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Cessna

Model 319A Report No. 1339-3

FLIGHT TEST OBSERVED & CORRECTED DATA REPORT: III-TAKE-OFF AND LANDING PERFORMANCE OF MODEL 319A

NONR CONTRACT 856(00)

Cessna Aircraft Company
Wichita, Kansas

FORM 486

CONFIDENTIAL

Cessna
Aircraft Company
Wichita, Kansas

Engineering Report - Research Department

MODEL 319A : REPORT NO. 1339-3

FLIGHT TEST OBSERVED & CORRECTED DATA REPORT: III - TAKE-OFF & LANDING PERFORMANCE OF MODEL 319A

NONR CONTRACT 856(00)

REPORT DATE: April 1, 1955

PREPARED BY: W. M. Gertsen

WITNESSED BY:

APPROVED BY: J. W. Fisher
A. N. Petroff

55 53683

A. OWEN HOLLIDAY

CONFIDENTIAL

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NOTE: All original data, film analyses, take-off and landing data corrections and reductions are on file in the Research Department, Cessna Aircraft Company. Copies are available upon request by authorized agencies.

I. SUMMARY

Flight tests were conducted with the Cessna Model 319A airplane on five different occasions from February through August 1954 for the purpose of determining take-off and landing performance over a 50 ft. obstacle. On two occasions, a record of the actual flight path of the airplane was made by means of a photographic flight path recording camera. Twice, data was obtained by observing distances required to take-off and land over an actual 50 ft. barrier. One series of tests was recorded by means of a 35 mm Ditto camera which took a series of still photographs covering the whole range of the take-off or landing test run.

Results of this take-off and landing test program revealed varying distances when corrected to same gross weights and standard sea level conditions. These differences are attributable to several changes made to the airplane and to changes in piloting technique throughout the program. These changes are fully discussed in Section IV of this report.

During the last phase of the program, after best piloting techniques had been established, a reduction in both take-off and landing distance over a 50 ft. obstacle of 25% was achieved by means of the boundary layer control system. An even larger reduction in ground run distance was achieved (approximately 36%).

II. INTRODUCTION

A. Object

Take-off and landing performance tests of Model 319A were administered by the Office of Naval Research for Army Transportation Corps under NONR Contract 856(00).

The object of this report is to set forth in detail all take-off and landing performance test data, reduced and corrected data, and all pertinent information regarding methods of obtaining the data and other factors influencing the program.

B. Place and Date

The tests in this program were conducted by Cessna Research Department and Flight Test personnel on the dates and in the places indicated below:

18 February 1954 - Cessna Aircraft Company field (not photographed)

4 March 1954 - Cessna Aircraft Company field (not photographed)

4 June 1954 - Wichita Municipal Airport (photographed)

16 June 1954 - Cessna Aircraft Company field (photographed)

24 August 1954 - Wichita Municipal Airport (photo sequence)

C. Methods and Equipment Used

On 18 February 1954, and 4 March 1954, the following procedure was used: All data was taken by observers at the scene. Wind velocity, pressure altitude, outside air temperature, time of day for each test run as well as actual distances required by the airplane to take-off and land over a 50 ft. obstacle were recorded. An actual obstacle 50 ft. high (consisting of a pole, the top of which was plainly marked so as to be visible from a considerable distance) was erected. This permitted observers to detect how high the airplane was when it passed by. Cases where the airplane failed to clear 50 ft. exactly at the obstacle were corrected to obtain the exact runway location where the airplane was 50 ft. high. This information, together with observed points of start and break ground (take-off), touch down and stop (landing) allowed exact distances to be determined.

On 4 June 1954, and 16 June 1954, the following procedure was used: The take-offs and landings were photographed with a CAA Bell & Howell Photographic Flight Path Recording camera set perpendicular to the runway at a specified distance. The film, superimposed upon a grid, recorded at the rate of four frames per second the horizontal and vertical location of the airplane. A stop watch was included in the camera field of view.

Observers at the scene recorded wind velocity, pressure altitude, outside air temperature, and time of day for each test run.

On 24 August 1954, tests were conducted in conjunction with a standard L-19A, the two airplanes being flown side by side. Still photographs of the entire flight paths were made by means of a Ditto 35 mm camera which takes up to 10 exposures in rapid order without resetting. Each photograph of each run overlapped the preceding photograph to such a degree that the entire flight path was traced. The runway location of the airplane in each photograph was determined by comparing location of the airplane with known objects in the background, together with the use of a map of the area where the tests were run (Wichita Municipal Airport). The point at which the airplane was at 50 ft. was determined by finding the point at which the airplane was 2 lengths above the runway, since the airplane was 25 feet long.

D. Description of Airplane

The Cessna Model 319A was designed to utilize the fuselage of a Cessna Model 305 (L-19), and the tail surfaces of a Cessna Model 180. It contained in a specially designed wing an improved "Arado" type Boundary Layer Control System. This system consisted of axial fans located in the wings, which were driven by hydraulic motors. The motors were run by a variable displacement pump which extracted its power from the main engine. The fans sucked air in through suction slots along the inboard portion of the wings into internal ducts and blew the air out through blowing slots along the outboard portions of the wings. A detailed description of the airplane appears in Reference 1.

E. List of Symbols

AF	Activity factor
BLC	Boundary Layer Control
CBHP	Corrected brake horsepower
$C_{L_{max}}$	Maximum lift coefficient, (W/Sq)
C_Q	Flow quantity coefficient (Q/SV)
MAC	Mean aerodynamic chord
OAT	Outside air temperature, °F
S	Wing area, sq. ft.
V	Velocity, ft/sec.
V_w	Wind velocity, mi/hr.
W	Aircraft weight, lbs.
c	Local wing chord, ft.
h_p	Pressure altitude, ft.
q	Dynamic pressure, lbs/ft^2
s_a	Air distance, ft.
s_g	Ground distance, ft.
s_t	Total distance, ft.
δ_A	Aileron droop, deg.
δ_F	Flap deflection, deg.

III. RESULTS - TABLES OF REDUCED AND CORRECTED DATA

(All data corrected to Standard Sea Level, Zero Wind Conditions)
Distances in Feet

18 February 1954 Observed Data (not photographed) W = 2250 lbs.

Take-off No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
5	$\delta_F = 30°, \delta_A = 15°$ BLC-on	Firm turf	207	257	464

Landing No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
7	$\delta_F = 45°, \delta_A = 30°$ BLC-on	Firm turf	192	401	593

4 March 1954 Observed Data (not photographed) W = 2250

Take-off No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
1	$\delta_F = 30°, \delta_A = 15°$ BLC-on	Firm turf	350	269	619
2			275	282	557
3			222	335	557
4			233	344	577
5			265	331	596
6			291	315	606
7			254	271	525 *
8			265	358	623
9			214	296	510 *
10			232	257	489 *
11			252	314	566
	* Average of best 3 (No. 7, 9, 10)		233	262	495

Landing No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
11	$\delta_F = 55°, \delta_A = 30°$ BLC-on	Firm turf	203	417	620 *
12			268	354	622 *
13			231	385	616 *
14			249	418	667
	* Average of best 3 (No. 11, 12, 13)		234	385	619

4 June 1954 CAA Camera Data W = 2250 lbs.

Take-off No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
1	$\delta_F=30°$, $\delta_A=15°$	Concrete	254	287	541
2	BLC-on		215	310	525 *
3			237	303	540
4			195	318	513 *
5			211	387	598
6			166	360	526 *
	* Average of best 3 (No. 2, 4, 6)		192	330	522
7	$\delta_F=20°$, $\delta_A=10°$	Concrete	201	356	557 *
8	BLC-on		187	393	580
9			181	400	581
10			188	390	578 *
11			228	299	527 *
	* Average of best 3 (No. 7, 10, 11)		206	348	554

Landing No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
1	$\delta_F=55°$, $\delta_A=30°$	Concrete	346	329	675
2	BLC-on		286	317	603
3			295	387	682
4			236	452	688
5			249	348	597 *
6			241	4[illegible]2	653
7			306	361	667
8			196	438	634
9			234	354	588 *
10			310	370	680
11			283	296	579 *
	* Average of best 3 (No. 5, 9, 11)		255	333	588

16 June 1954 CAA Camera Data $W = 2250$ lbs.

Take-off No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
1	$\delta_F=30°, \delta_A=15°$	Firm turf	289	440	729
2	BLC-off		305	373	678
3			280	399	679
4			380	305	685
5			327	319	646 *
6			390	229	619 *
7			338	289	627 *
	* Average of best 3 (No. 5, 6, 7)		355	276	631
8	$\delta_F=0°, \delta_A=0°$	Firm turf	466	416	882 *
9	BLC-off		569	360	929
10			562	328	890 *
11			416	397	813 *
	* Average of best 3 (No. 8, 10, 11)		483	379	862

Landing No.	Configuration	Remarks	Ground Run	Air Distance	Total Distance
1	$\delta_F=55°, \delta_A=30°$	Firm turf	392	644	1036
2	BLC-off		334	332	666 *
3			242	388	630 *
4			397	313	710
5			326	262	588 *
6			230	514	744
7			388	337	725
	* Average of best 3 (No. 2, 3, 5)		301	327	628
8	$\delta_F=0°, \delta_A=0°$	Firm turf	799	366	1165 *
9	BLC-off		734	396	1130 *
10			1110	552	1662
	* Average of best 2 (No. 8, 9)		767	381	1148

TITLE Take-offs and Landings

PREPARED BY WMG DATE 4-1-55

CHECKED BY JWF DATE 4-1-55

CESSNA AIRCRAFT CO.
WICHITA, KANSAS

REPORT NO 1339-3

MODEL 319A

FORM 484

24 August 1954 — Ditto Camera Photo Sequence

(Concrete runway)

Take-off Performance:

	BLC-on	BLC-off
Ground Run	190	297
Air Distance	260	303
Total	450	600

Landing Performance:

	BLC-on	BLC-off
Ground Run	160	258
Air Distance	290	342
Total	450	600

NOTE: BLC-off data is L-19A data

SUMMARY TABLE - MEASURED TAKE-OFF AND LANDING DISTANCES

Date	BLC ON			BLC OFF			Remarks	
	s_g	s_a	s_t	s_g	s_a	s_t	$\delta_F - \delta_A$	
Take-off								
2-18	207	257	464	--	---	---	30 - 15	50 ft. barrier by observation
3-4	233	262	495	388	274	662	" "	50 ft. barrier by observation
6-4	190	331	521	--	--	--	" "	CAA Camera Hydraulic pressure 3200 psi
6-16	--	--	--	355	276	631	" "	" " " " " "
8-24	190	260	450	297	303	600	" "	Photo sequence
Landing								
2-18	192	401	593	---	---	---	45 - 30	Prop low pitch 7 1/2°
3-4	234	385	619	330	379	709	55 - 30	Prop low pitch 4°
6-4	255	333	588	--	---	---	" "	Prop low pitch 4°
6-16	---	---	---	301	327	628	" "	" " " "
8-24	160	290	450	258	342	600	" "	Prop low pitch 2 1/2° Reverse sense propeller

NOTE: On 3-4 and 8-24, BLC-off data is taken from L-19A data.
On 8-24, 319A W=2300 lbs., L-19A W = 2100 lbs; all other cases, W = 2250

IV. DISCUSSION

General

Take-off and landing performance of Model 319A was measured on five different occasions as shown in the preceding tables of results. The first case (18 February 1954) gives values of only the best take-off and landing in a short series. All the other cases give the averages of the best three measurements made, except in the case of BLC-off landing, $\delta_F=0, \delta_A=0$, where the best two of three measurements were used.

More exact distances were obtained in the second test series (4 March 1954). At that time the desired take-off distance improvement was achieved; however, obstacle landing performance improvement was somewhat less than expected.

The third and fourth series of tests (4 June 1954 and 16 June 1954) were photographed by means of the CAA flight path recording camera, and consisted of BLC on and off take-off and landing performance data. These tests did not produce the desired improvements in distance. This situation was subsequently corrected by improved piloting technique and changes made to the aircraft. These changes resulted in the final distance improvements as shown by the tests of 24 August 1954.

On that date a standard L-19A was flown side-by-side with the Model 319A. Flights were made with a 200 lb. difference of gross weight in favor of the L-19A. This exceeded the estimated weight of a production BLC system by 50 lbs. Even with this weight penalty, ground roll for both take-off and landing was reduced by over 35% and total distance by 25%.

During the program, an endeavor was made to obtain superior barrier performance by shortening air distance rather than continuing to shorten ground run by technique and by an investigation of the many flap-aileron deflection combinations available. Further gains could doubtless have been achieved; however, funds were depleted before the program of shortening ground run was completed.

The better performance obtained in the latter portion of the testing program was the result of several factors. Important among these was improved piloting technique. Also strongly influencing the results were the following changes made to the aircraft.

(1) Hydraulic pressure, which had been raised to 3200 psi in the hope of increasing $C_{L_{max}}$, was lessened to 3000 psi. This in turn lessened the power drain on the main engine, allowing greater propeller thrust to develop. Angle of climb and acceleration were thereby increased, and distance to a 50 ft. obstacle was decreased.

(2) Stall strips, which had been quite large, were made smaller, after a systematic series of tests showed smaller strips to be equally as effective as the larger ones in controlling stalling

motions. This change prevented so much of the wing from being blanketed, thus improving lifting power of the wing. See Reference 7 for a detailed explanation of the stall strip tests and installation.

(3) Landing air distance was improved by changing the propeller low pitch setting from 4° to 2 1/2°, and by use of a "reverse sense" propeller which insured that the propeller blades would remain on the low pitch setting during landing runs at the 1400 rpm engine speed required for a BLC landing. This constant lower pitch setting increased drag, and thereby shortened landing air distance.

During the flight test program, erratic sawtooth glide data was found to be caused by the idling propeller (See Reference 8). The propeller installed at that time was forced onto the low pitch stop by governor oil pressure, and pitch was increased at high engine speeds by the propeller counterweights. The trouble was eliminated by use of a "reverse sense" propeller, which, without counterweights, tended to ride on the low pitch stop, and which depended on governor oil pressure for higher pitch settings. (References 5 and 9). Use of this propeller improved sawtooth glide data as well as shortening landing air distances.

Importance of Technique

During this testing program, the importance of piloting technique became increasingly apparent, particularly in the case of landing.

Previously, the pilot experienced difficulty in controlling a floating tendency prior to touch down. This was also experienced in earlier tests of BLC research aircraft at Cessna (Reference 2). If approach speeds were allowed to get too high, the reduction in speed during transition caused a rather sudden increase in C_Q and of the lifting effectiveness of the wing, thus causing floating. If speed was too low, a proper flare could not be executed. The range of allowable airspeed variation for optimum performance for the 319A was approximately ± 2 mph, which was difficult to maintain in gusty air. The piloting technique which produced the best results consisted of making the approach at a somewhat higher speed and closing the throttle after the airplane had slowed down at the end of the flare. Closing the throttle reduced the power input to the BLC system, and, as wing lift diminished, the airplane settled onto the ground instead of floating. Maximum braking was then applied, making possible a very short ground roll.

Take-off technique which was used consisted of raising the tail wheel off the ground as soon as possible in order to reduce drag, allowing the aircraft to become airborne as soon as possible, then accelerating just above the ground to 1.1 x stall speed before pulling up into transition and climb-out, and maintaining that speed throughout the climb-out over the 50 ft. obstacle.

It was noted during the tests, and later analysis of the data substantiated the fact, that in a number of instances, the airplane actually left the ground at a speed below previously determined stall speeds. This apparent discrepancy was thought to have been caused either by dynamic maneuvering, or some unaccountable influence of the ground proximity, or both. This phenomenon appeared to be fertile ground for possible future investigation.

Optimum Flap Deflections

On the basis of wind tunnel data (Reference 3), and limited flight testing, take-off flap and aileron deflections were determined to be $\delta_F = 30$, $\delta_A = 15°$. Landing flap and aileron deflections were intended to be $\delta_F = 60°$, $\delta_A = 45°$. However, poor lateral control characteristics with BLC on prevented use of full aileron droop for landing. Thus, the maximum aileron deflection used was $\delta_A = 30°$.

Observation of the tufted airplane helped explain lack of lateral control. In a rolling maneuver the down aileron separated while flow on the up aileron remained smooth. This indicated loss of lift on the up going wing, causing poor lateral control. Subsequent widening of the blowing slot from 0.4%c to 0.6%c increased flow quantities and resulted in improved response to lateral control motion. Had a further increase in flow quantity been possible, lateral control probably would have improved enough that full aileron droop could have been used to shorten further the landing distances.

It should be noted that it is not certain that the $\delta_F = 30°$, $\delta_A = 15°$ was the optimum for take-off performance. It was felt that further gains in performance may have been possible by exploring other combinations. However, limited funds prevented a comprehensive investigation of this subject. For this reason, further testing to yield optimum deflection would seem to be in order.

Insufficient Elevator Power

At forward center of gravity locations (20% MAC) the pilot was unable to trim the airplane at low speeds with BLC on and was unable to achieve a 3-point attitude for landing with engine power off. For this reason, ballast had to be placed in the airplane, thus moving the center of gravity aft to a degree sufficient to allow 3-point landings.

This same phenomenon also was experienced in previous tests with BLC research aircraft at Cessna (See Reference 4).

This difficulty indicates that BLC airplanes need considerably greater elevator power than conventional ones. The logical way to achieve greater elevator power would be to increase the tail volume coefficient. However, if this proved impractical due to the size of tail which would be required, then boundary layer control applied to the tail surfaces would produce the necessary improvement in power. Reference 6 contains details of a method of application of BLC to tail surfaces.

Hard Landing

During the tests of 16 June 1954, on the fourth barrier landing with clean configuration and BLC system off, the airplane made an abnormally hard landing with resultant damage to propeller, main landing gear spring, and tail gear spring. Damage was caused by gusty weather conditions. Early in the day, testing was begun under almost zero wind conditions, but as the testing progressed, surface wind increased and became gusty. Since weather conditions for several months had been adverse, testing was continued even though conditions were marginal. The approach for the fourth landing was normal until part way through the landing flare, when a gust dropped the airspeed approximately 5 mph. The airplane mushed into the ground, still in a nose low attitude, before power was developed, even though it had been applied. The main gear spread out on impact with the brake drums dragging. The nose low attitude was thus aggravated, nearly causing the airplane to nose over. (See Reference 5)

It appeared as a result of this minor accident, that performance of barrier landings in gusty conditions is extremely critical at speeds just above stall without the BLC system. This illustrates the fact that an aircraft with BLC can approach and land with airspeeds at a greater margin over stall speed, for safety in gusty conditions, and still retain excellent short field landing characteristics.

V. CONCLUSIONS AND RECOMMENDATIONS

Analysis of the results of the Model 319A take-off and landing performance test program led to the following conclusions:

1. The use of Boundary Layer Control resulted in an improvement of 25% in overall take-off and landing distance over a 50 ft. obstacle. Improvement in ground run was 36% on take-off and 38% on landing.

2. Piloting technique is of the utmost importance in obtaining maximum take-off and landing performance over an obstacle. This factor is extremely important in obtaining optimum landing performance.

3. Optimum flap deflections for take-off performance were not determined due to limited funds available for the program. It is therefore recommended that a flight test program be conducted to determine optimum flap deflections.

4. Lack of sufficient elevator power at forward center of gravity locations with BLC on, engine power off, indicates that BLC aircraft need more elevator power than conventional ones. Application of boundary layer control to tail surfaces is recommended to achieve this greater power, in the event that increase in tail volume coefficient proves impracticable.

5. As a result of the minor accident which occurred during this testing program, it is concluded that performance of barrier landings in gusty conditions is hazardous without the BLC system operating.

