumed by fire. The ailerons, however, were found intact. There was no indication of structural failure or mechanical malfunction.

The abundance of weather reporting stations in the New York area facilitated an accurate determination of weather conditions. On the date of the accident a cold front extending from Ontario, Canada, southward through Ohio, Kentucky and Tennessee was moving 30 to 35 miles an hour to the east. Approximately 200 miles in advance a prefrontal squall line had developed which was accompanied by thunderstorms, rain and hail. At 1630 the squall line had moved to a position 40 miles northwest of Albany, New York, and thence through southeastern Pennsylvania. By 1730 both the U. S. Weather Bureau and United Air Lines had made amendments to their previous forecast for LaGuardia, indicating that this squall line would pass the LaGuardia terminal at 1900.

Weather observation stations located at Newark, New Jersey; Teterboro, New Jersey; Battery Place, New York City; Central Park, New York City; the Administration Building, LaGuardia, and Floyd Bennett and Mitchell Fields, New York, noted the passage of the squall line by the change in the direction of the wind. This "windshift" occurred at Newark and Teterboro at 1850 and at Central Park at 1859.

In the Pan American Airways' weather office, located in the Marine Terminal Building on LaGuardia Field (700 feet west of Runway 18) no official observations actually were made of the passage of the windshift. However,

wind direction and velocity were noted by the Pan American Meteorologist. He stated that at the time of United's take-off (1905), the wind was from the south west at 11 miles per hour. The U. S. Weather Station in the LaGuardia Field Administration Building, located approximately 3100 feet east of Runway 18, recorded the passage of the windshift at 1909. This weather observation station made a preceding entry at 1902 for wind showing it to be south at 19 miles per hour.

In addition to the above evidence obtained from weather reporting stations, considerable testimony from other observers was introduced into the record. Two Pan American Airways' pilots present in the Marine Terminal Building for weather briefing observed United's Flight 521 on its take-off roll. They stated that they noted the readings for the wind direction and velocity in Pan American Airways' weather office at the time that the aircraft was taking off. According to them the wind was at that time south to southwest 15 to 20 miles per hour. Several lay witnesses testified concerning the direction of smoke travel from the burning wreckage. This evidence was conflicting, and not reliable since the time of observation could not be definitely determined in relation to the time of the accident.

An examination of the gust lock control in several of United's C-54s disclosed that the mechanism had been adjusted to allow the locking handle located to the immediate right of the pilot's seat to remain in the up or "on" position without being held by either the gust lock warning tape or by a locking pin attached to the tape. Very slight pressure on the handle would release the lock; however, if no tape was strung from the reel at the top of the cockpit to the locking handle, no visual warning would be present to the pilot before take-off that the control surfaces of the aircraft were actually locked.

Investigation also disclosed that the warning tape was used in two different ways. One method was to string the tape through the control wheel, which constituted a very definite impediment to the pilot in operating the aircraft, therefore, a positive warning. The second method was to place the tape behind and underneath the elevator trim tab control, then directly to the gust lock handle. If the second method was used, the tape was forward and to the right of the control wheel, and it was also far enough removed from the idle position of the throttles as to offer no restriction to movement until throttles had been advanced to almost take-off power setting. The second method had been employed in this case at the time that the airplane was parked in front of the terminal prior to the loading of the passengers.

According to Douglas engineering data, the stalling speed of a C-54 loaded to 60,319 pounds, the gross weight of United's flight, power off, 15 degree flaps, is 93 miles per hour (see Douglas Report SM-11840). The aircraft on a level, hard surface runway at sea level will accelerate to that speed in a take-off roll of 1550 feet. Under no wind conditions, if the aircraft accelerates for take-off over a distance of 2000 feet, the same engineering data indicates that an air speed of 103 miles per hour will be attained and if over a distance of 2500 feet, the air speed will increase to 112 miles per hour.*

Captain Baldwin stated that he saw 90 miles per hour on the air speed indicator during his take-off roll. He also stated that it was his practice when taking off not to look at the air speed indicator after he had attained an air speed of 90 miles per hour, but to then fly by the "feel" of the

* Critical engine failure speed for the C-54 (see Douglas performance charts) loaded to 60,319 pounds, standard atmospheric conditions, is 104 miles per hour. After the aircraft attains this speed, the distance to stop is equal to the distance to continue to a 50-foot height above the ground, three-engine operation.

airplane. In the present case, according to Captain Baldwin, the "feel" of the controls was "heavy", and the aircraft did not respond to the control pressures applied.

