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RESEARCH MEMORANDUM

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FIRST LANDING OF BELL X-2 RESEARCH AIRPLANE

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

October 1, 1952

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RESEARCH MEMORANDUM

FIRST LANDING OF BELL X-2 RESEARCH AIRPLANE

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SUMMARY

The Bell X-2 supersonic research airplane is equipped with a skid main landing gear and a nose wheel. Pending completion of the rocket engine, glide flights are being performed to determine low-speed handling qualities of the airplane and the landing characteristics with the skid-type landing gear. The present paper presents data obtained during the approach and landing of the X-2 airplane on its first flight.

The approach speed was about 215 miles per hour and touchdown was made at 142 miles per hour, indicated airspeed, with a normal-force coefficient of 0.77. Immediately on contact of the skid the airplane pitched down and the nose-wheel support assembly failed. The deceleration during most of the ground run was between 0.4g and 0.8g. The total distance of the ground run was 1,010 feet.

INTRODUCTION

The Bell X-2 supersonic research airplane has been constructed as part of the joint Air Force - Navy - National Advisory Committee for Aeronautics high-speed flight research program. The X-2 airplane is intended to investigate the characteristics of swept-wing airplanes at high supersonic speeds. The airplane has several unconventional features among which are the circular-arc wing section profile and the skid-type landing gear.

Pending the completion of the rocket engine for the X-2 airplane, glide flights are being performed by the Bell Aircraft Corp. These flights are for the purpose of determining the landing characteristics and flight characteristics at low speeds.

The first glide flight was performed June 27, 1952. The airplane was launched from the Boeing B-50 mother airplane at an altitude of 31,500 feet and made a 9-minute flight terminated by a landing on the dry lake bed.

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The purpose of the present paper is to document the approach and landing data of the first flight. Other data recorded during the flight are now being analyzed.

SYMBOLS

h_p	pressure altitude, ft
V_i	indicated airspeed, mph
δ_e	elevator deflection, deg
δ_{a_t}	total aileron deflection, deg
δ_r	rudder deflection, deg
F_e	elevator force, lb
F_a	aileron force, lb
A_Z	normal acceleration, g units
A_X	longitudinal acceleration, g units
A_Y	lateral acceleration, g units
$\dot{\theta}$	pitching angular velocity, radians/sec
$\dot{\phi}$	rolling angular velocity, radians/sec
$\dot{\psi}$	yawing angular velocity, radians/sec
α	angle of attack, deg
β	angle of sideslip, deg
g	acceleration due to gravity, ft/sec^2

AIRPLANE AND INSTRUMENTATION

The X-2 airplane is a low-wing single-place research airplane having 40° sweep of the quarter chord and 10-percent-thick circular-arc airfoil sections normal to the quarter chord. For the flight reported herein the rocket motor was not installed. The geometric characteristics of the

airplane are presented in table I and a sketch of the airplane is shown as figure 1. The leading-edge flaps were deflected 15° for the entire flight.

The landing gear of this airplane consists of a main landing skid, nose wheel, and wing-tip skids. A drawing of the landing-gear arrangement is presented as figure 2 and a photograph of the airplane in the normal ground attitude is shown as figure 3.

The airplane was instrumented to record the following quantities on internal recording instruments:

Altitude
Airspeed
Normal, transverse, and longitudinal acceleration
Rolling angular velocity
Pitching angular velocity
Yawing angular velocity
Elevator angle
Aileron angle
Stabilizer angle
Rudder angle
Flap angles
Elevator stick force
Aileron stick force
Sideslip angle
Angle of attack

The accelerometer is located 123 inches forward of the center of gravity of the airplane.

In addition to the internal instrumentation, a modified SCR 584 radar set was employed to obtain the airplane flight path and landing trajectory. All instrumentation was synchronized by a common timer.

TESTS, RESULTS, AND DISCUSSION

The landing approach pattern as recorded by radar is shown in figure 4. The winds at the ground level were about 5 miles per hour and were from the south-southwest. The approach was started on the downwind leg opposite the touchdown point at geometric altitude of 6,500 feet and indicated airspeed of 223 miles per hour with trailing-edge flaps up. The speed was approximately 220 miles per hour, indicated airspeed, during the downwind and base legs. The trailing-edge flaps were lowered 28° at 210 miles per hour and an altitude of 1,000 feet in the final approach. The flight path was not obtained below an altitude of 200 feet because of intervening obstacles.