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VII. APPENDIX

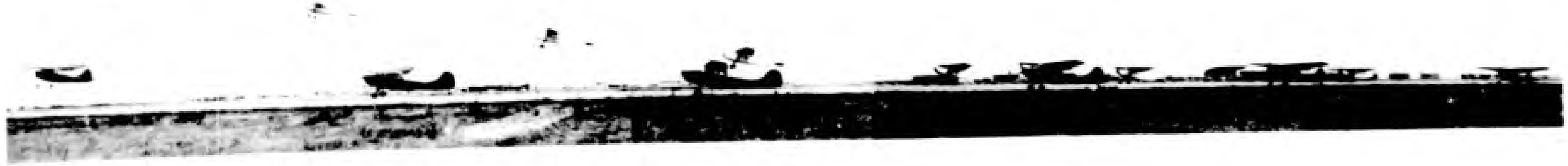


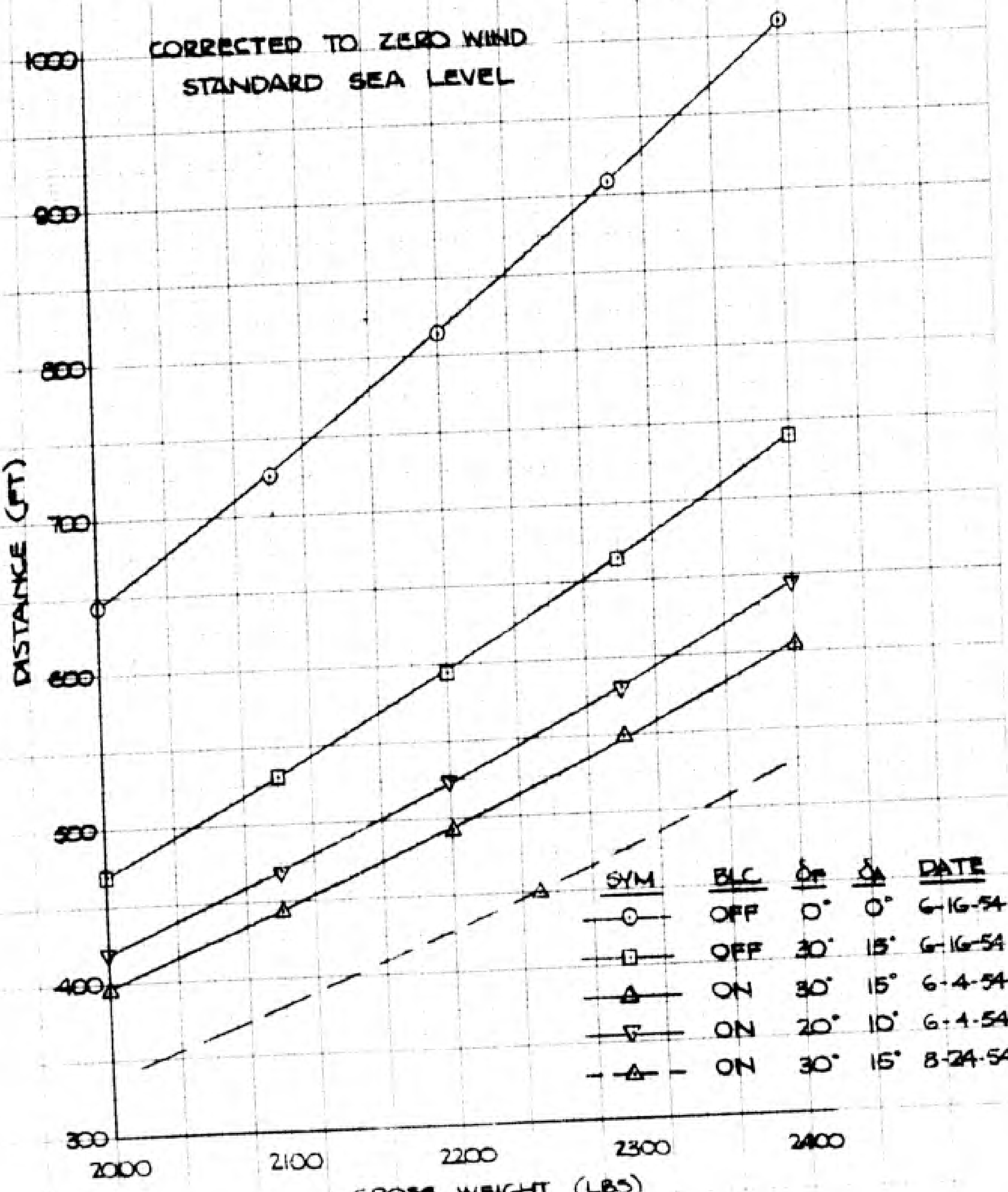
Fig. 1

The above figure is a photograph of a typical take-off of Model 319A along with a standard L-19A. This photograph is a composite of a sequence of photographs, made with a Ditto 35 mm camera, taken from the beginning and throughout the take-off run. The two aircraft were side by side at the beginning of the run, and as the run progressed, the L-19A gained velocity faster, but required a considerably greater length of runway in order to break ground and to climb to 50 ft. In this sequence the L-19A weighed 2100 lbs., and the 319A weighed 2300 lbs.

FIG. 2

MODEL 319A

TOTAL TAKE-OFF DISTANCE OVER 50 FT OBSTACLE
VS
GROSS WEIGHT



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MODEL 319A

FIG. 3

TAKE-OFF GROUND RUN AND AIR DISTANCE VS GROSS WEIGHT

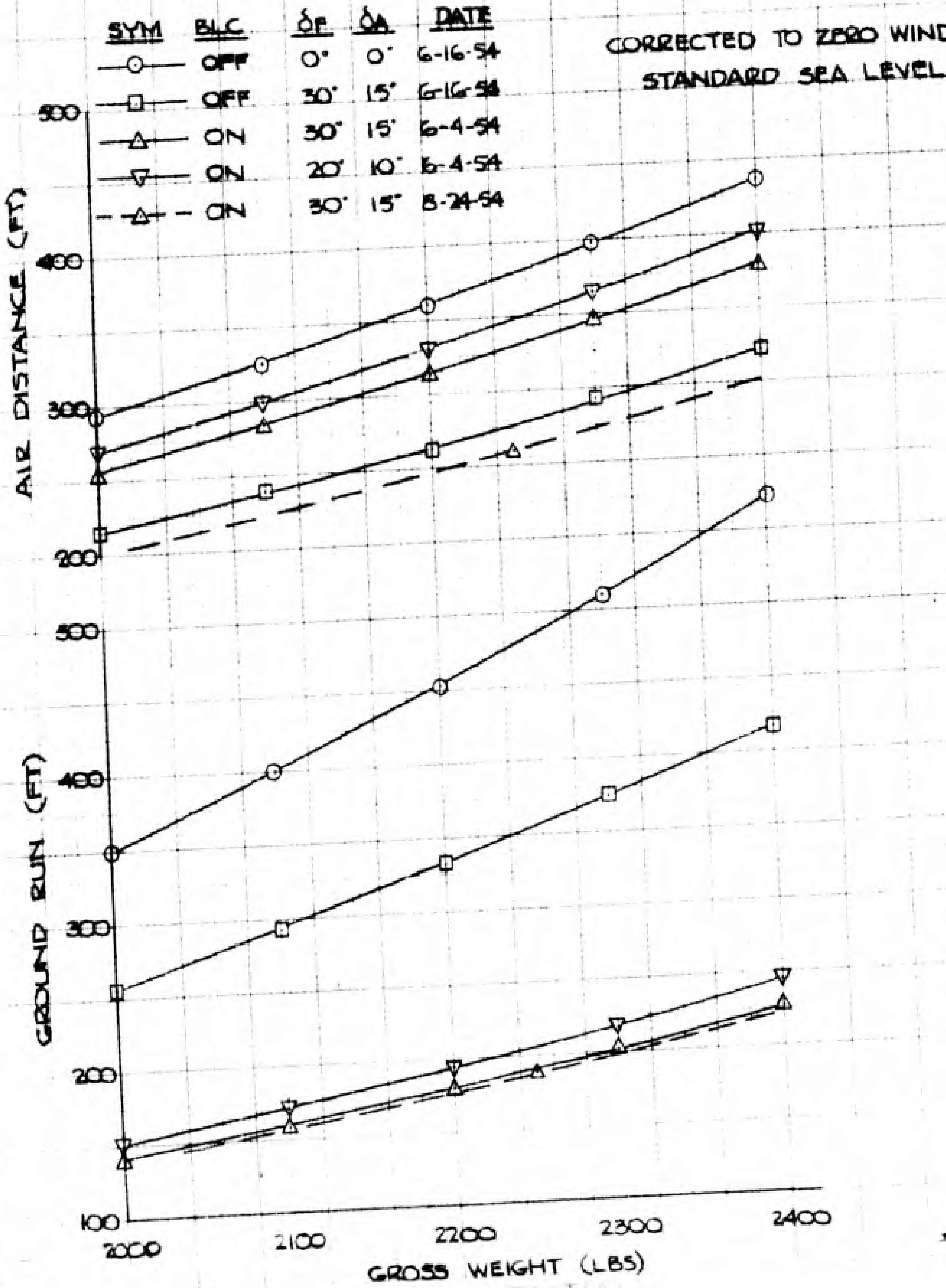

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FIG. 4

MODEL 319A

TOTAL LANDING DISTANCE OVER 50 FT OBSTACLE
VS
GROSS WEIGHT

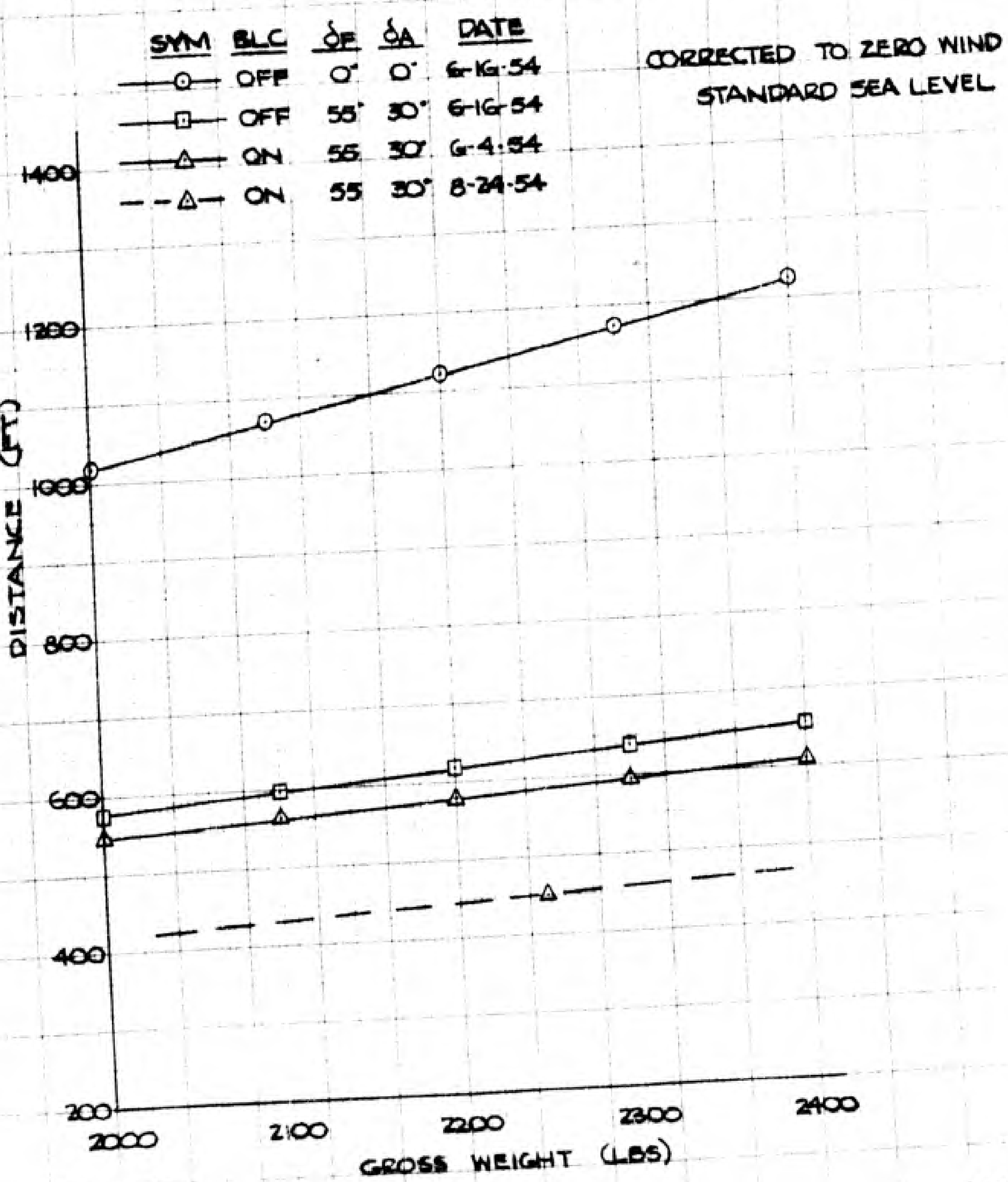

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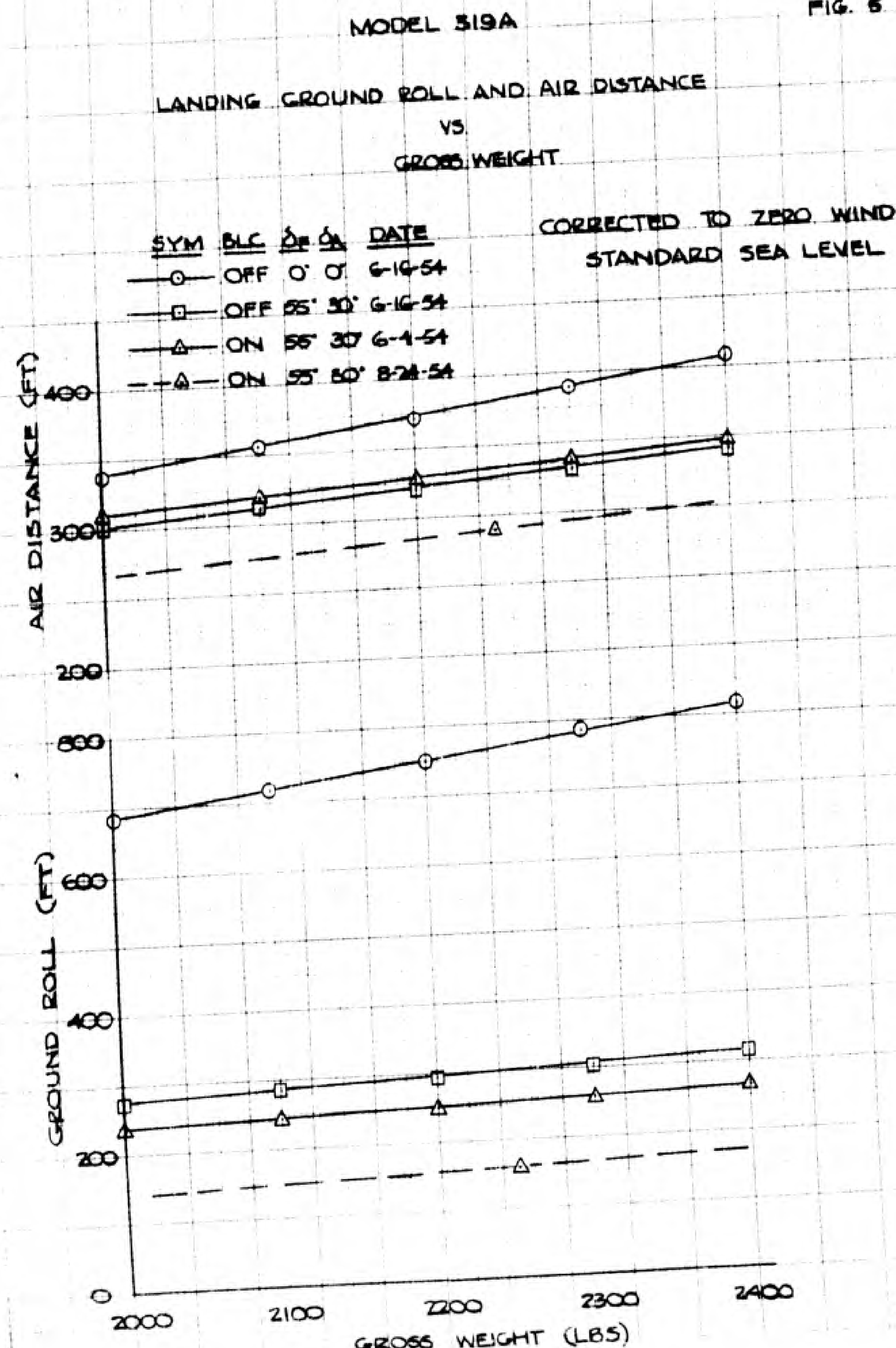
FIG. 5



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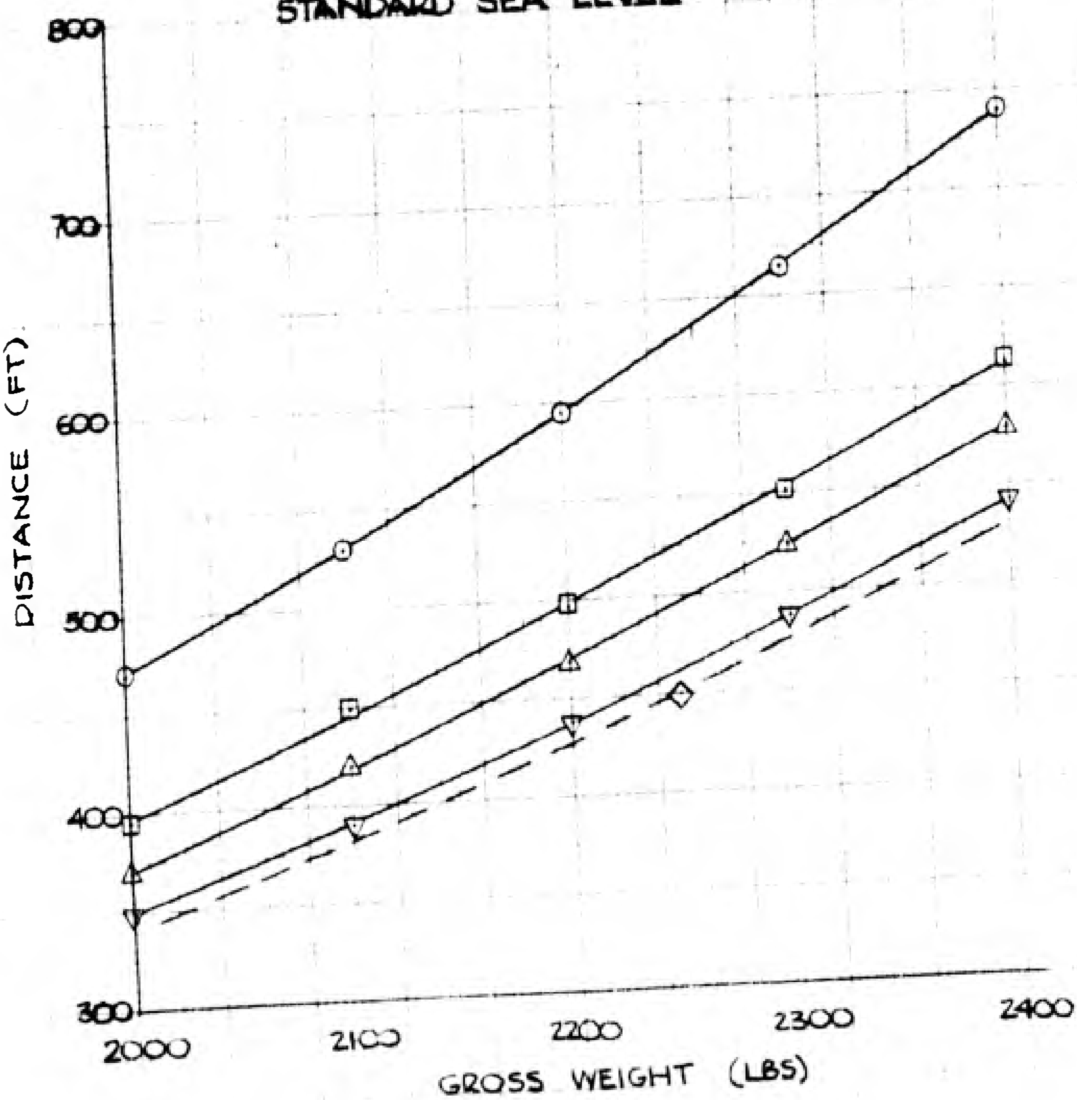
MODEL 319A