The Civil Aeronautics Administration's approved "Airplane Operating Manual", prepared by the Douglas Aircraft Company, is required by Civil Air Regulations to be carried in the airplane. This manual contains in addition to information concerning airplane operation certain graphs from which a pilot can determine minimum take-off runway length and critical engine failure speed for any particular gross weight or wind condition. Since these graphs are not suitable for quick and easy reference in the airplane, United placed the information concerning minimum runway lengths in tabular form called "Gross Weight Charts". These are also carried in the airplane and issued to the pilots.

Certain discrepancies exist between the data published by Douglas and the data prepared by United. Reference to the "Airplane Operating Manual" discloses that a C-54 loaded as was United's Flight 521, 60,319 pounds, requir under the transport category regulations, a runway 3600 feet long (this is based on critical engine failure) if there is a headwind of 20 miles per hour. Runway 18 at LaGuardia is only 3530 feet long. Furthermore, the graph does not include any allowance for obstructions.

United's Gross Weight Charts gave greater allowable weights for Runway 18 The weight allowed for this particular runway was 60,550 with a headwind of 20 miles per hour.

At the time of the compilation of these gross weight charts no allowance was made for the gradient in the runway*, nor for two obstacles at the end of the runway then in existence. The gradient of Runway 18 was ten feet or approximately 1 in 300 rising in the direction of take-off. A United States Coast and Geodetic Survey map of LaGuardia showing all obstacles and their height had been published and available for about a year prior to the accident. United Air Lines, however, had not acquired it until about two months prior to the accident. No correction had as yet been made for the obstacles referred to above.

Had the gradient been allowed for and the existing obstacles taken into consideration, the gross allowable weight with a headwind of 20 miles per hour for Runway 18 would only have been 57,850 pounds. Or, for the actual weight, under the transport category requirements, a runway of 3,893 feet would have been required. These requirements, in the interests of safety, provide for a 50 foot clearance of the end of the runway and of all obstacles in the take-off path with a one engine failure at or after the critical speed.** Thus, assuming no engine malfunctioning and performance of the airplane according to the criteria set forth in the Airplane Operating Manual, the airplane with full power would have undoubtedly cleared the end of a runway 3,893 feet long together with the existing obstacles with a margin of more than 50 feet.

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* A custom, whose origin is somewhat obscure, seems to have been prevalent in the industry to disregard all gradients in the calculation of allowable gross weights unless they exceeded 1 in 200.

** In the event of an engine failure at or before the critical speed, the formula requires runway distance sufficient to permit the airplane to be brought to a stop within the take-off area.

All certificated commercial lines are required by the Civil Aeronautics Administration to file gross operating weights for all runways employed. But these limitations are in no sense "approved" by the Administration. Indeed, after prolonged questioning in this investigation, it was discovered that the gross weights filed by the airlines have never been checked by any official and that no standard calculations have ever been made against which the weights filed could easily be checked. Indeed, there is no uniformity among the airlines with reference to the allowable weights that they file for identical planes. And indeed, these filings are not even made at one central point for the same airport. Instead they are made at the Civil Aeronautics Administration regional office that has jurisdiction over the particular carrier -- for example, United's gross weights for operation out of LaGuardia are filed in Chicago and are not even officially available at the LaGuardia office of the Civil Aeronautics Administration.

It is of interest to note also that when Captain Baldwin chose Runway 18, he had before him the weight manifest which showed the actual weight he was carrying. But he made no reference to the table of allowable weights when he decided to use the short Runway 18. Later he testified that he believed the allowable gross weight for Runway 18 with a wind of 20 miles per hour was some 60,000 pounds.

The utilization of winds to increase allowable weights is a significant element of the transport category formula.

Each mile-per-hour of wind, according to engineering calculations, permits an increase of 320 pounds. But the formula allows only half of this wind component to be utilized. Of course, the engineering calculations rest upon the assumption that the wind is both steady and directly on the nose of the

plane. Unsteadiness of the wind is naturally not subject to engineering calculations, but variation in the direction of the wind can be computed. If the direction of the take-off is south and the wind is southwest, the lifting capacity of a 20 mile per hour southwest wind is only the equivalent of a 14 per hour south wind.