Time histories of the measured quantities during the flaps-down portion of the approach and landing are shown in figure 5. The speed in the approach was reduced gradually from 206 miles per hour at time zero to 183 miles per hour at time 26 seconds. After time 26 seconds the speed decreased more rapidly as the pilot held the airplane off until the contact occurred at indicated airspeed of 142 miles per hour and with a normal-force coefficient of 0.77. Integration of the accelerometer records indicated that vertical velocities were less than 5 feet per second near and at touchdown. It was expected that the pilot would be able to control the pitching at contact. However, the pitching at touchdown was uncontrollable and the airplane experienced a peak longitudinal deceleration, exceeding the 1.75g range of the recorder. The airplane developed a maximum pitching velocity of -0.45 radian per second resulting in about a 3.8g acceleration on the nose gear at contact. The airplane slid along on the main skid and nose wheel leaving a track the width of the skid and approximately $1\frac{1}{2}$ inches deep in the lake bed. A sketch of the skid marks on the lake is shown as figure 6. At time 39.5 seconds the pilot applied left aileron control causing the airplane to roll to the left and despite corrective aileron control applied at time 41.5 seconds, the left wing tip contacted the ground at the point 764 feet from touchdown. This contact was comparatively light but the drag on the tip yawed the airplane about 14°. The right wing-tip skid then struck the ground heavily and broke off. The airplane yawed about 35° to the right and the left tip contacted again. The left skid was bent inward at this impact and the leading edge of the wing dug into the lake bed and the airplane came to a stop. The total distance covered on the ground was 1,010 feet. Inspection of the nose wheel revealed that the support assembly had failed during the landing. It was indicated from remains of the yaw vane found on the lake bed and from comments of the chase pilot that the nose wheel collapsed immediately after ground contact.

Figure 7 is a photograph of the skid marks on the lake and the final resting position of the airplane. The marks made by the wing-tip skids are clearly visible in the photograph.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va.

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TABLE I

PHYSICAL CHARACTERISTICS OF BELL X-2 AIRPLANE

Wing:	
Area, sq ft	260.4
Span, ft	32.3
Aspect ratio	4.0
Taper ratio	0.5
Sweep at 0.25 chord, deg	40.0
Airfoil section	10-percent-thick circular-arc
Incidence:	
Root, deg	3.0
Tip, deg	3.0
Dihedral, deg	3.0
Aileron:	
Area, sq ft	10.8
Travel, deg	±17.0
Flap, trailing edge:	
Area (total), sq ft	21.2
Travel, deg	45
Flap, leading edge:	
Area (total), sq ft	12.2
Travel, deg	15
Horizontal tail:	
Area, sq ft	43.7
Span, ft	12.8
Aspect ratio	3.75
Sweep at 0.25 chord, deg	40.0
Airfoil section	NACA 65-008
Elevator:	
Area, sq ft	8.4
Travel:	
Up, deg	15
Down, deg	10
Stabilizer:	
Travel:	
Leading edge up, deg	7
Leading edge down, deg	10

TABLE I.- Concluded

PHYSICAL CHARACTERISTICS OF BELL X-2 AIRPLANE

Vertical tail:	
Area, excluding dorsal, sq ft	38.6
Sweep of leading edge, deg	40.6
Airfoil section:	
Root	NACA 27-010
Tip	NACA 27-008
Fuselage:	
Length, ft	37.8
Fineness ratio	9.5
Airplane weight, lb	10,337
Center-of-gravity location, percent M.A.C.	22.62