TOTAL TAKE-OFF DISTANCE OVER 50 FT OBSTACLE
VS
GROSS WEIGHT

SYM	BLC	DATE	FILM	RUNWAY	δ_F	δ_A
—○—	OFF	6-16-54	YES	TURF	30°	15°
—□—	ON	6-4-54	YES	CONCRETE	30°	15°
—△—	ON	3-4-54	NO	TURF	30°	15°
—▽—	ON	2-18-54	NO	TURF	30°	15°
- -◇- -	ON	8-24-54	YES	CONCRETE	30°	15°

CORRECTED TO ZERO WIND
STANDARD SEA LEVEL



3-24-55

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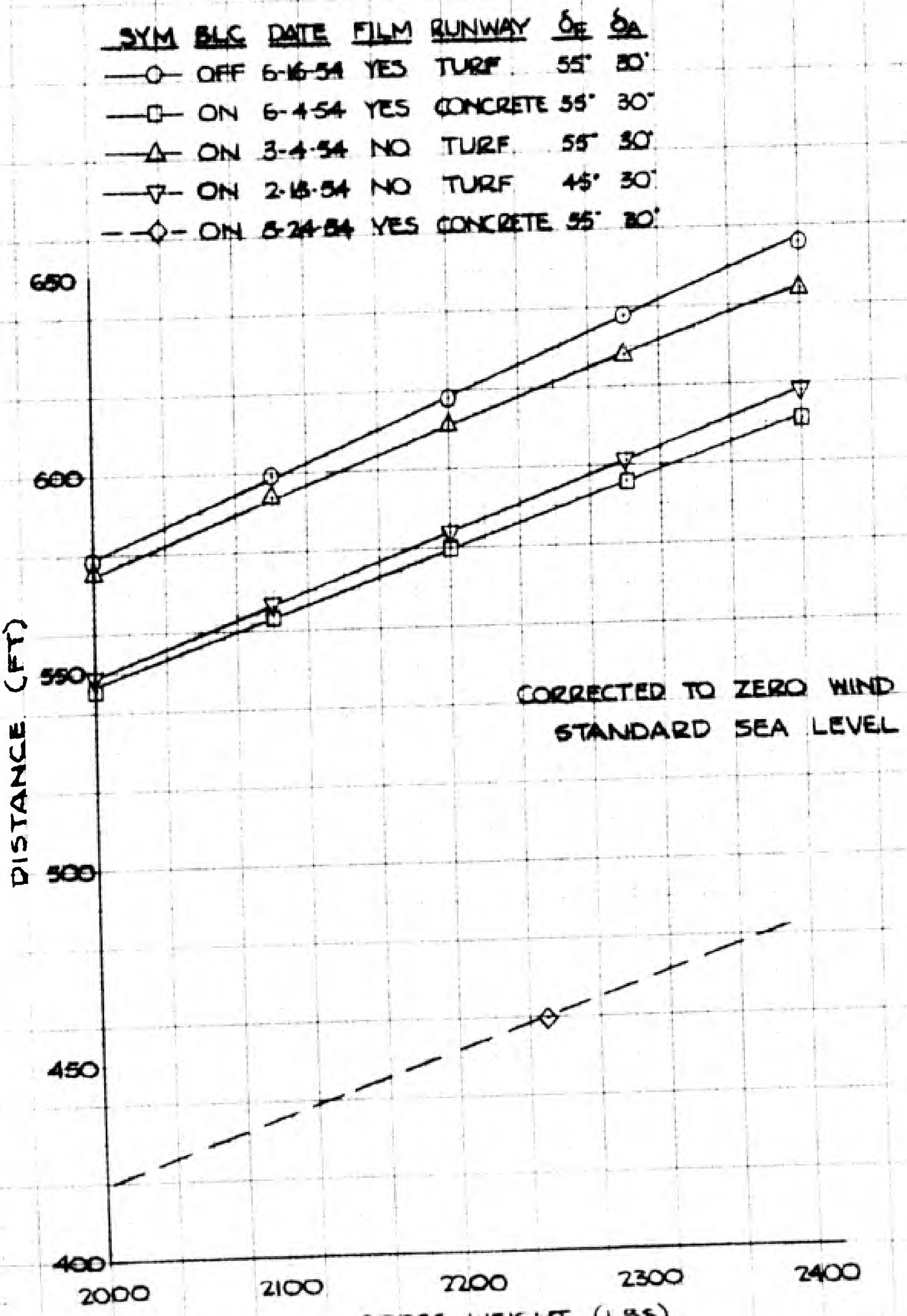
MODEL 319A

TOTAL LANDING DISTANCE OVER 50 FT OBSTACLE
VS
GROSS WEIGHT



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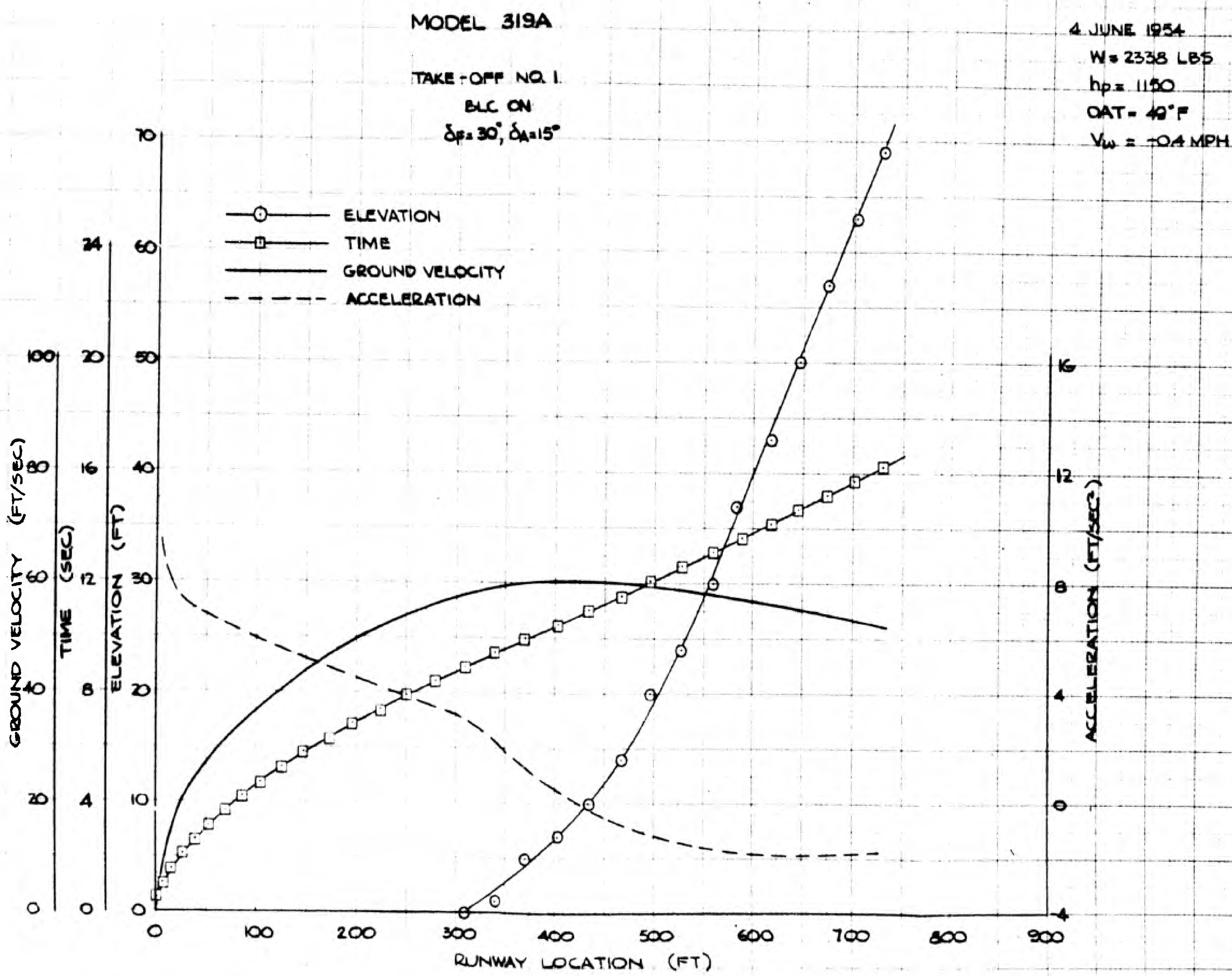
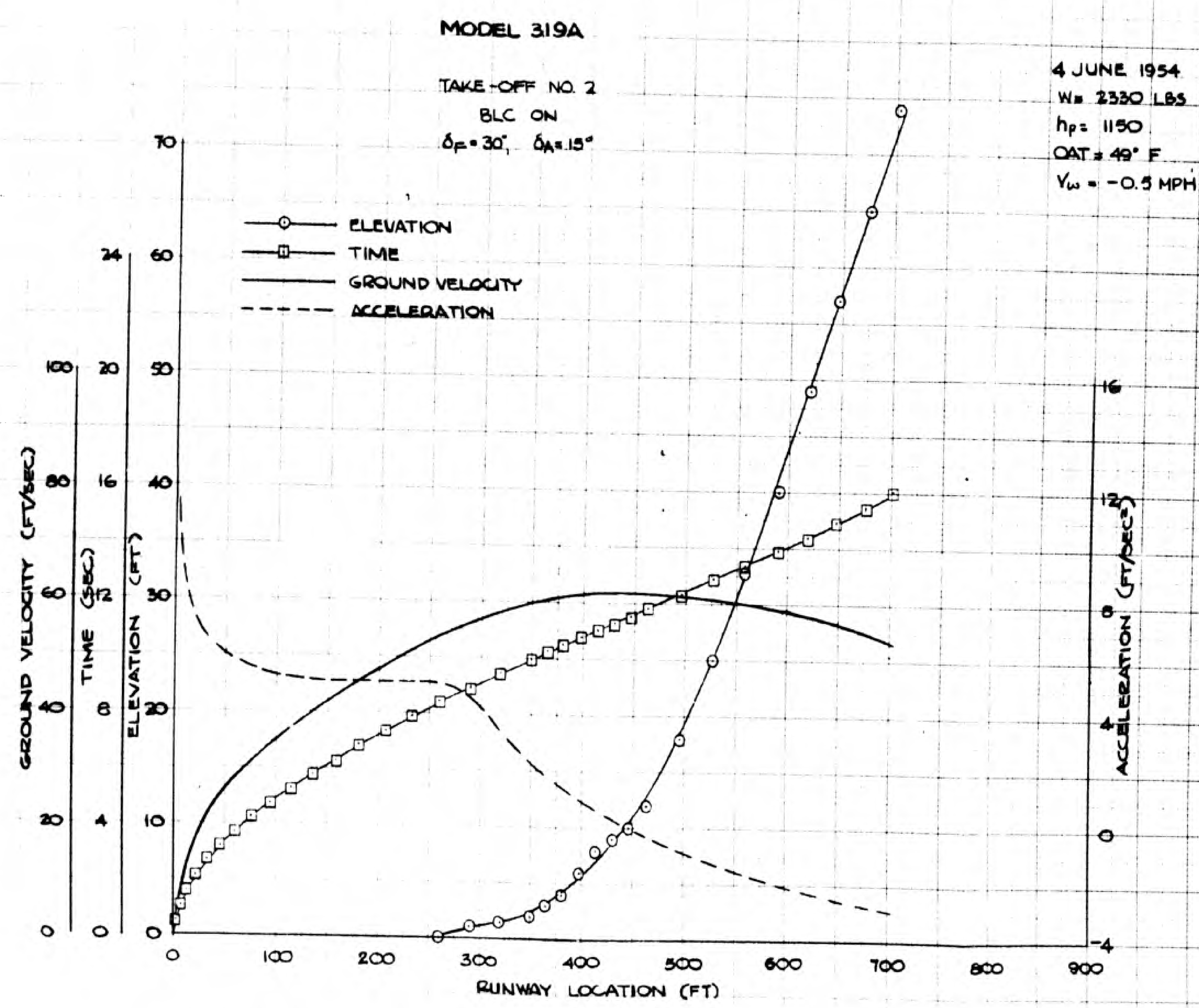

MODEL 319A
TAKE-OFF NO. 1
BLC ON
$\delta_F = 30°$, $\delta_A = 15°$
4 JUNE 1954
W = 2338 LBS
hp = 1150
OAT = 49°F
V_w = +0.4 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

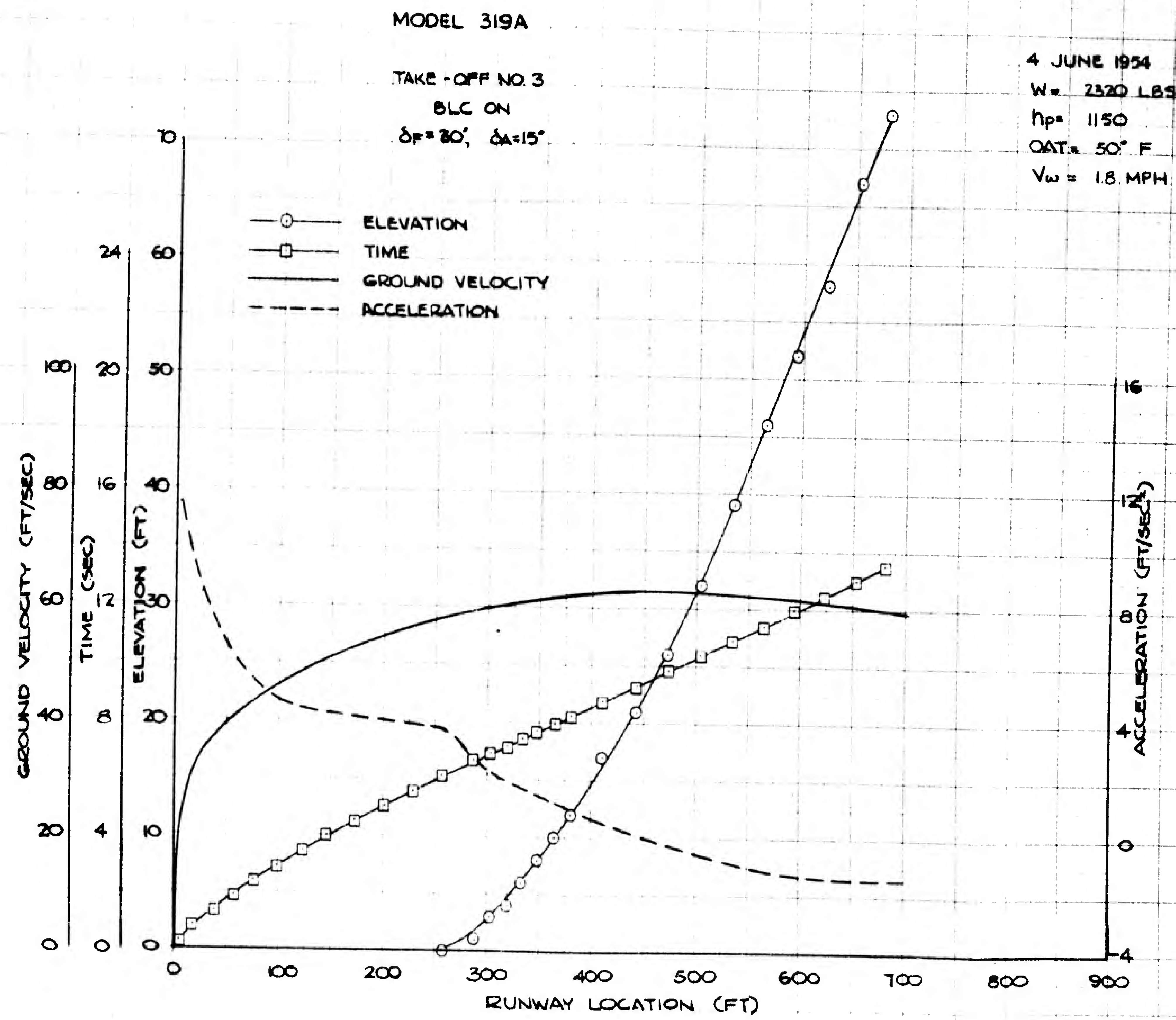
2-2-65

FIG. 9

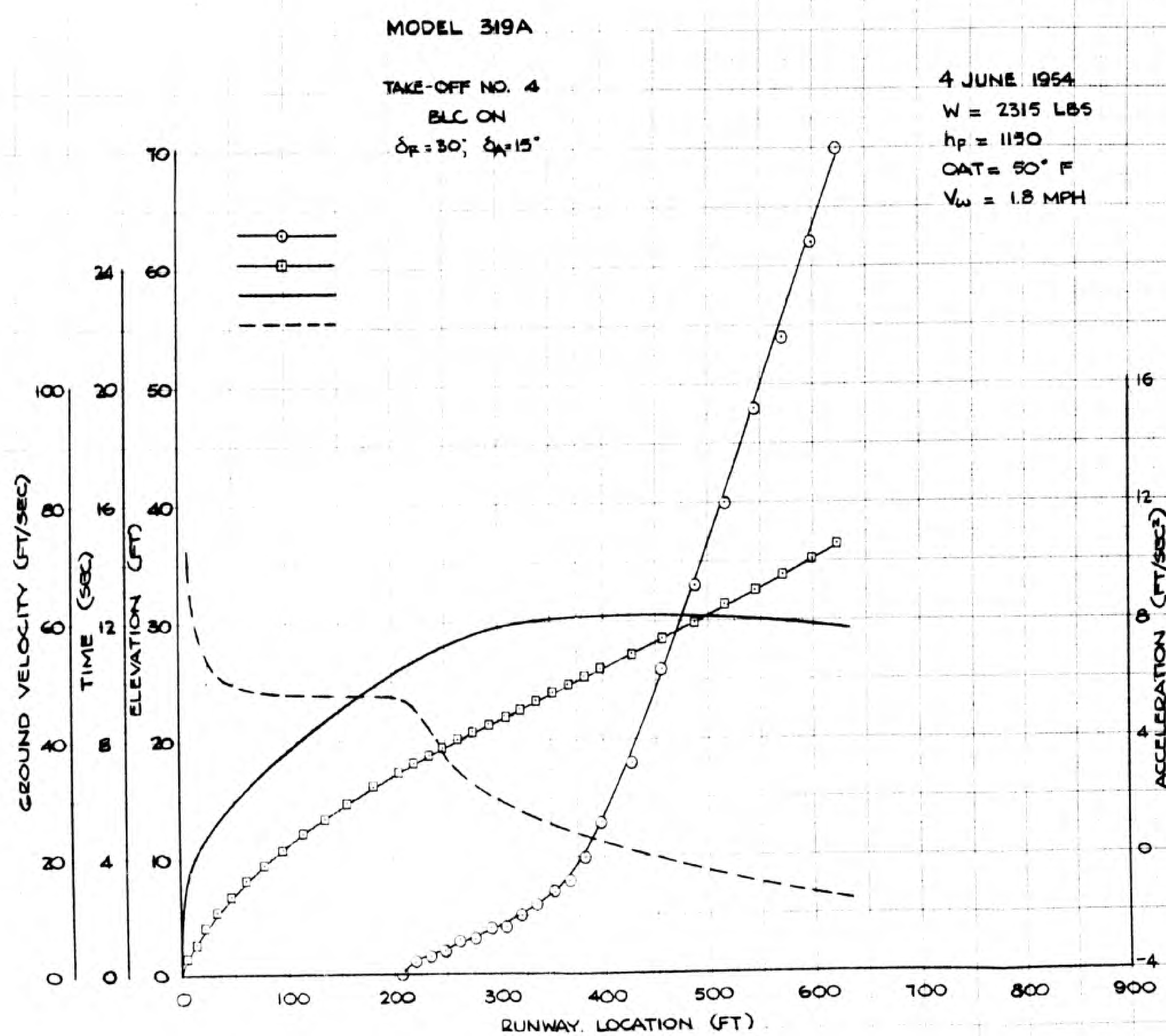

MODEL 319A
TAKE-OFF NO. 2
BLC ON
δF = 30°, δA = 15°
4 JUNE 1954
W = 2330 LBS
hp = 1150
OAT = 49° F
Vω = -0.5 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
10
20
30
40
50
60
70
4
8
12
16
24
-4