The formula again takes no account of the effect of temperature. All weights are calculated on the basis of standard temperature, 59° Fahrenheit. A one degree rise in temperature in a DC-4 of the type here involved has the effect of increasing the gross weight approximately 180 pounds. A take-off at 99° would mean that the gross weight has been increased approximately 7,200 pounds or, to put it another way, 36 unseen passengers estimated at 200 pounds with their baggage have boarded the plane.

Another factor to note is that automatic wind recorders seldom show steady conditions with reference to either direction or velocity. In this case, the direction was fluctuating between south and southwest, and the velocity varied as much as 10 miles per hour in a short period of fluctuations Thus, it will be seen that not only was the wind variable at the observing point, but it was not necessarily in phase with the variations at the end of Runway 18, about two-thirds of a mile away; however, the general pattern of change at the two points was essentially the same.

Again, the thrust developed by the power plant of an airplane may not always be that set forth in the engineering manuals. Neither manifold pressure nor tachometer readings are an accurate gauge of power.* Also nicks on propeller blades, dents on wings or stabilizers may considerably reduce lift requiring longer distances in order to get an airplane airborne.

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* It is to be noted that the more modern planes such as the DC-6's and the Constellations have installed torque meters.

These and other factors, such as normal variations in the proficiency of a pilot, are assumed to be compensated by the other safety margins that are built into the transport category formula. Chief of these is the one-engine-out 50 foot clearance requirement. One engine of the airplane is assumed to fail at the so-called critical speed. Nevertheless the airplane must be able to take-off and clear the end of the runway by 50 feet with the undercarriage still unretracted and the propeller of the failed engine windmilling and unfeathered. Similarly, it is assumed if the engines are cut at the precise moment that the airplane reaches the critical speed, the airplane can be brought to a full stop at the precise point where the take-off area ends.

Discussion

The first assumption indulged in as the probable cause of this accident was that the airplane failed to clear the end of the runway because of a sudden windshift occurring during the midst of its take-off roll. Considering the closeness of the actual weight of the airplane to its allowable weight, the significance of wind as an element in increasing lift, and the known gustiness of the winds at the time of take-off, such a hypothesis seemed highly plausible. Under the transport category formula requirements a wind shift could precipitate a crash. But, the evidence as more fully developed leaves this hypothesis highly suspect. The wind shift according to the tower did not occur until four minutes after the accident. Admittedly the tower was some 3,100 feet to east of the runway in question. But observers in the Pan American meteorological station, some 700 feet to west of the runway also testified that no wind shift had occurred at the time they observed the airplane on its take-off roll. The runway thus is practically bracketed against the wind shift theory. Moreover, the very full meteorological evidence

introduced, which, however never has the exactness that its proponents assume, supports the absence of any wind shift.

But to the lay mind the very fact that a wind shift might produce such a tragic accident as this is a matter upon which one can well pause. Certainly the safety of air transportation, if it is to gain wide public confidence, cannot be allowed to let the lives of passengers hinge on a mere wind shift. A pilot, who knows the significance of the relation of wind to lift, is certainly to be criticized if his lift is dependent on wind and he takes off in the face of a known gusty wind condition. Captain Baldwin did this.

Again, it may be surmised that the plane was overloaded and hence failed to take off. It is true that the plane was overloaded according to the correct calculations for this runway derivable from the approved operating manual for this type of plane with due reference to gradients and obstacles present on Runway 18. But, if the engineers and other experts are to be believed, an airplane loaded to this weight, whatever the legal requirements might be, should have taken off without difficulty from this runway provided that the airplane was functioning normally. And there is not the slightest proof, except one matter later to be mentioned, that the airplane was not functioning in a normal fashion. Nevertheless, the airplane should not have been loaded to this weight for this runway. The fact that it was can be attributed to the miscalculations of United, the lack of any exercise of supervision over the filed weights by the Civil Aeronautics Administration, and the failure of Captain Baldwin even to glance at his chart of operating weights prior to take-off on this runway.