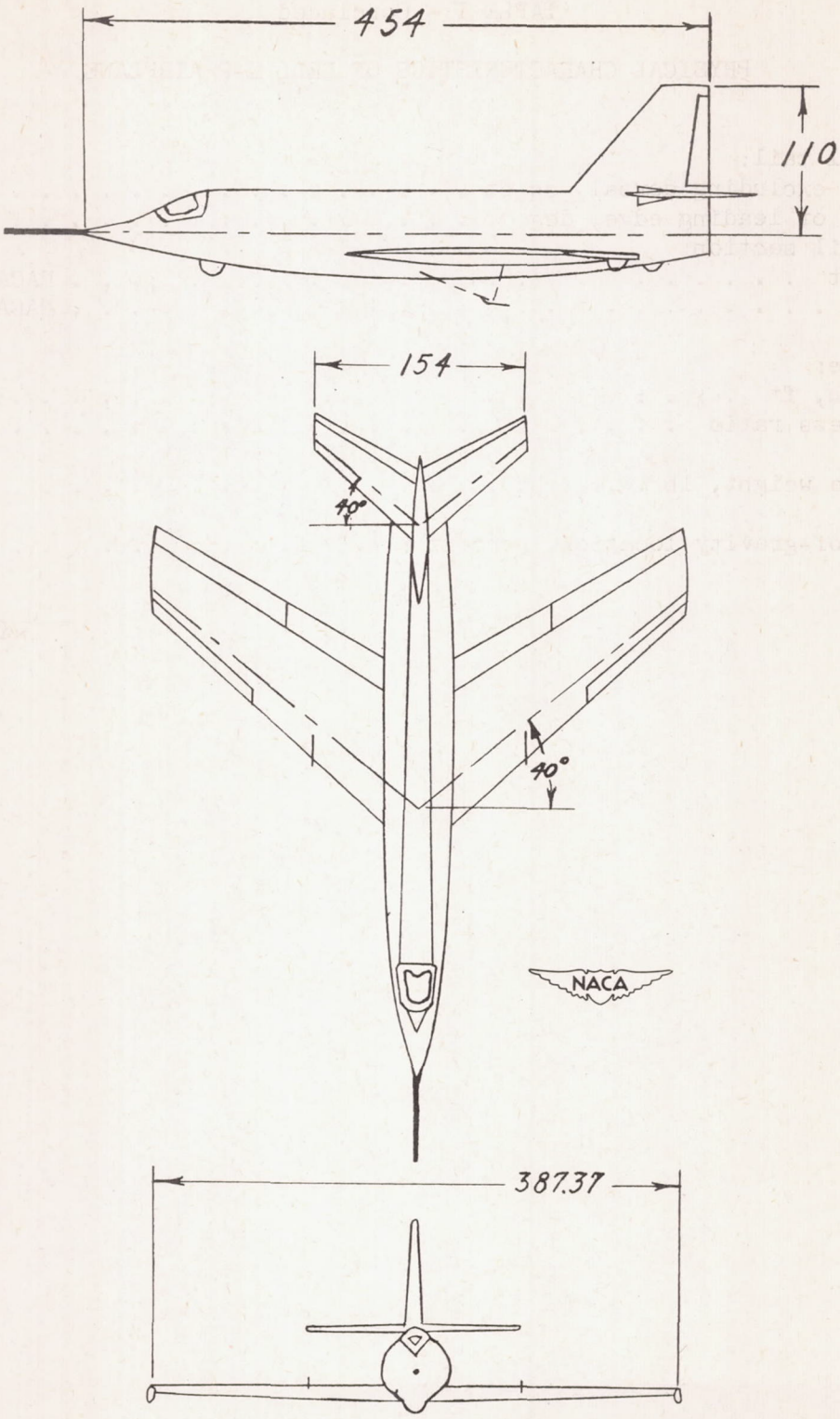


Figure 1.- Three-view drawing of the Bell X-2 research airplane. All dimensions are in inches.