2-22-55

FIG. 10

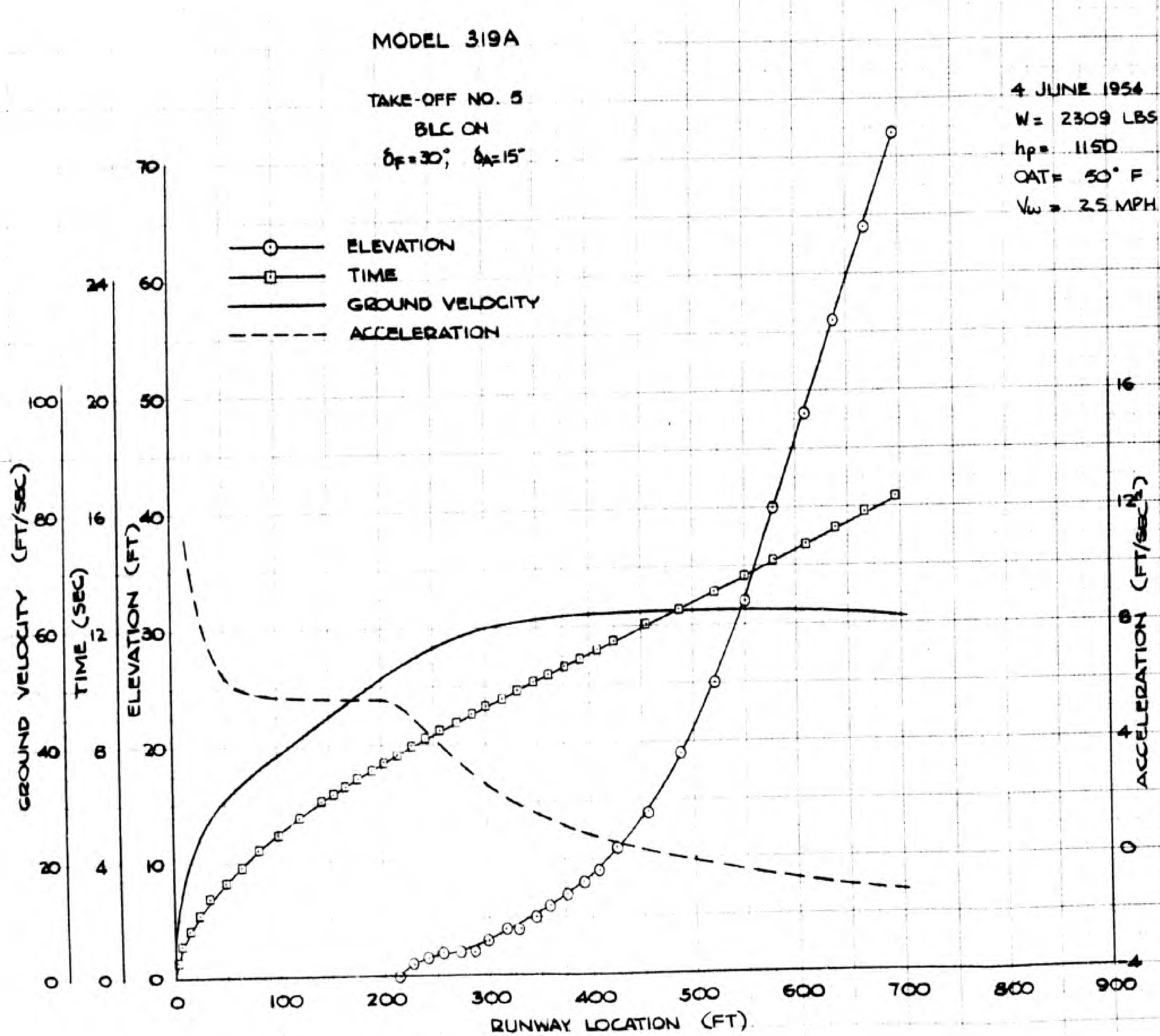

MODEL 319A
TAKE-OFF NO. 3
BLC ON
$\delta_F = 30°$, $\delta_A = 15°$
4 JUNE 1954
W = 2320 LBS
hp = 1150
OAT = 50° F
V_ω = 1.8 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
10
20
30
40
50
60
70
4
8
12
16
24
80
-4

2-23-55

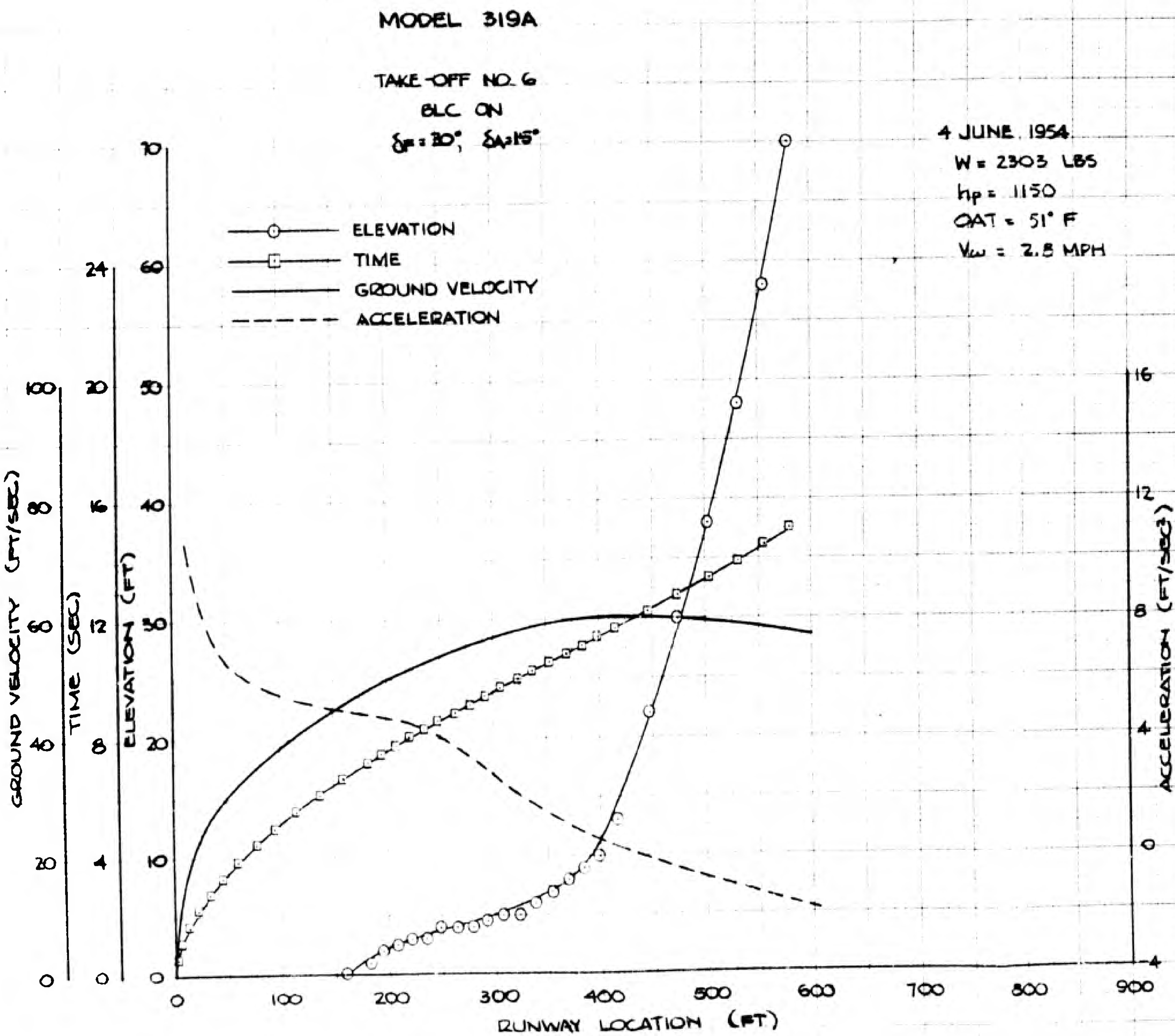

MODEL 319A
TAKE-OFF NO. 4
BLC ON
$\delta_F = 30°$; $\delta_A = 15°$
4 JUNE 1954
W = 2315 LBS
h_p = 1150
OAT = 50° F
V_w = 1.8 MPH
GROUND VELOCITY (FT/SEC)
0
20
40
60
80
100
TIME (SEC)
0
4
8
12
16
20
24
ELEVATION (FT)
0
10
20
30
40
50
60
70
ACCELERATION (FT/SEC²)
-4
0
4
8
12
16
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900

2-23-55

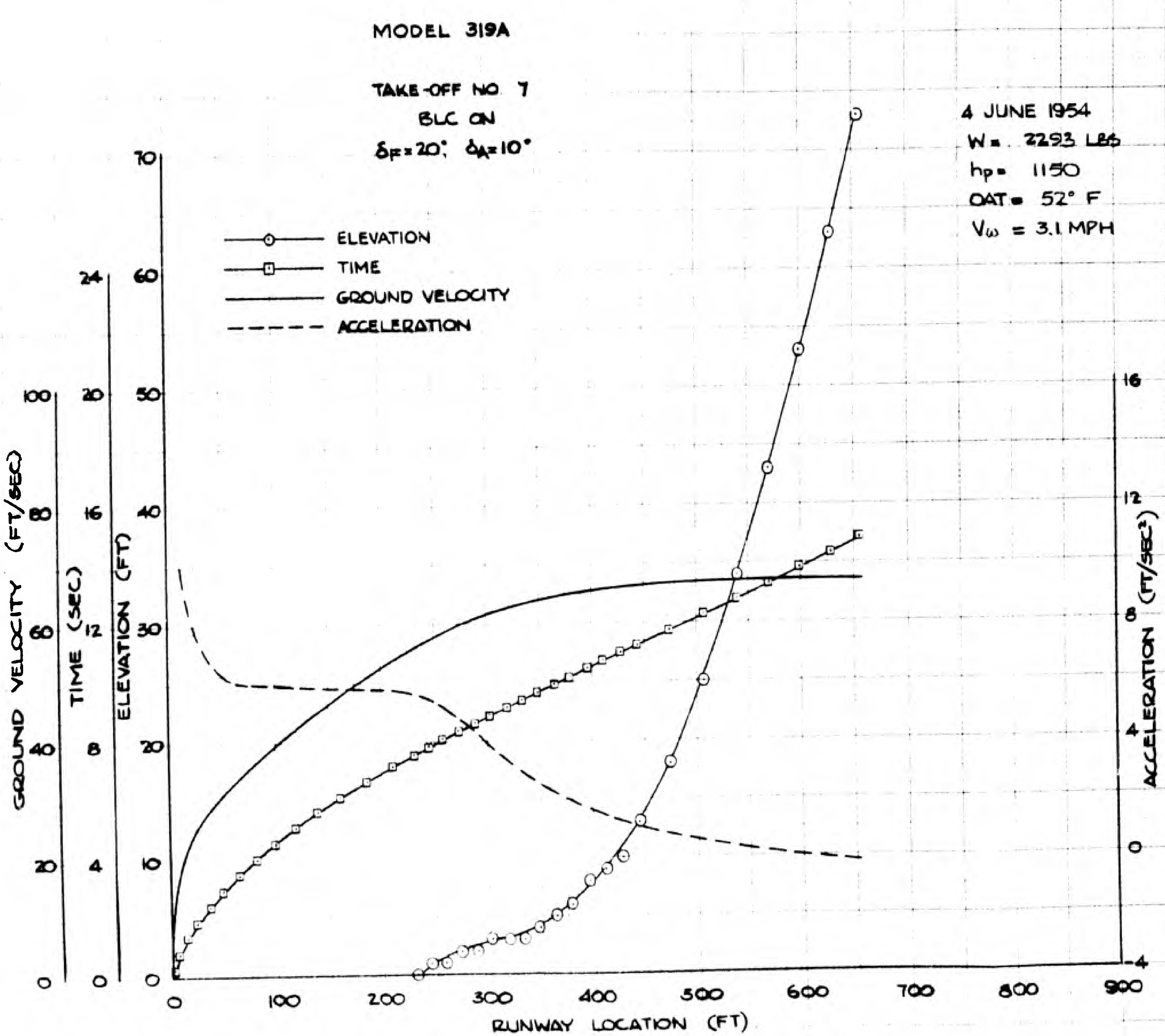
FIG. 12


MODEL 319A
TAKE-OFF NO. 5
BLC ON
$\delta_F = 30°$; $\delta_A = 15°$
4 JUNE 1954
W = 2309 LBS
hp = 1150
OAT = 50° F
V_w = 2.5 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

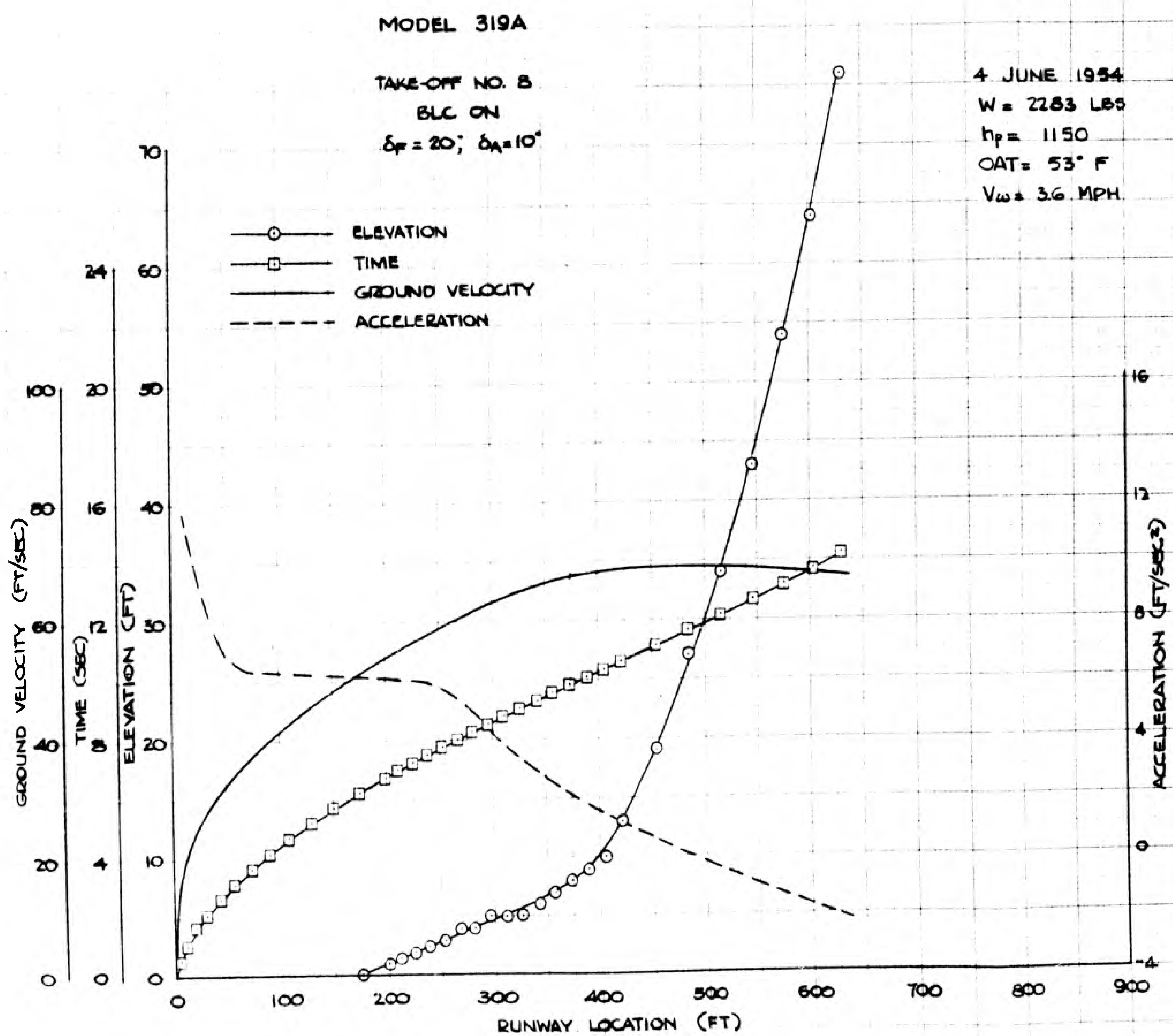
2-23-55


MODEL 319A
TAKE-OFF NO. 6
BLC ON
δF = 30°, δA = 15°
4 JUNE 1954
W = 2303 LBS
hp = 1150
OAT = 51° F
Vw = 2.8 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
0
20
40
60
80
100
TIME (SEC)
0
4
8
12
16
20
24
ELEVATION (FT)
0
10
20
30
40
50
60
70
ACCELERATION (FT/SEC²)
-4
0
4
8
12
16
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900

2-23-55
45


MODEL 319A
TAKE-OFF NO. 7
BLC ON
δF = 20°, δA = 10°
4 JUNE 1954
W = 2293 LBS
hp = 1150
OAT = 52° F
Vω = 3.1 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
10
20
30
40
50
60
70
4
8
12
16
20
24
-4

2-24-58


MODEL 319A
TAKE-OFF NO. 8
BLC ON
$\delta_F = 20$; $\delta_A = 10°$
4 JUNE 1954
W = 2283 LBS
h_p = 1150
OAT = 53° F
V_ω = 3.6 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
20
40
60
80
100
4
8
12
16
20
24
10
30
50
70
-4