Two possibilities remain. The first is simply poor pilot technique by Captain Baldwin. He may, for reasons unknown, have become extremely agitated

by the sudden approach of the end of the runway--a suddenness that would not be too surprising in the light of the fact that he had never taken off a DC-4 on this runway before. In the light of that realization he may have decided wrongly to cut power instead of pushing his controls forward and grasping for the reserve power that would have made for clearance. But this is only surmise.

A more probable hypothesis is that the gust lock had not been released. Several factors incline towards this conclusion. Due to the gusty character of the winds the gust lock was obviously on when the ship was being taxied to its holding point just off Runway 18. Due to the delay, occasioned partly by the difficulty in securing an appropriate clearance from Airways Traffic Control, the gust lock was probably left on after the pre-take-off check with the intent that it should be immediately released upon starting the take-off roll. That roll, it will be remembered, was hurried.

As further evidence of this theory the attitude of the airplane during the take-off roll is to be noted. It was some 2500 feet down the runway before the power was cut at the order of Captain Baldwin.* At that point, even if no wind conditions prevailed, the airplane would have had a speed of 112 miles per hour. At such a speed it could easily have been pulled aloft; certainly its nose-wheel should have left the ground. But the nose-wheel did not leave the ground, according to the testimony of all the observers including that of Captain Baldwin.

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* There can be no question that the power was actually cut by the co-pilot at the time the airplane crossed Grand Central Parkway. A TWA pilot at that particular moment happened to be driving in his car on the parkway reporting to work. The airplane dented the top of his car with its under-carriage. This pilot testified that the airplane had its flaps down and made no noise. The happenstance of such conclusion testimony is most unusual.

True, the recollection of Captain Baldwin is to the contrary. But recollections of that character are by their very nature treacherous. The common story of mislaid articles is sufficiently eloquent to remind that many honest and well-intentioned people remember having done things that they never did.

Assuming this hypothesis is the correct one, what, one may well ask does it prove? Thousands of people daily attempt to start their automobiles with the emergency brake on. Emergency brakes and gust locks are necessities. They cannot and should not be legislated out of existence. Fortunately the consequences of leaving an emergency brake on are not serious; unfortunately leaving a gust lock on is not only serious, it is tragic. It will not suffice for us to say simply that this is a case of "pilot error" and wash our hands of the affair. A better device than those that now exist of assuring that the gust lock on these airplanes is released prior to the take-off roll is demanded.

But the story that this accident unfolds is more than this. If the gust lock was on--and this seems most probable--to assign that as the probable cause is to neglect matters of major causation. Few accidents respond to the simple analysis of one probable cause. Fortunately, the airplane of today is so designed and so built that one human or one mechanical failure will not produce disaster. If one engine fails, the other provides safety. If one ignition system fails, another is in reserve. If one airport is closed, another is normally available. These are typical of the criteria that today dominate the philosophy of air safety.

Throughout this series of events that in this case produced disaster, one can sense unfortunately too much insistence on speed of dispatch, too much of

a tendency to carry loads up to the full amount that the regulations stretched to a bulging point will allow. No one checked Captain Baldwin in his effort to beat the storm. The twenty minute delay in the dispatch of the airplane with the breaking of the squall line predicted exactly as of the time of dispatch was not even communicated to the dispatcher. No responsibility of any character was assumed by that office. The tower, true to its traditions, assumed no responsibility beyond that of traffic separation.* The airplane, loaded for the longest runway in traditional dispatching form, was shifted by the pilot to a shorter runway on the assumption that the wind component would be sufficient compensation--an assumption that happened to be true. The need to meet schedules as against a potential delay of an hour or so to wait out a storm determined a take-off under marginal conditions.

Safety, if it is to be achieved, has elements of cost. The line between unsafe and safe operations--whatever regulations or experts may say--is not delineated with the exactness that characterizes Sicnnese painting or an Ingres drawing. It is possible as, in the case of any cliff, to say where the precipice is, but it is not possible to say just how near one can come to the edge without falling in. Facts that do not respond to slide rules are sometime controlling. Airplanes, as any machine, have temperament and pilots, because they are human beings, possess the same frailty. Allowance in the tightness of

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* It may be noted at this point that salaries provided tower operators under existing regulations are such that it can be hardly expected that men enticed by these rewards can be entrusted with much responsibility. It can be noted also in this case that the particular tower operator involved, whose actions are not open to question, received more as an employee of the municipal administration than later as an employee of the Federal Government, when the Civil Aeronautics Administration took over from New York City the tower operations.

operations, in the tightness of formulas, must be made for these. And no such allowances were made. This method of doing things should appropriately be designated as the basic cause of this accident.