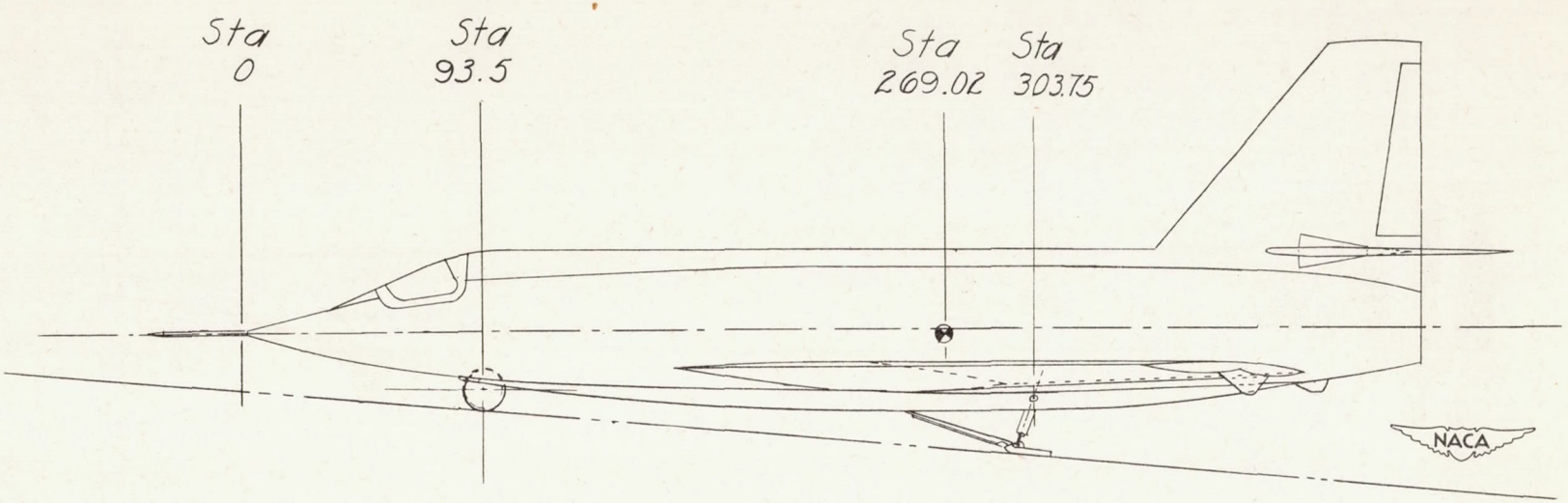
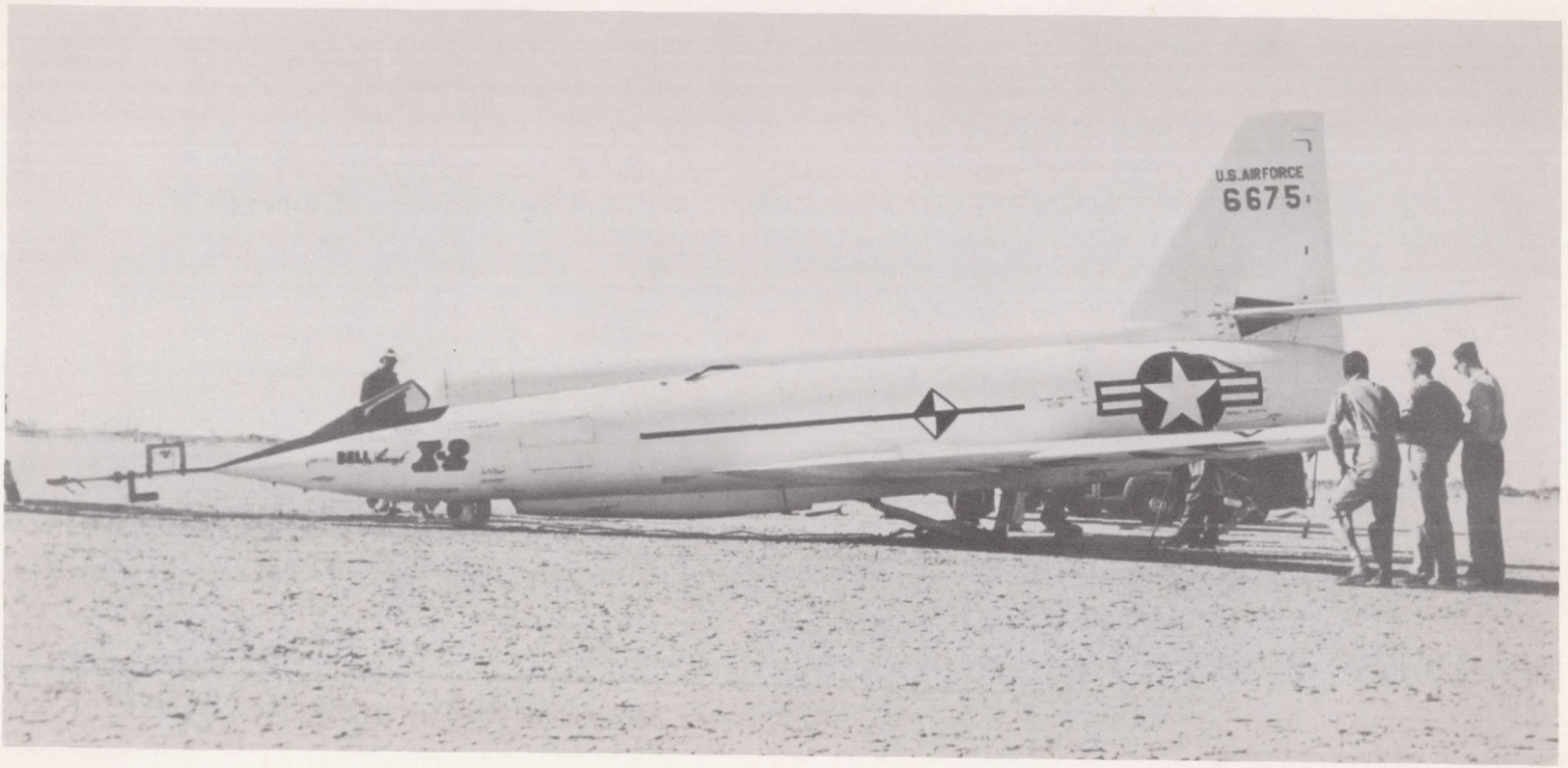


Figure 2.- Drawing showing the landing-skid and nose-wheel installation on the Bell X-2 research airplane.



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Figure 3.- Photograph of the X-2 research airplane in normal ground attitude.