2-24-55
K

FIG. 16

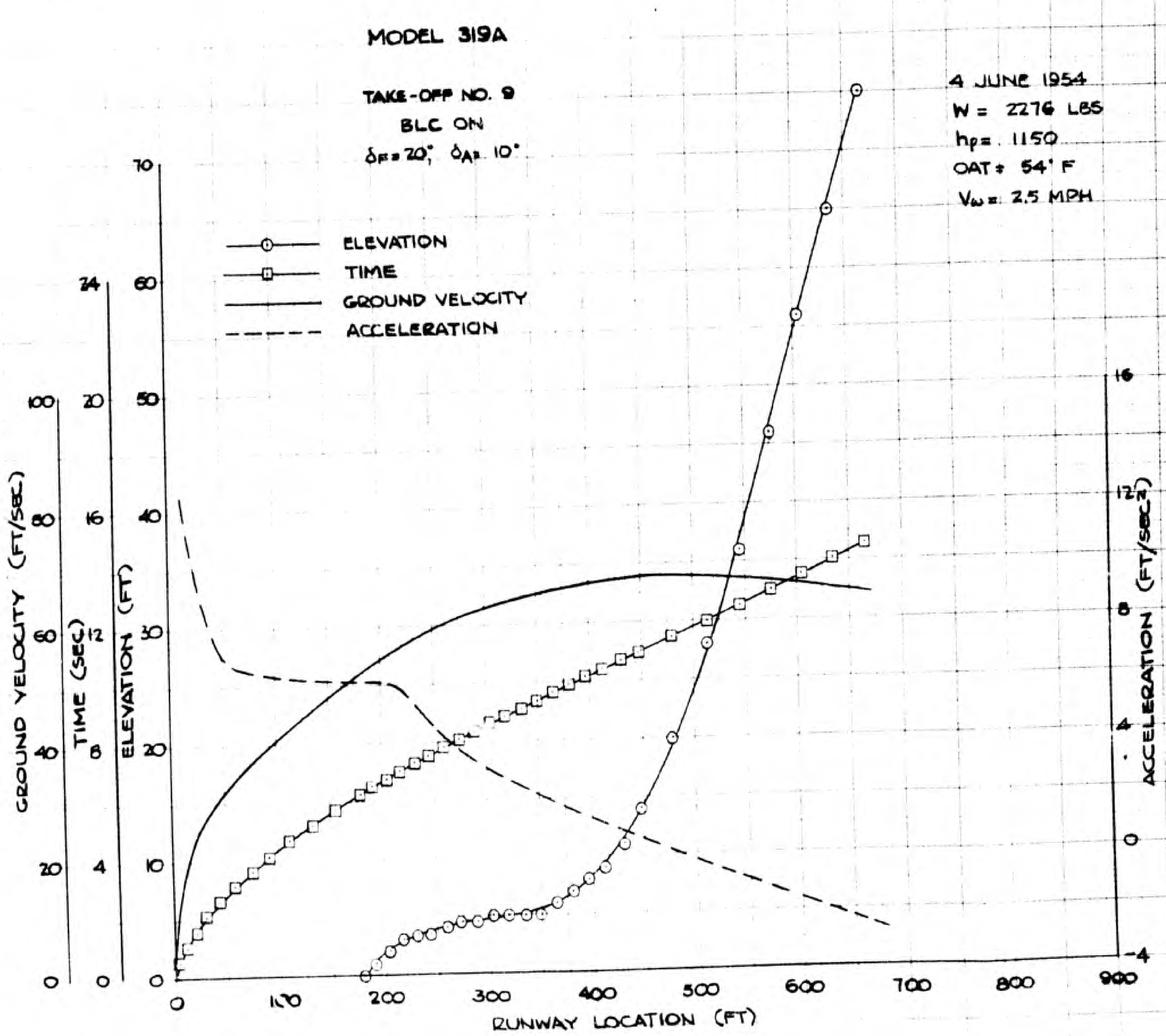
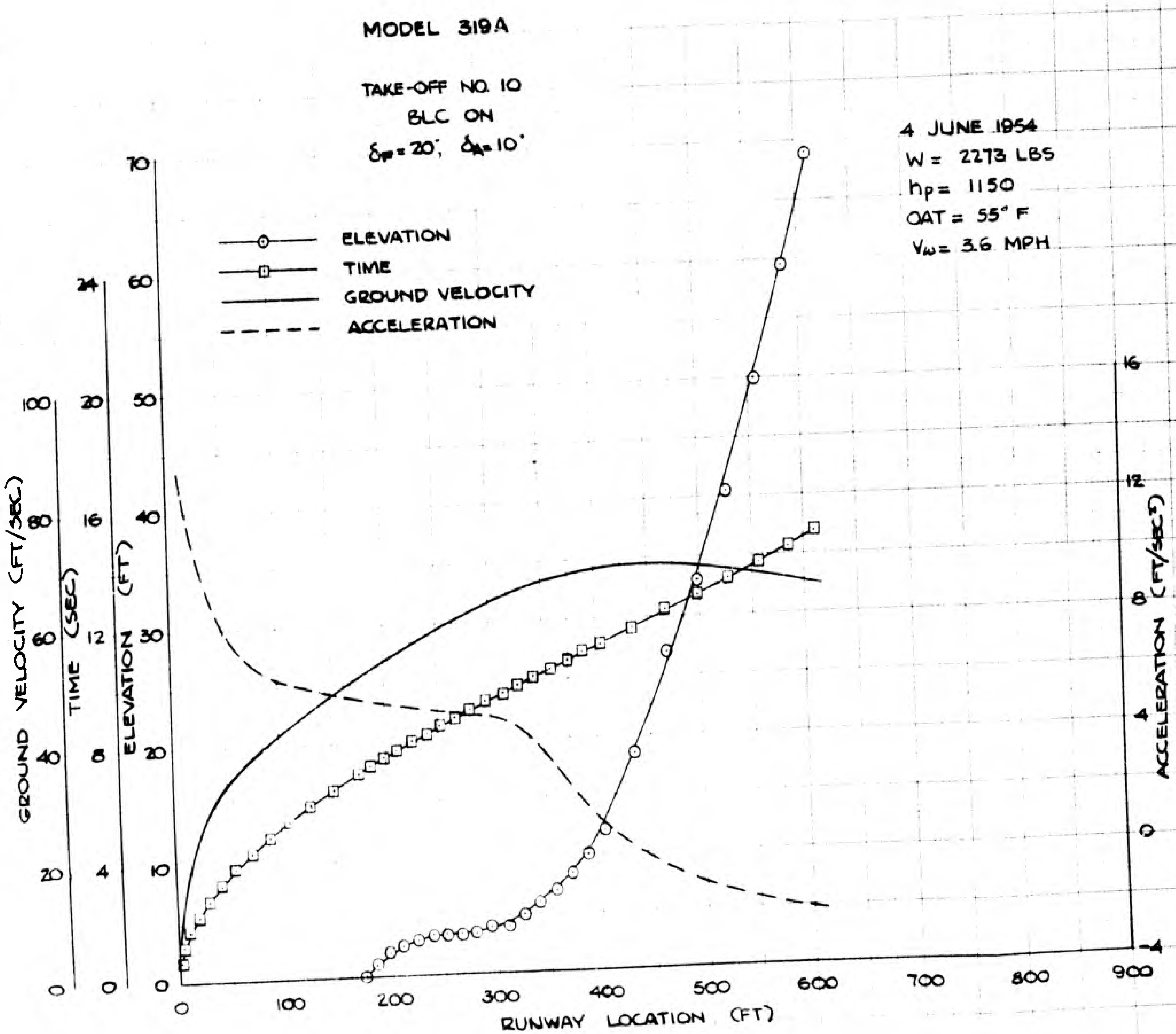

MODEL 319A
TAKE-OFF NO. 9
BLC ON
$\delta_F = 20°$; $\delta_A = 10°$
4 JUNE 1954
W = 2276 LBS
hp = 1150
OAT = 54° F
V_W = 2.5 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
10
20
30
40
50
60
70
4
8
12
16
20
24
80
100
-4
3-1-55

FIG. 17


MODEL 319A
TAKE-OFF NO. 10
BLC ON
δF = 20°, δA = 10°
4 JUNE 1954
W = 2273 LBS
hp = 1150
OAT = 55° F
Vw = 3.6 MPH
ELEVATION
TIME
GROUND VELOCITY
ACCELERATION
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
20
40
60
80
100
4
8
12
16
20
24
10
30
50
70
-4

3-1-55

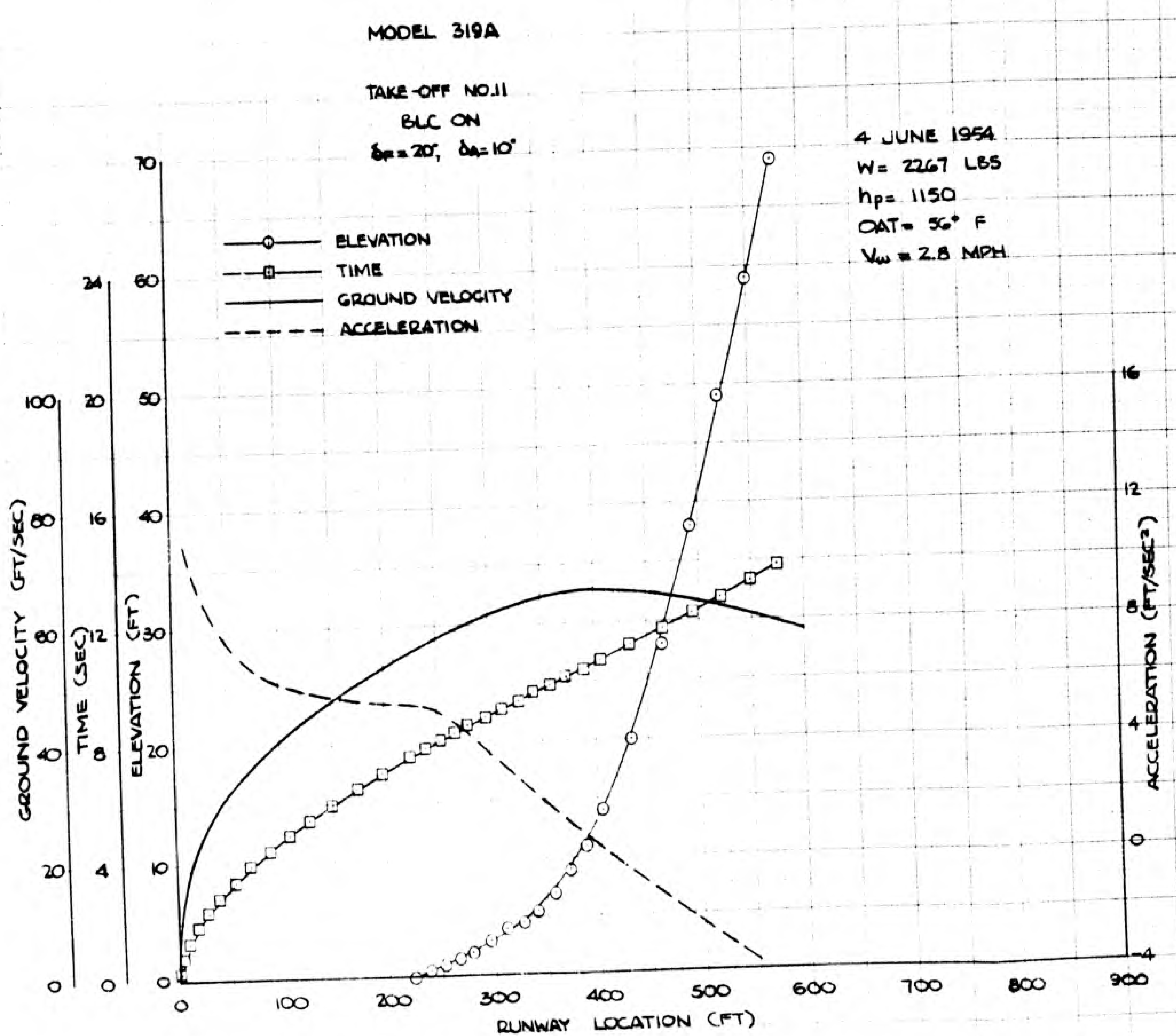
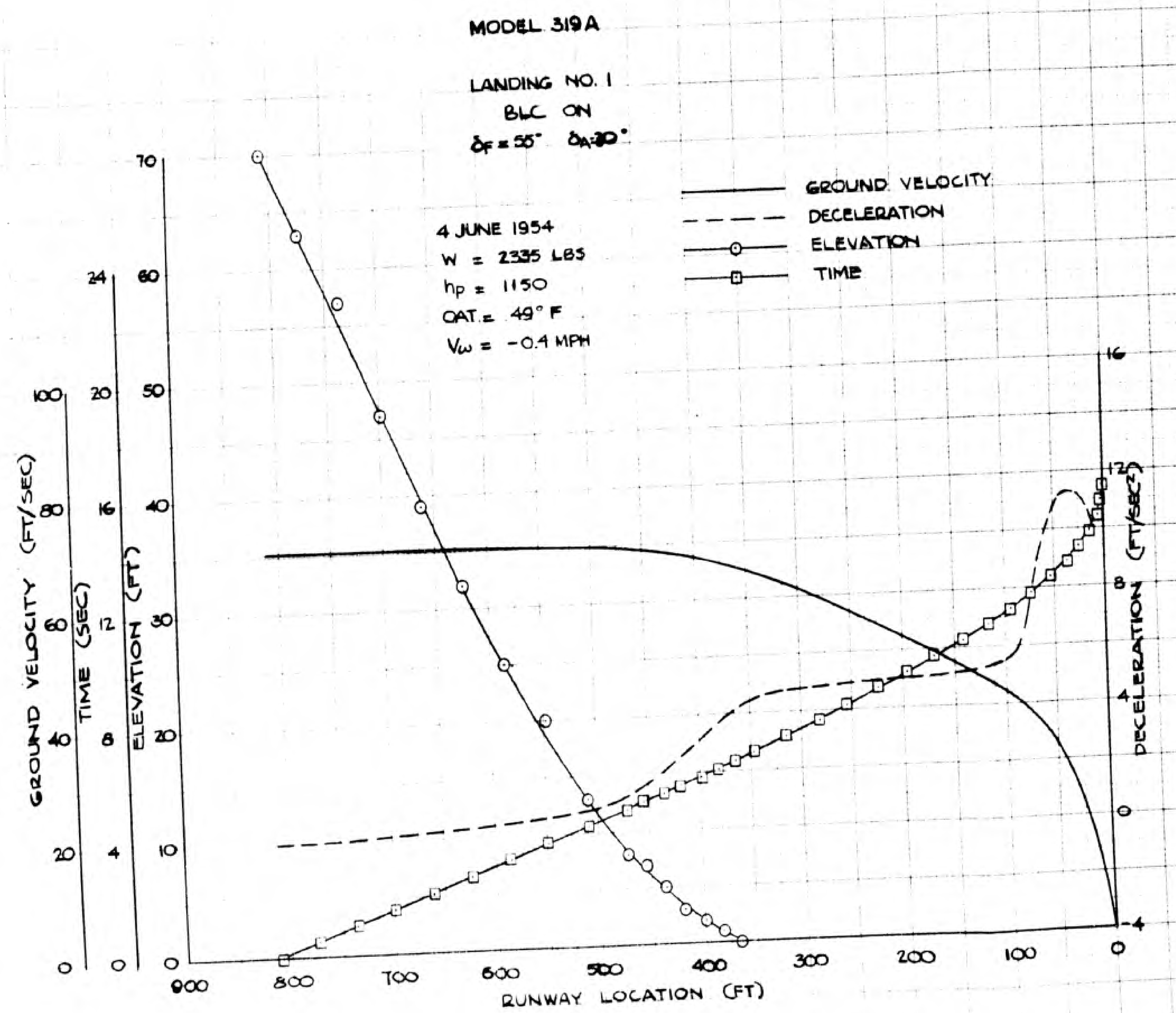


FIG. 18

3-1-55
4/6

FIG. 19


MODEL 319A
LANDING NO. 1
BLC ON
$\delta_F = 55°$ $\delta_A = 30°$
4 JUNE 1954
W = 2335 LBS
hp = 1150
OAT = 49° F
V_w = -0.4 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

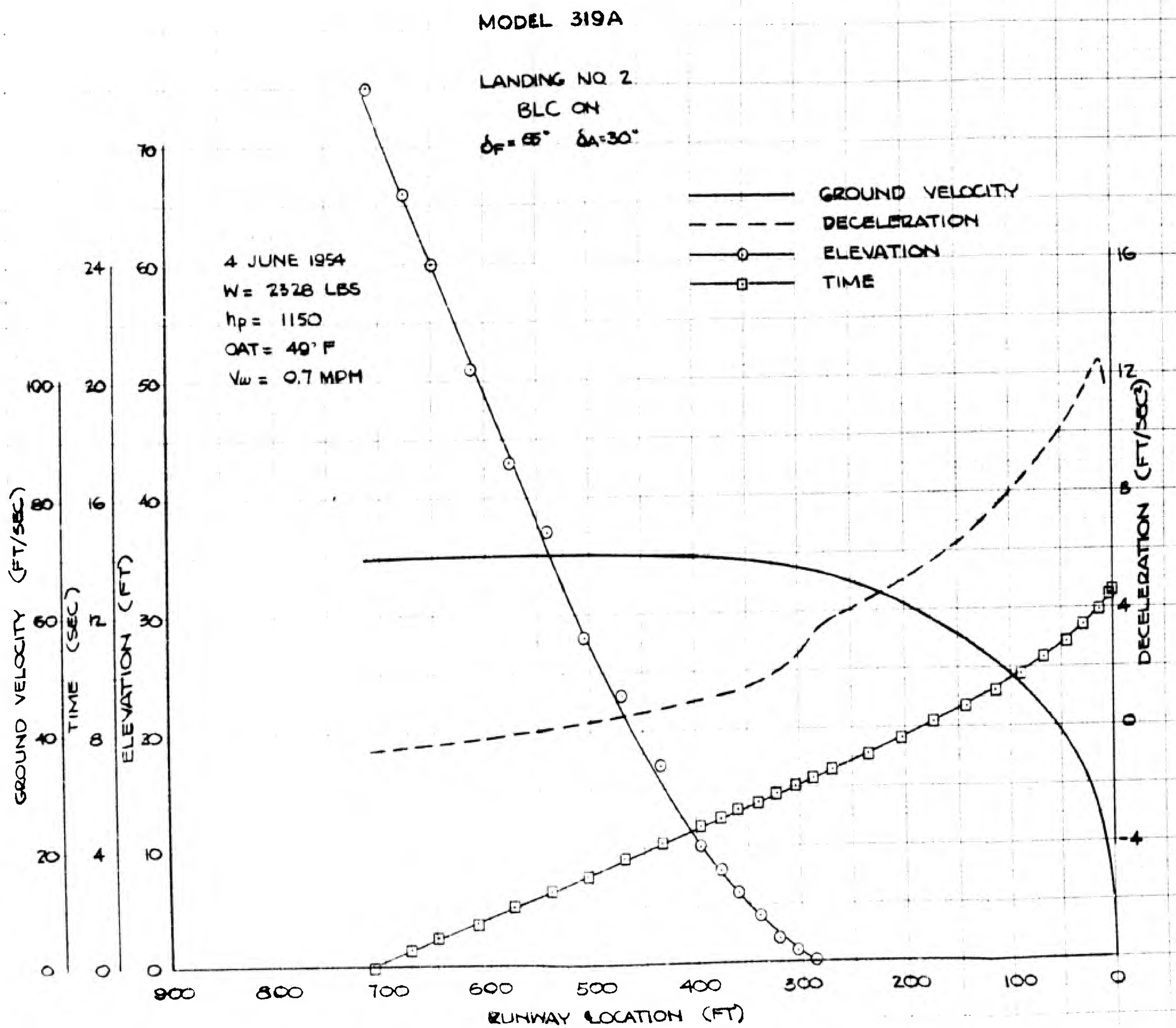
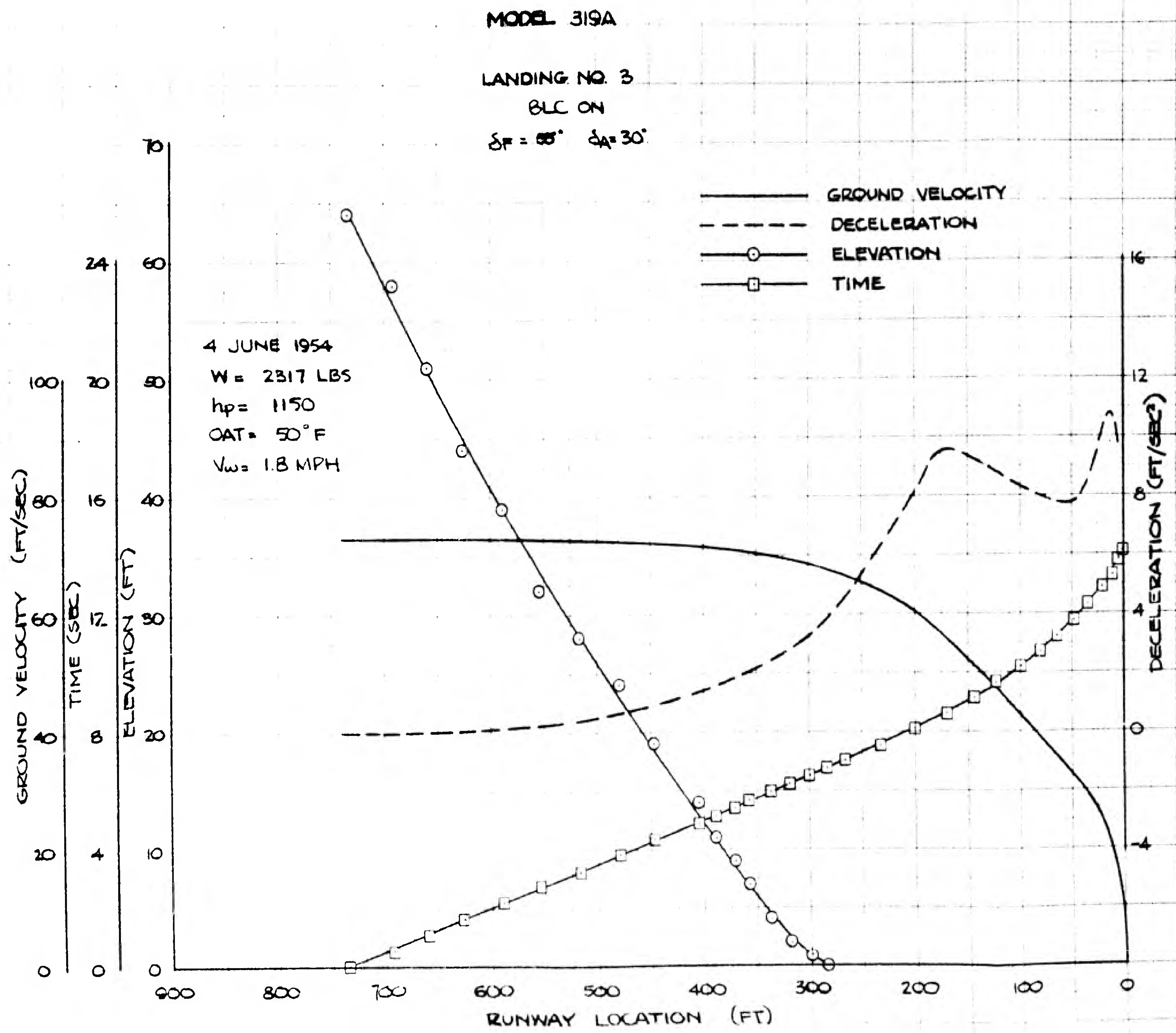