The Civil Aeronautics Act in its demand that we try and locate the "probable" cause hardly permits such unorthodoxy. We, therefore, proceed to our formal findings.

Findings

Upon the basis of all available evidence, the Board finds that.

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

2. No evidence has been found which indicates that there was any mechanical failure or malfunction of the aircraft or any of its components.

3. Wind was reported by the tower immediately prior to the time of take-off to be south 20 to 22 miles per hour.

4. Runway 18 at LaGuardia, 3,530 feet long, has a gradient of 1 to 300, and has obstructions 32 feet high within 150 feet from the south end.

5. United's Flight 521 loaded to a gross weight of 60,319 pounds required a runway 3600 feet long under 20 miles per hour headwind conditions, based on critical engine failure, according to the CAA Approved Airplane Operating Manual. Under the same conditions, United's Gross Weight Chart shows Runway 18 at LaGuardia to be usable though only 3530 feet long with obstructions 32 feet high existing 150 feet from the south end of that runway.

6. The airplane accelerated normally for a distance of approximately 2000 feet to an air speed in excess of 90 miles per hour after which the pilot applied brakes and ordered the co-pilot to cut the engines.

7. After the application of brakes the aircraft skidded for a distance of 800 feet to the end of Runway 18, and 1700 feet before coming to rest. It was then almost immediately enveloped in flames.

Findings (continued)

8. Of the 48 occupants 43 were killed, 4 seriously injured and one, the pilot, only slightly injured.

Probable Cause

The Board determines that the probable cause of this accident was either the failure of the pilot to release the gust lock before take-off, or his decision to discontinue the take-off because of apprehension resulting from rapid use of a short runway under a possible calm wind condition.

SUPPLEMENTAL DATA

Investigation and Hearing

Notification of this accident was given by eye witnesses to the Chief of Region I for the Civil Aeronautics Board, and investigation was immediately initiated in accordance with the provisions of Section 702 (a)(2) of the Civil Aeronautics Act of 1938, as amended. On June 11, 1947, a public hearing was held in New York City, New York.

Air Carrier

United Air Lines, Inc., was incorporated under the laws of the State of Delaware on June 20, 1934. The company is the holder of a certificate of public convenience and necessity for Route 1 issued by the Civil Aeronautics Board. This route, from LaGuardia to Cleveland, was the one over which United's 521 was scheduled to fly.

Flight Personnel

Captain Benton R. Baldwin, age 38, held Air Transport Certificate No. 29879 with a multi-engine 1050-10,800 h.p. rating. He had a total of 8703 flying hours, 336 of which were in C-54 type equipment. During the month preceding this accident, Captain Baldwin flew 84 hours and had a rest period of 5 days before departing on this flight. His last physical examination was given by the company January 24, 1947, at which time he was found fully qualified to fly. His last CAA physical examination was given January 20, 1947

Robert E. Sands, age 28, holder of Commercial Pilot Certificate No. 308303, had a total of 2323 flying hours, 256 of which were in C-54 equipment. During the month preceding this flight, he flew a total of 79 hours and was given a rest period of 41 hours preceding the departure time for this flight. Last company physical examination was given April 3, 1947, at which time he

was found qualified for flight. His last CAA physical examination was September 14, 1946.

The Aircraft

NC 30046, United's Flight 521, was a C-54B-DC airplane manufactured by the Douglas Aircraft Company March 17, 1944. The aircraft was purchased by United from the War Assets Corporation, and was converted to CAA and United Air Lines standards by Douglas Aircraft Company, April 6, 1946. It had a total of 5950 flying hours. The last No. 3 check was accomplished May 26, 1946, and the last No. 1 check accomplished May 26, 1947.