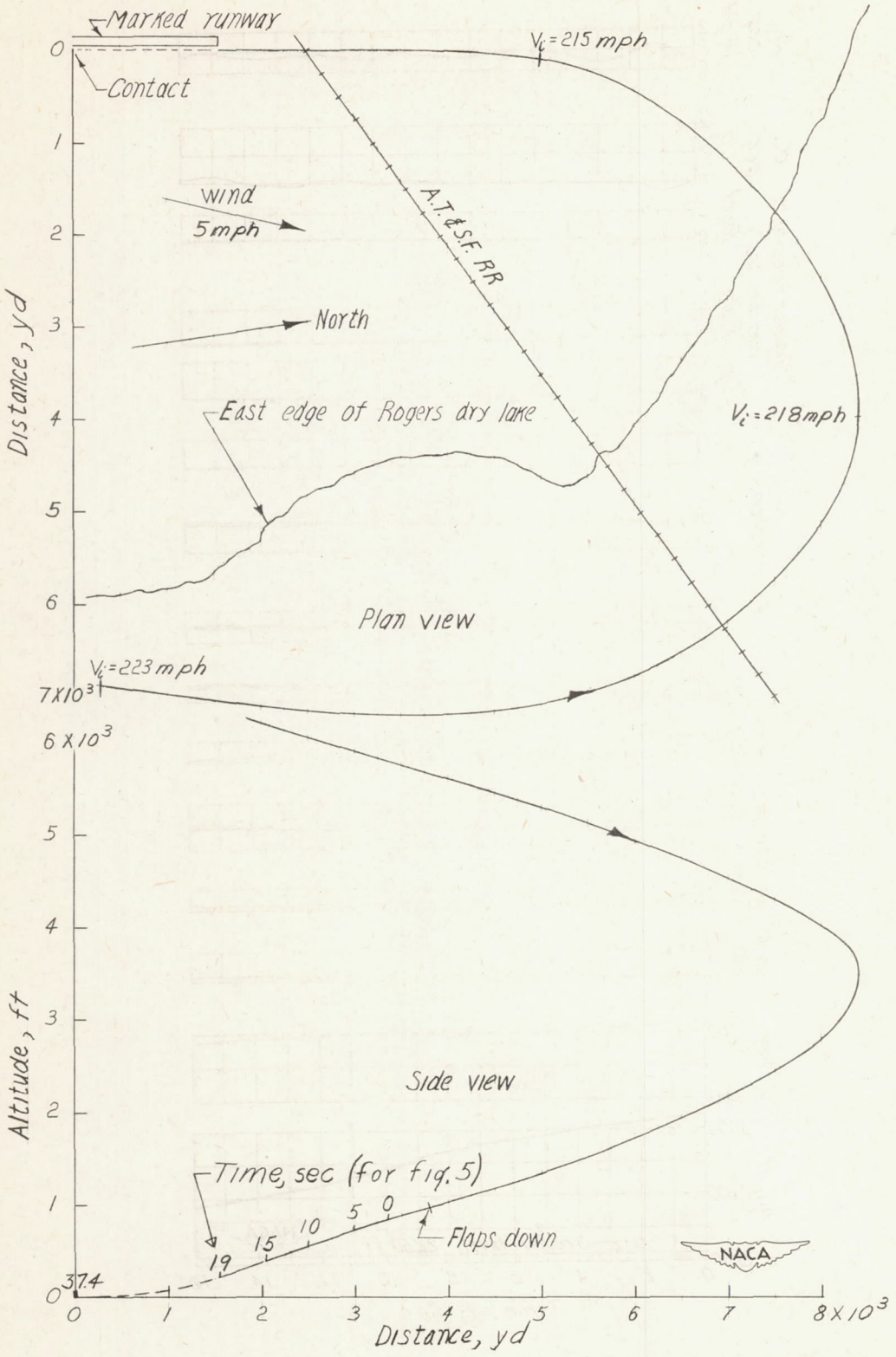


Figure 4.- Landing approach pattern of the Bell X-2 research airplane.