MODEL 319A
LANDING NO. 2
BLC ON
δ_F = 65° δ_A = 30°
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2328 LBS
hp = 1150
OAT = 40° F
Vw = 0.7 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0 20 40 60 80 100
0 4 8 12 16 20 24
0 10 20 30 40 50 60 70
-4 0 4 8 12 16
900 800 700 600 500 400 300 200 100 0

FIG. 20

3-2-55

CONFIDENTIAL

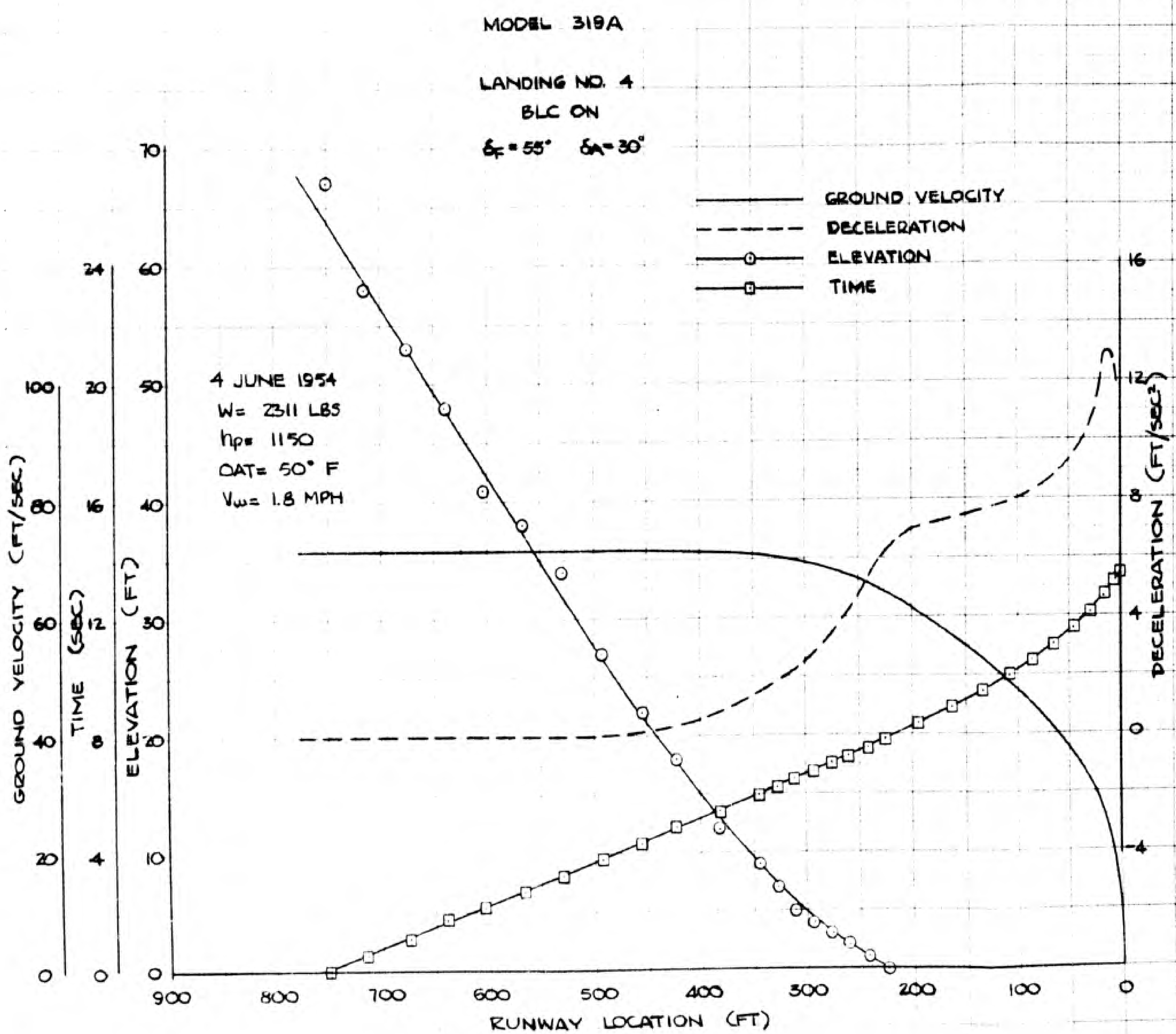
FIG. 21



3-3-55

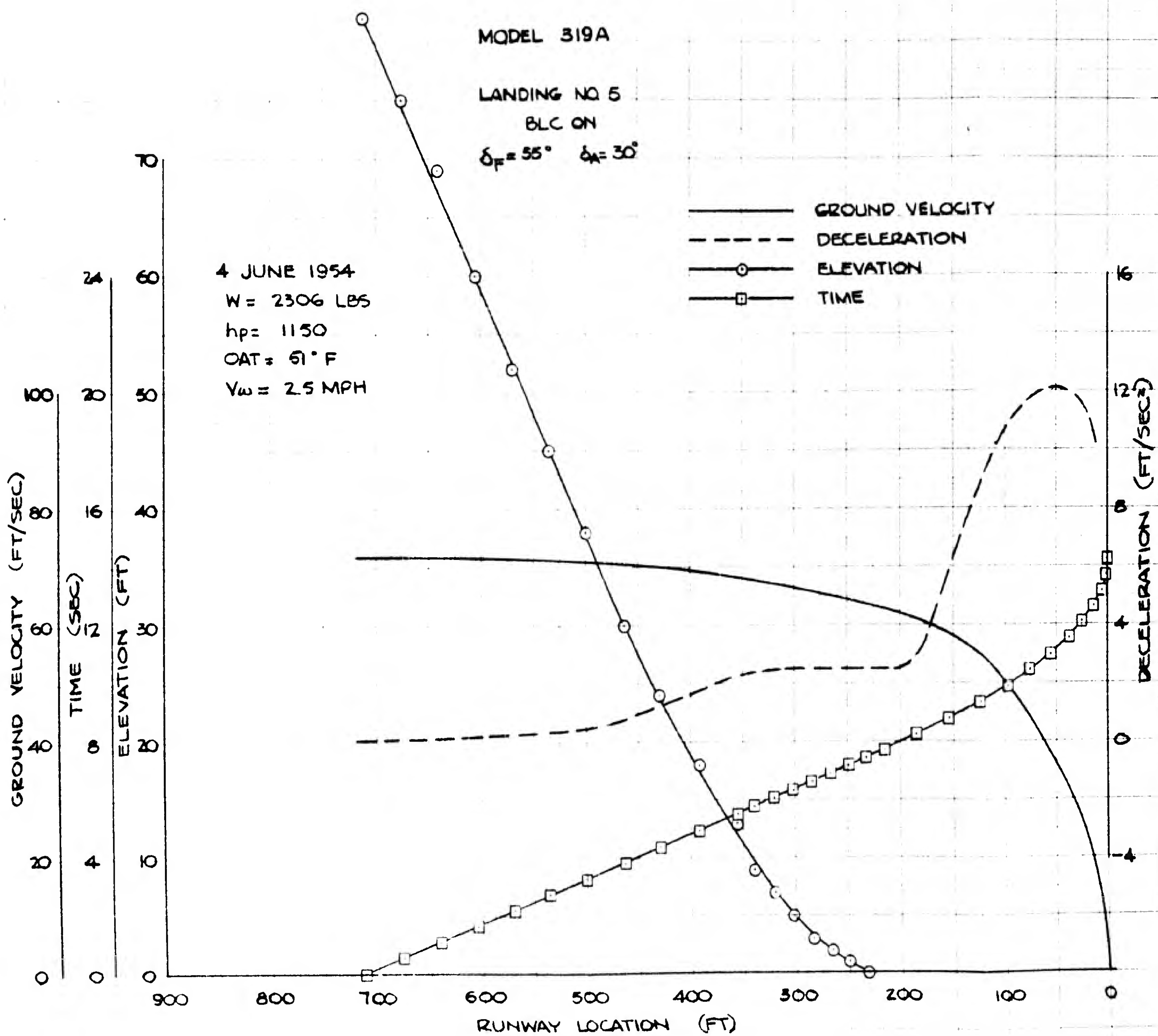
CONFIDENTIAL

FIG. 22


MODEL 319A
LANDING NO. 4
BLC ON
$\delta_F = 55°$ $\delta_A = 30°$
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W= 2311 LBS
hp= 1150
OAT= 50° F
Vw= 1.8 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
0
4
8
12
16
20
24
0
10
20
30
40
50
60
70
-4
0
4
8
12
16
900
800
700
600
500
400
300
200
100
0