Engines

No. 1 Engine -	Serial Number	P-102764	
	Date of last overhaul	3-26-47	
	Time Accumulated during previous run	846:13	(normal removal for overhaul)
	Time since Overhaul at time of Accident	483:08	
	Total Time at Last Overhaul	2434:31	
	Total Time at Time of Accident	2917:39	
No. 2 Engine -	Serial Number	P-104353	
	Date of Last Overhaul	3-13-47	
	Time Accumulated During Previous run	726:27	(normal change acct. time)
	Time Since Overhaul at time of Accident	483:08	
	Total Time at Last Overhaul	3396:42	
	Total Time at Time of Accident	3879:50	
No. 3 Engine -	Serial Number	P-103362	
	Date of Last Overhaul	3-21-47	
	Time Accumulated During Previous Run	410:01	(normal change acct. time)
	Time Since Overhaul at Time of Accident	483:08	
	Total Time at Last Overhaul	2411 00	
	Total Time at Time of Accident	2894.08	

No. 4 Engine -	Serial Number	P-105262
	Date of Last Overhaul	4-2-47
	Time Accumulated During Previous Run	376:23 (removed acct. failure at SF)
	Time Since Overhaul at Time of Accident	483:08
	Total Time at Last Overhaul	3291:23
	Total Time at Time of Accident	3774:31

Propellers:

		At Time of Accident	
		Time Since Overhaul	Total Time
No. 1	#300183		
Hub No. RRA	7556	1477:17	5054:16
Blades No.	RRE 4939	1477.17	5054:16
	RRE 4940	1477:17	5054·16
	RRE 4941	1477·17	5054·16
No. 2	#3001143		
Hub No. RRD	1155	483:08	4974·09
Blades No.	RRN 1480	483:08	4974:09
	RRN 1481	483·08	4974:09
	RRN 1482	483:08	4974:09
No. 3	#3001136		
Hub No. RRC	7321	481:05	5337:52
Blades No.	RRL 2351	481:05	5337:52
	RRL 2352	481:05	5337:52
	RRL 2353	481:05	5337:52
No. 4	#300156		
Hub No. RRB	2968	483:08	6522:31
Blades No.	RRU 8155	1477:15	1477·15
	RRU 8156	1477:15	1477·15
	RRU 8157	1477:15	1477:15

Corrective Action

This accident has not only been of concern to the Civil Aeronautics Board but also to the President's Special Board of Inquiry on Air Safety. A close liaison between the two as well as the Civil Aeronautics Administration has been maintained. The corrective action that has been taken thus stems from all three bodies as well as the municipal airport authority.

1. The Civil Aeronautics Board has amended Civil Air Regulation--so as to eliminate the word "appreciable". The result is that all gradients must be included in calculating allowable weight limitations on all runways.

2. The Civil Aeronautics Board has promulgated for adoption two regulatio (1) a regulation providing for an arbitrary reduction in allowable weight limitations that will take account of temperature as affecting take-off loads; (2) a more permanent but still interim regulation permitting the adjustment of allowable loads to changes in temperature on a more scientific basis.

3. The Civil Aeronautics Board and the Civil Aeronautics Administration have instructed their respective staff to reconsider the transport category requirements for take-off and landing both with regard to the formulation of a United States position on these matters for the purposes of international standardization under the auspices of the International Civil Aviation Organization and with regard to increased safety in American domestic and international requirements. This will take time. Some five or six years of effort went into the formulation of the present transport category requirements. Their revision, other than for interim purposes, is not a matter of days.

4. The Civil Aeronautics Administration in cooperation with the airlines will work out uniform weight limitations for all runways used by the certificated commercial airlines in the United States on the basis of the revised interim formulas.

5. The Civil Aeronautics Administration has defined and promulgated the definition of winds that are not too unsteady and too variable so as to limit the use of reasonably steady and constant winds as components in the transport category requirements.

6. The Civil Aeronautics Administration and the Air Transport Association are taking steps to indoctrinate pilots more thoroughly in the meaning and use of the transport category formulas.

7. The President's Special Board has requested the manufacturers of this airplane to redesign several aspects of the gust-lock, so as to provide against its locking during take-off or flight and so as to provide more adequate warning against it being locked at the time of take-off. One design feature has already been completed and is being installed.

8. The President's Special Board has recommended the installation of lighted wind socks at the ends of all runways utilized by certificated commercial aircraft. Failure of the municipalities to respond to this suggestion may call for further propulsive action.

9. The municipal authorities of New York City have closed Runway 18 to all four engine aircraft.

In short, all action that it seems sensible to take has already been taken.