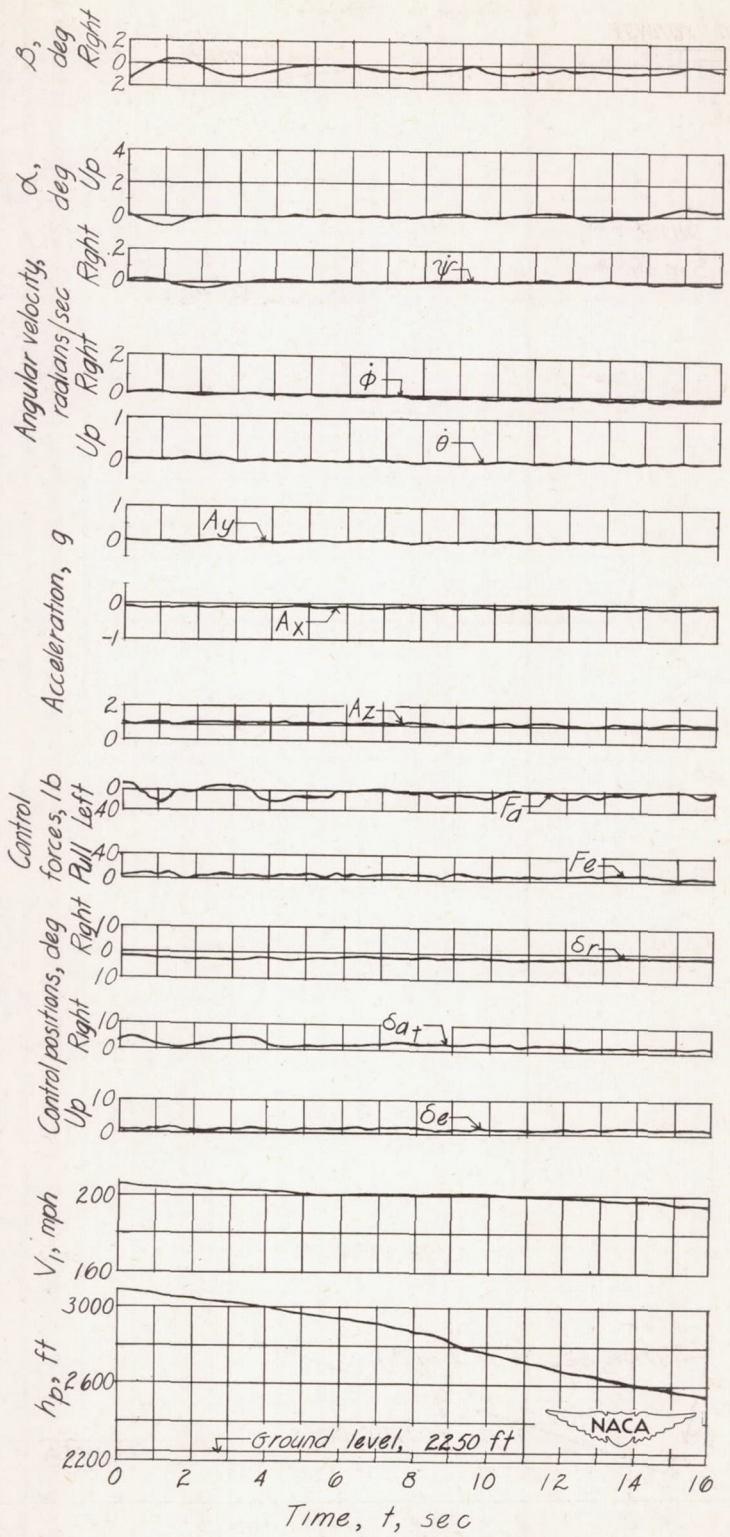


Figure 5.- Time history of landing of Bell X-2 research airplane. Stabilizer setting, 2.2° leading edge down; weight, 10,337 pounds.