CONFIDENTIAL

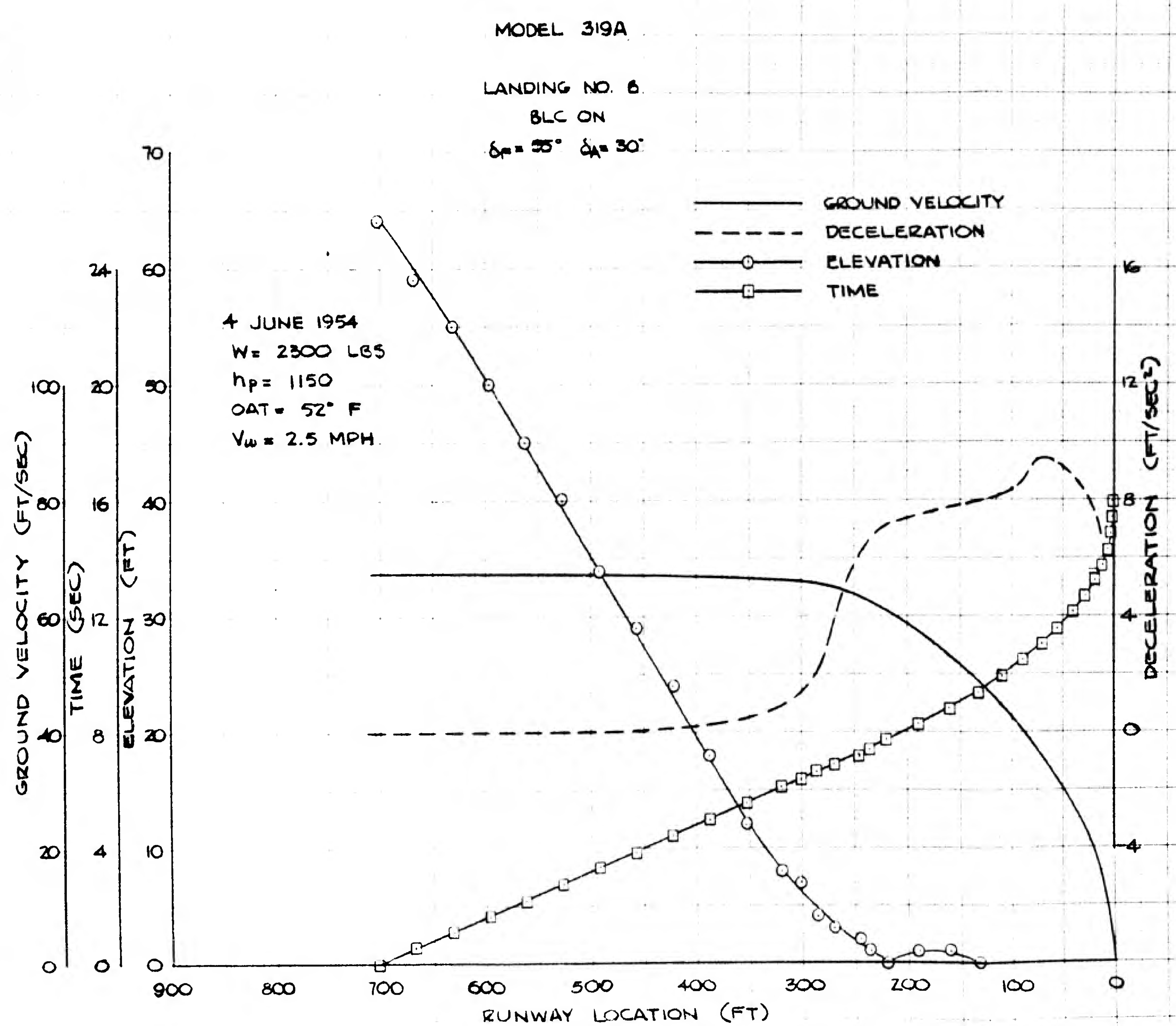
FIG. 23

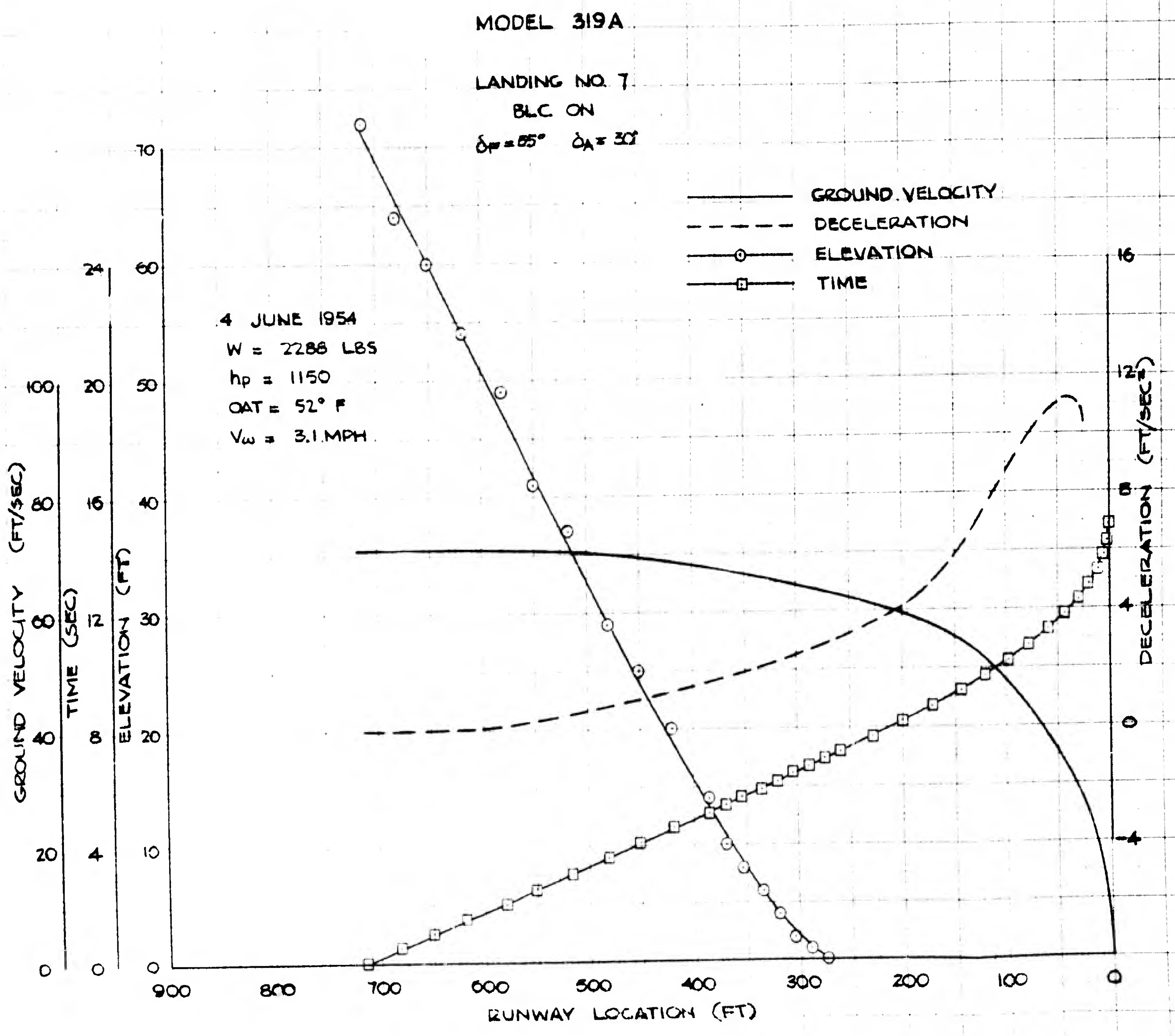


7345

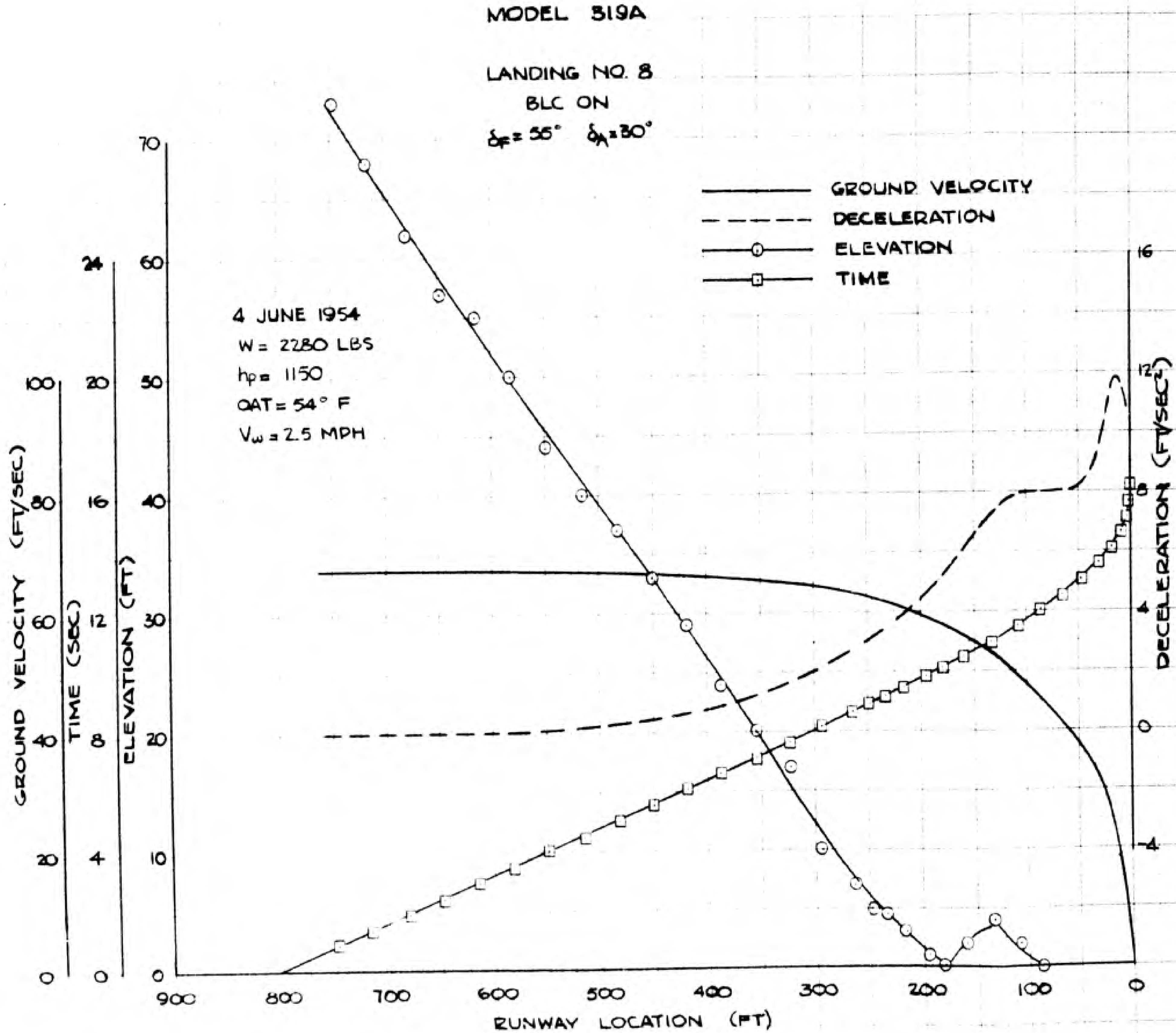
CONFIDENTIAL

FIG. 24

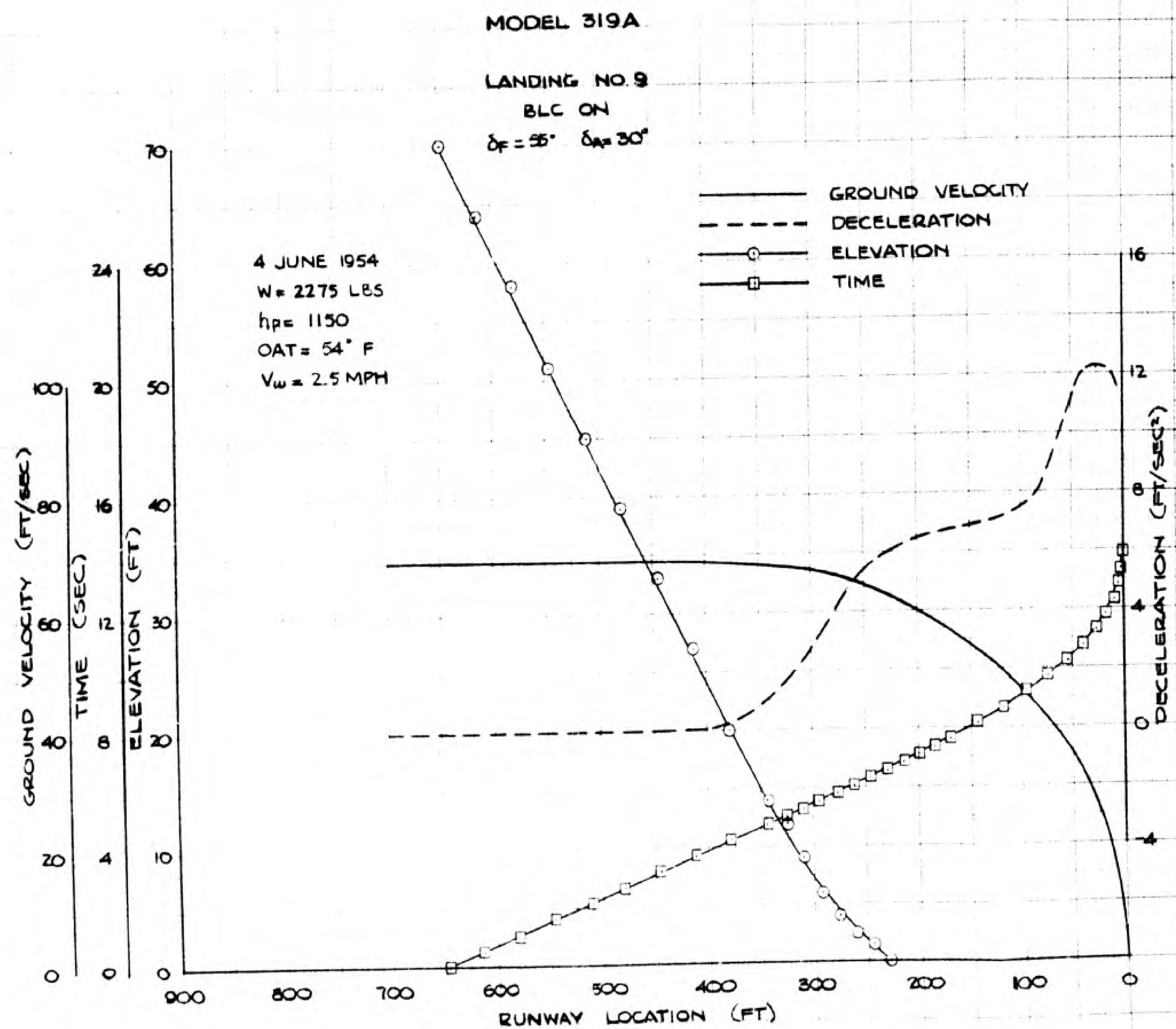

MODEL 319A
LANDING NO. 6
BLC ON
δF = 55° δA = 30°
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2300 LBS
hp = 1150
OAT = 52° F
Vw = 2.5 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
0
4
8
12
16
20
24
0
10
20
30
40
50
60
70
900
800
700
600
500
400
300
200
100
0
-4
0
4
8
12
16


MODEL 319A
LANDING NO. 7
BLC ON
δF = 85° δA = 30°
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2288 LBS
hp = 1150
OAT = 52° F
Vω = 3.1 MPH
GROUND VELOCITY (FT/SEC)
0
20
40
60
80
100
TIME (SEC)
0
4
8
12
16
20
24
ELEVATION (FT)
0
10
20
30
40
50
60
70
DECELERATION (FT/SEC²)
-4
0
4
8
12
16
RUNWAY LOCATION (FT)
900
800
700
600
500
400
300
200
100
0

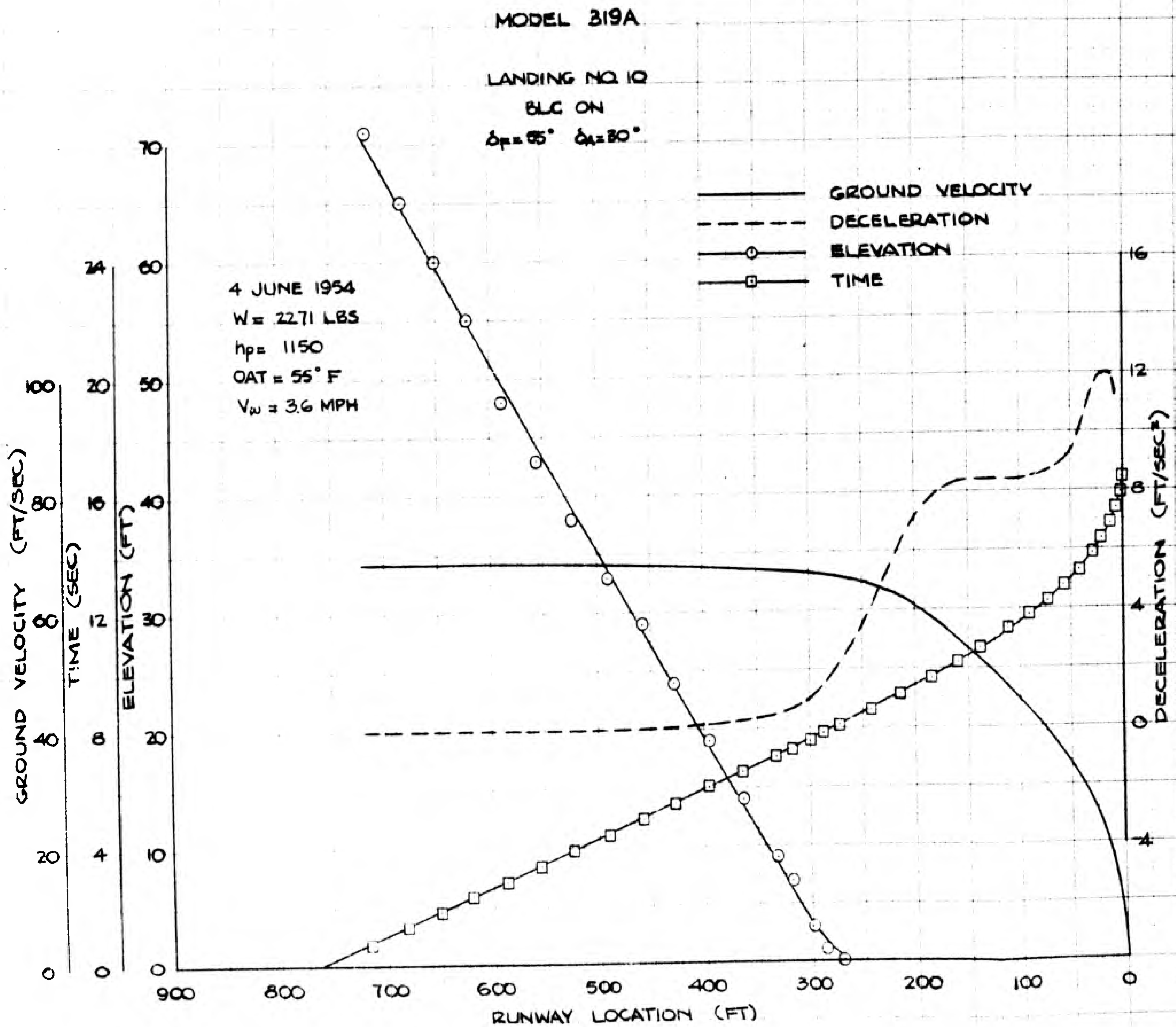
3455
#


MODEL 319A
LANDING NO. 8
BLC ON
δF = 55° δA = 30°
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2280 LBS
hp = 1150
OAT = 54° F
Vω = 2.5 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

3-7-55

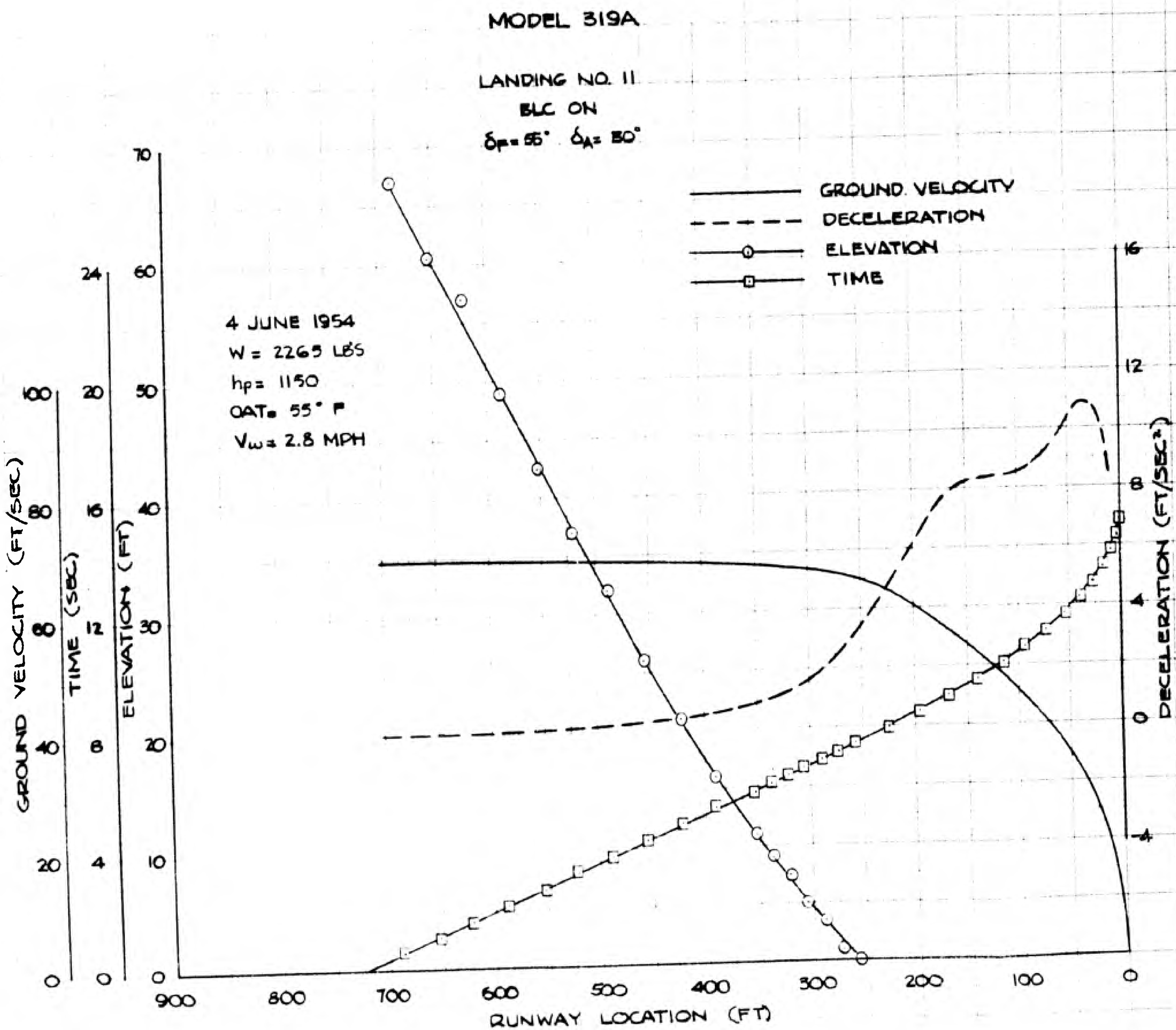

MODEL 319A
LANDING NO. 9
BLC ON
$\delta_F = 55°$ $\delta_A = 30°$
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2275 LBS
h_p = 1150
OAT = 54° F
V_w = 2.5 MPH
GROUND VELOCITY (FT/SEC)
0 20 40 60 80 100
TIME (SEC)
0 4 8 12 16 20 24
ELEVATION (FT)
0 10 20 30 40 50 60 70
DECELERATION (FT/SEC²)
-4 0 4 8 12 16
900 800 700 600 500 400 300 200 100 0
RUNWAY LOCATION (FT)

3-7-55
MG


MODEL 319A
LANDING NO. 10
BLC ON
$\delta_F = 55°$ $\delta_A = 30°$
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2271 LBS
hp = 1150
OAT = 55° F
V_w = 3.6 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

5-7-55

FIG. 29


MODEL 319A
LANDING NO. 11
BLC ON
δF = 55° δA = 30°
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
4 JUNE 1954
W = 2265 LBS
hp = 1150
OAT = 55° F
Vw = 2.8 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
4
8
12
16
24
10
30
50
70
-4
900
800
700
600
500
400
300
200
100

3-7-55

FIG. 30

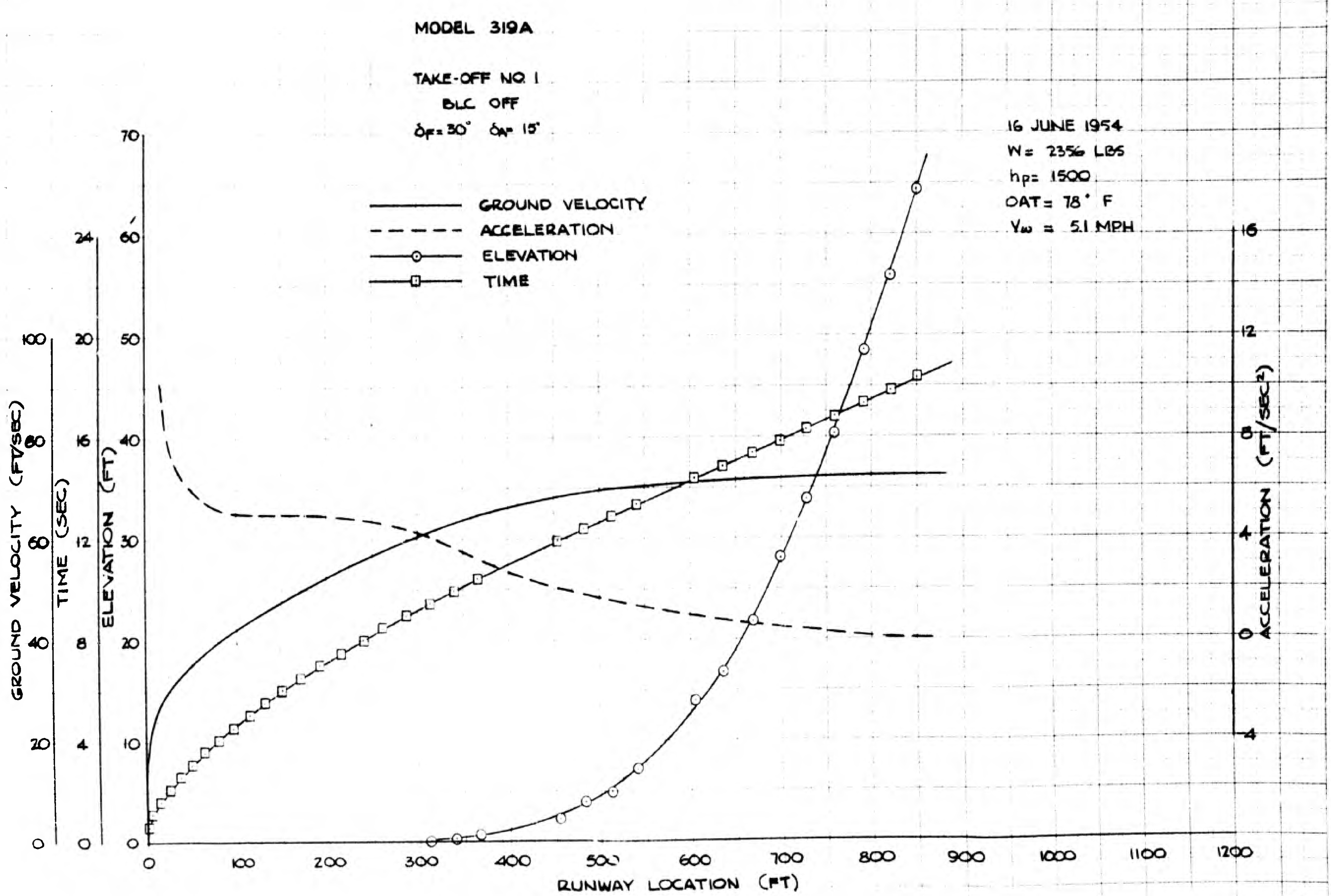

MODEL 319A
TAKE-OFF NO. 1
BLC OFF
$\delta_F = 30°$ $\delta_A = 15°$
16 JUNE 1954
W = 2356 LBS
hp = 1500
OAT = 78° F
V_w = 5.1 MPH
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
10
20
30
40
50
60
70
4
8
12
16
24
-4