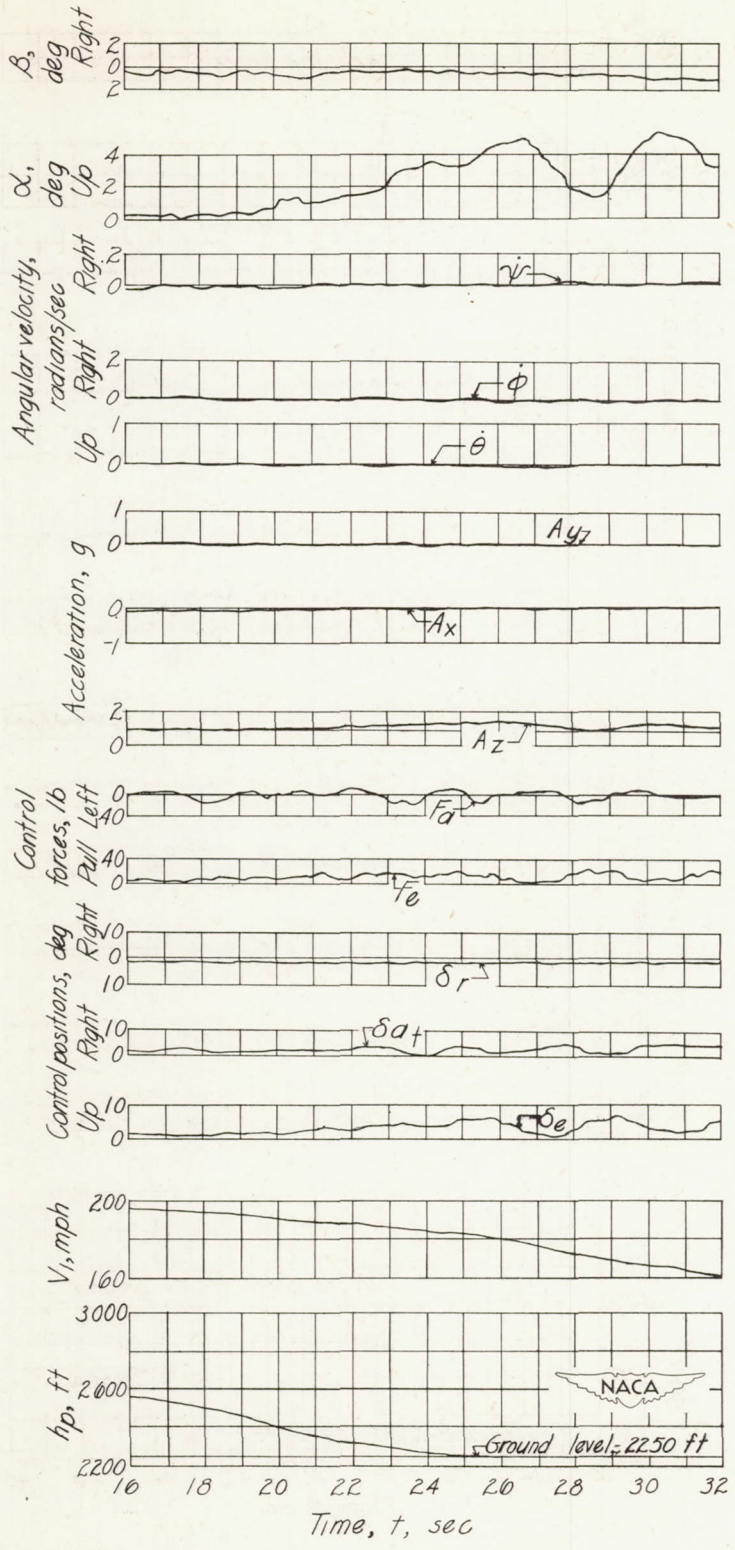


Figure 5.- Continued.

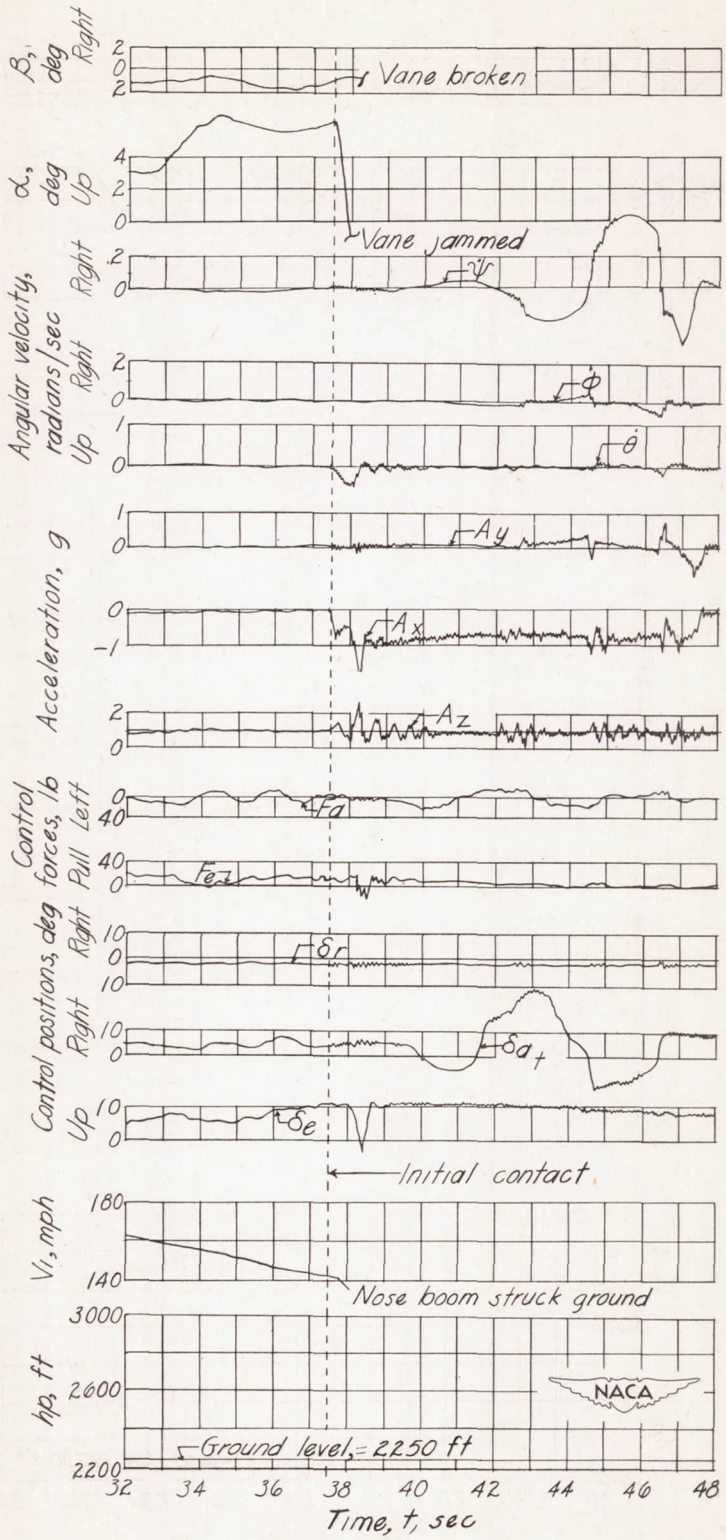


Figure 5.- Concluded.

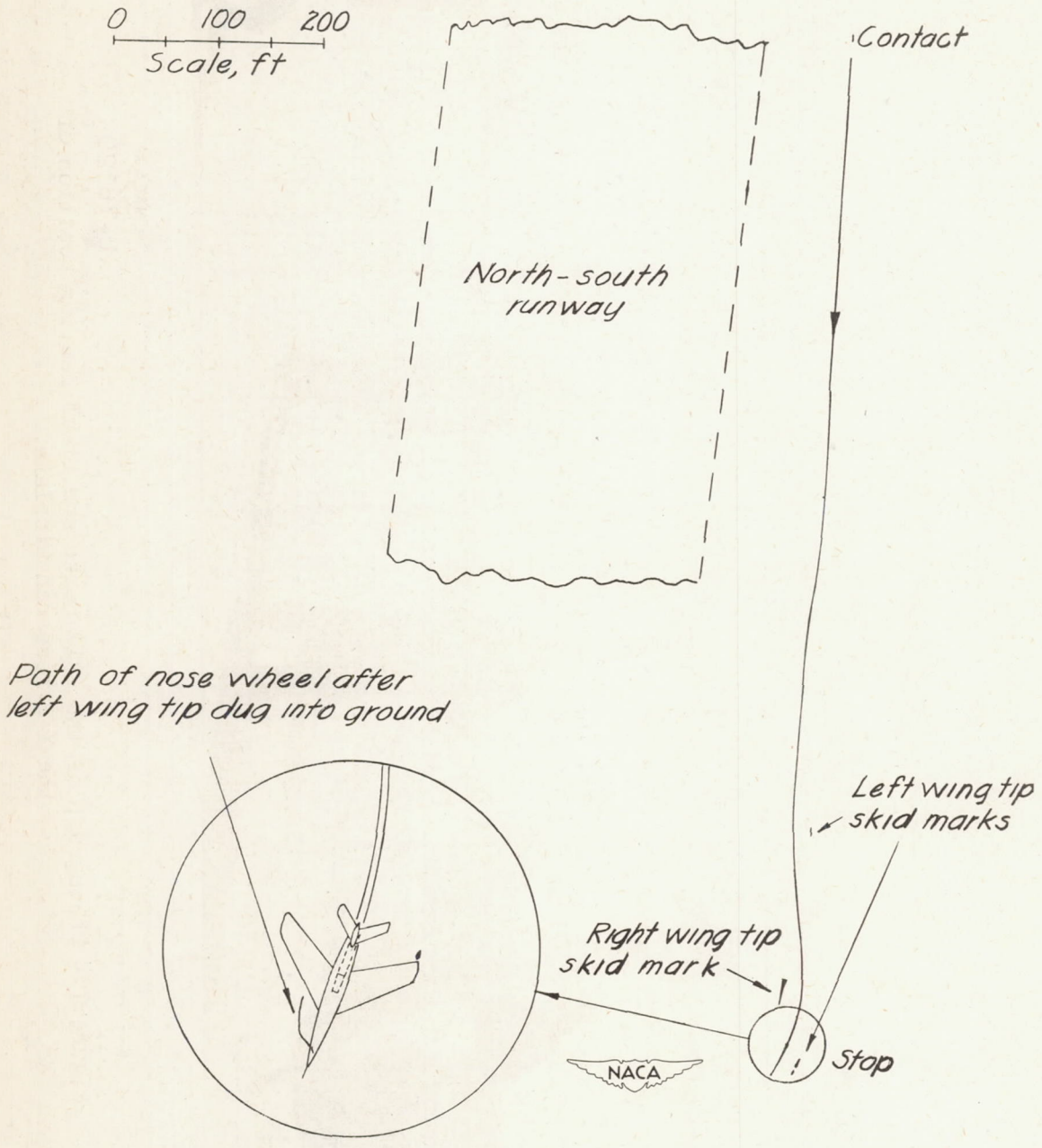


Figure 6.- Ground path of the Bell X-2 research airplane.



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Figure 7.- Photograph of the skid marks and final resting position of the X-2 research airplane.

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