FIG. 31

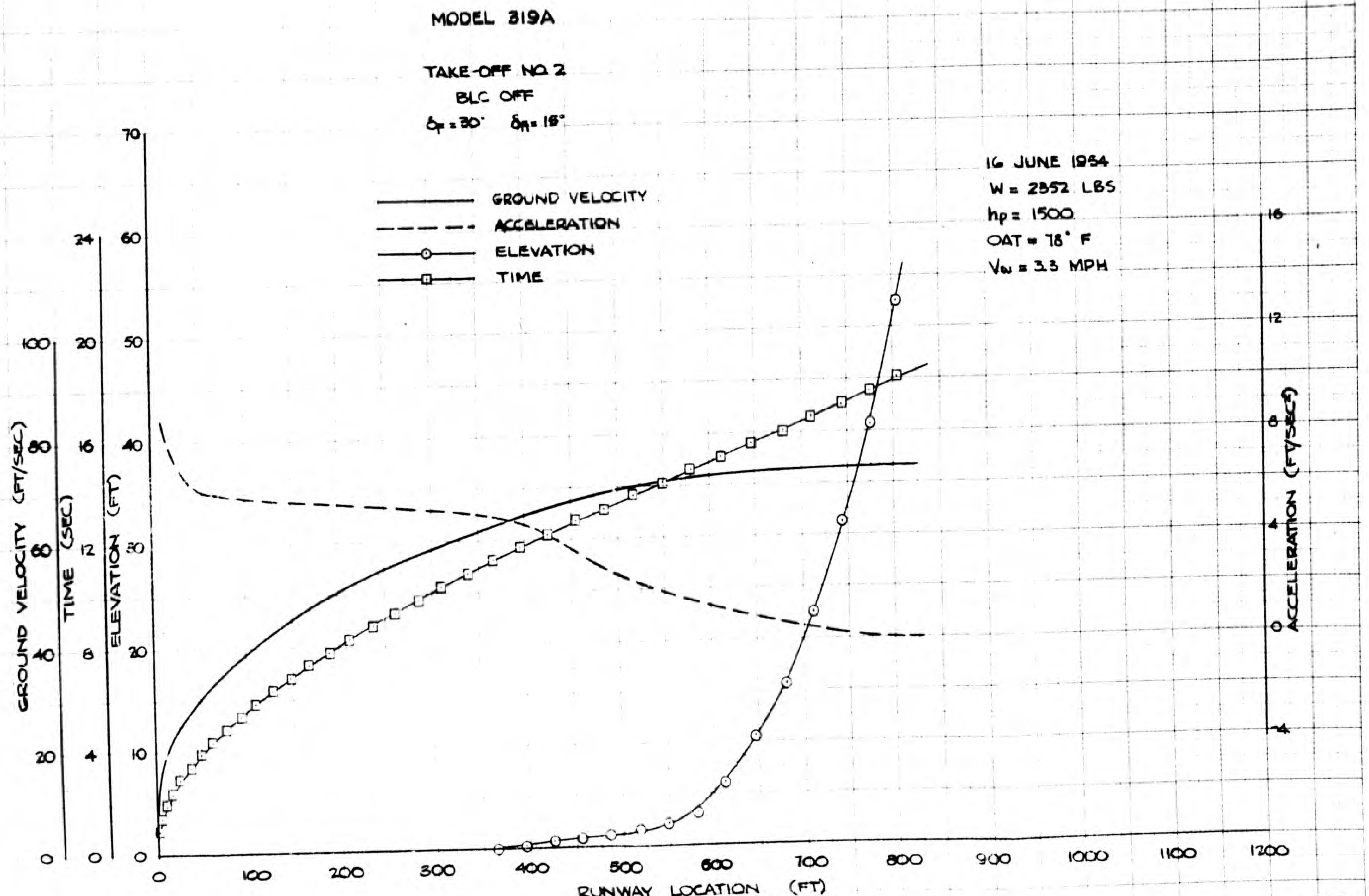

MODEL 319A
TAKE-OFF NO. 2
BLC OFF
$\delta_F = 30°$ $\delta_A = 15°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2352 LBS
hp = 1500
OAT = 78° F
V_W = 3.3 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

FIG. 32

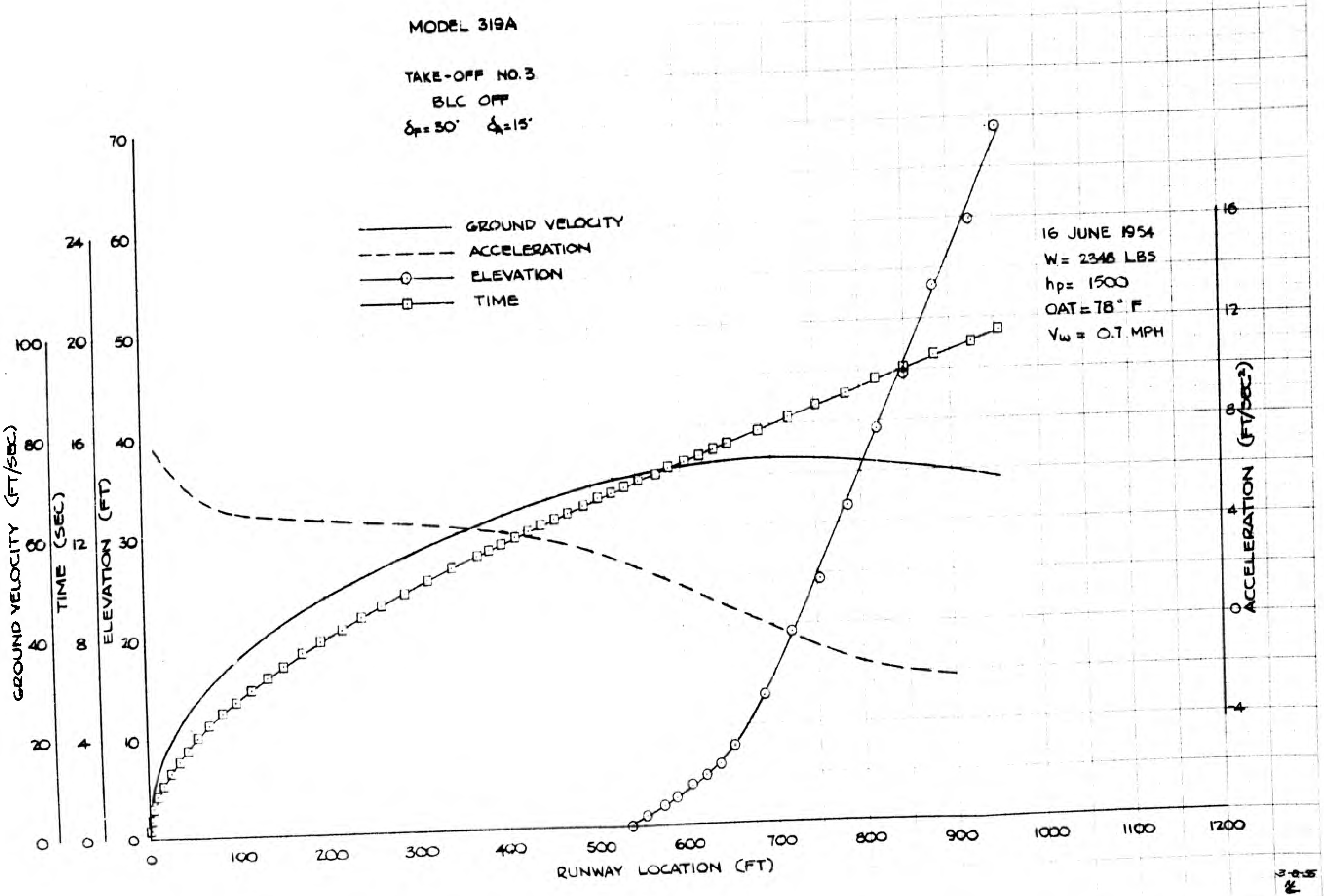
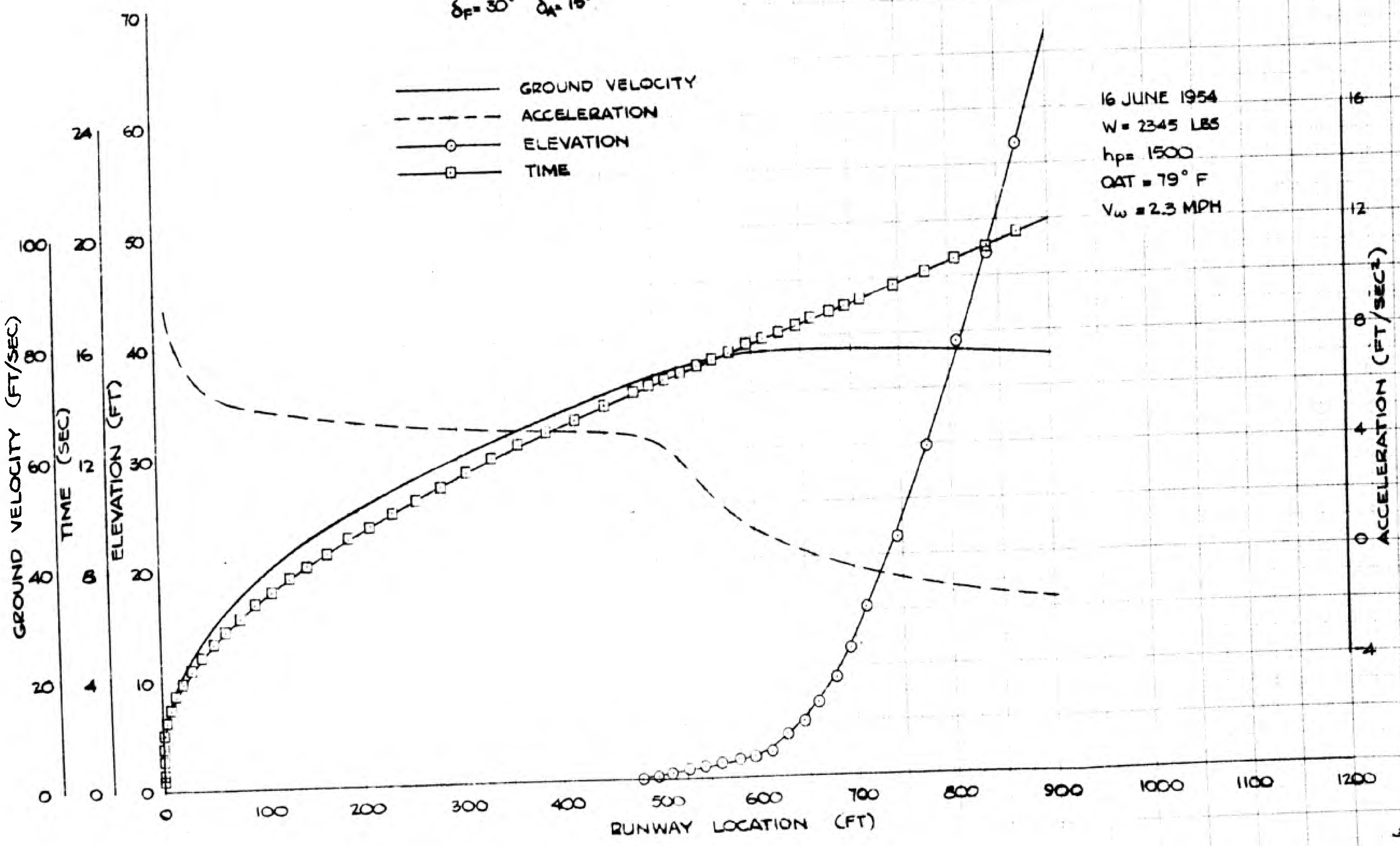

MODEL 319A
TAKE-OFF NO. 3
BLC OFF
δF = 30°   δA = 15°
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2348 LBS
hp = 1500
OAT = 78° F
Vw = 0.7 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
20
40
60
80
100
4
8
12
16
20
24
10
20
30
40
50
60
70
-4
0
4
8
12
16

FIG. 83


MODEL 319A
TAKE-OFF NO. 4
BLC OFF
$\delta_F = 30°$ $\delta_A = 15°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2345 LBS
hp = 1500
OAT = 79° F
V_ω = 2.3 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

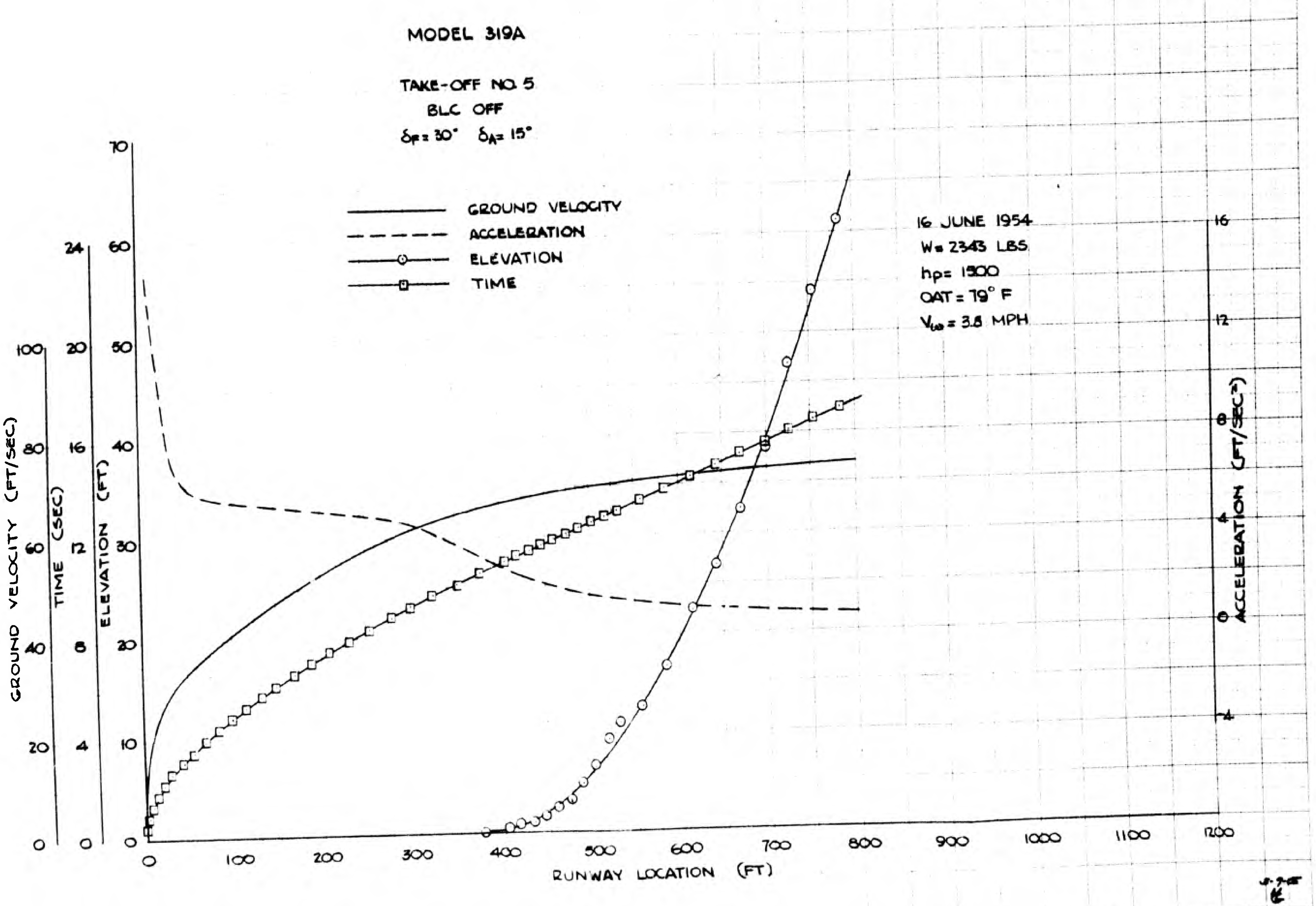
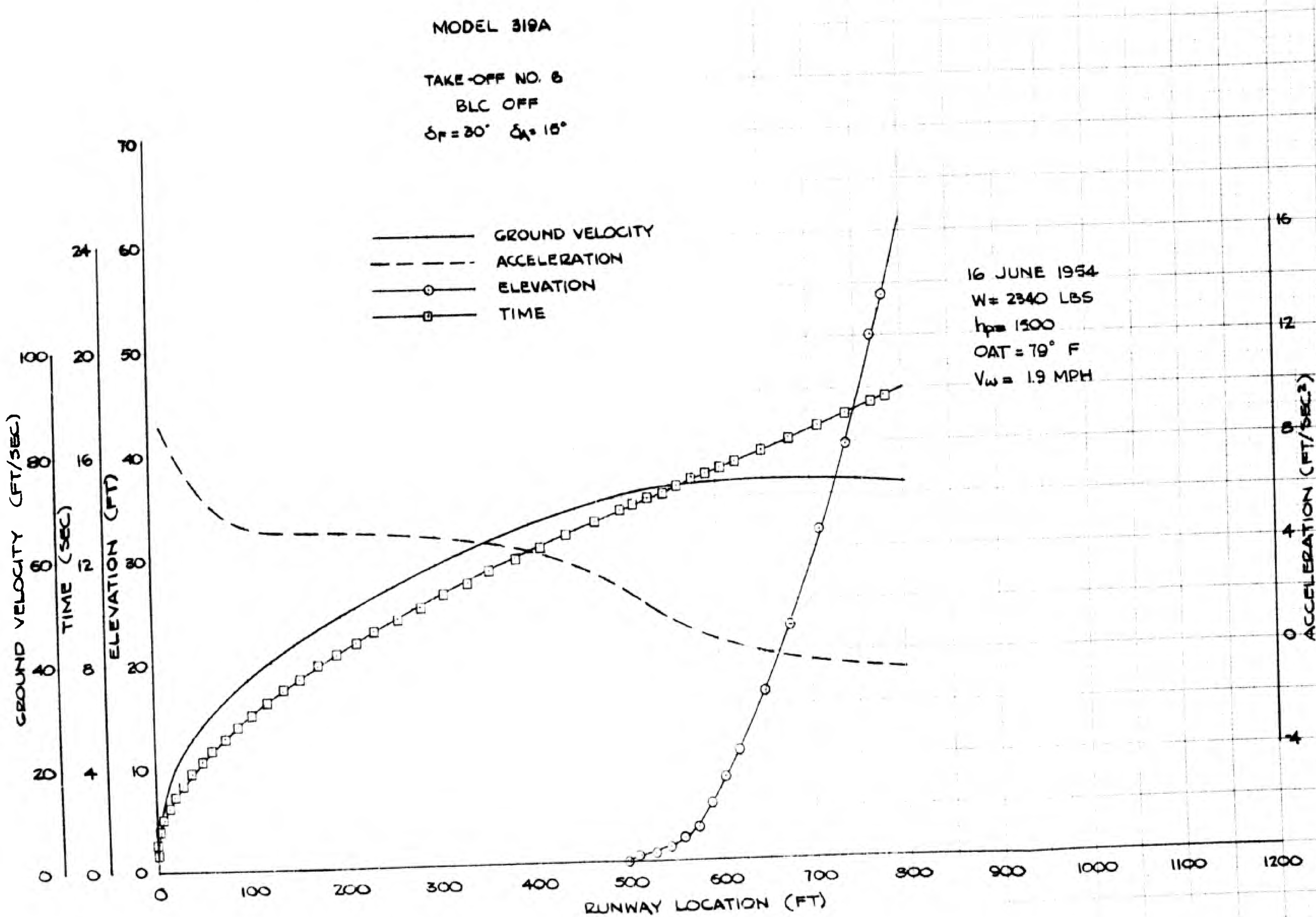

MODEL 319A
TAKE-OFF NO. 5
BLC OFF
$\delta_F = 30°$ $\delta_A = 15°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2343 LBS
hp = 1500
OAT = 79° F
V_W = 3.8 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

FIG. 55


MODEL 319A
TAKE-OFF NO. 6
BLC OFF
$\delta_F = 30°$ $\delta_A = 15°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2340 LBS
h_p = 1500
OAT = 79° F
V_w = 1.9 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

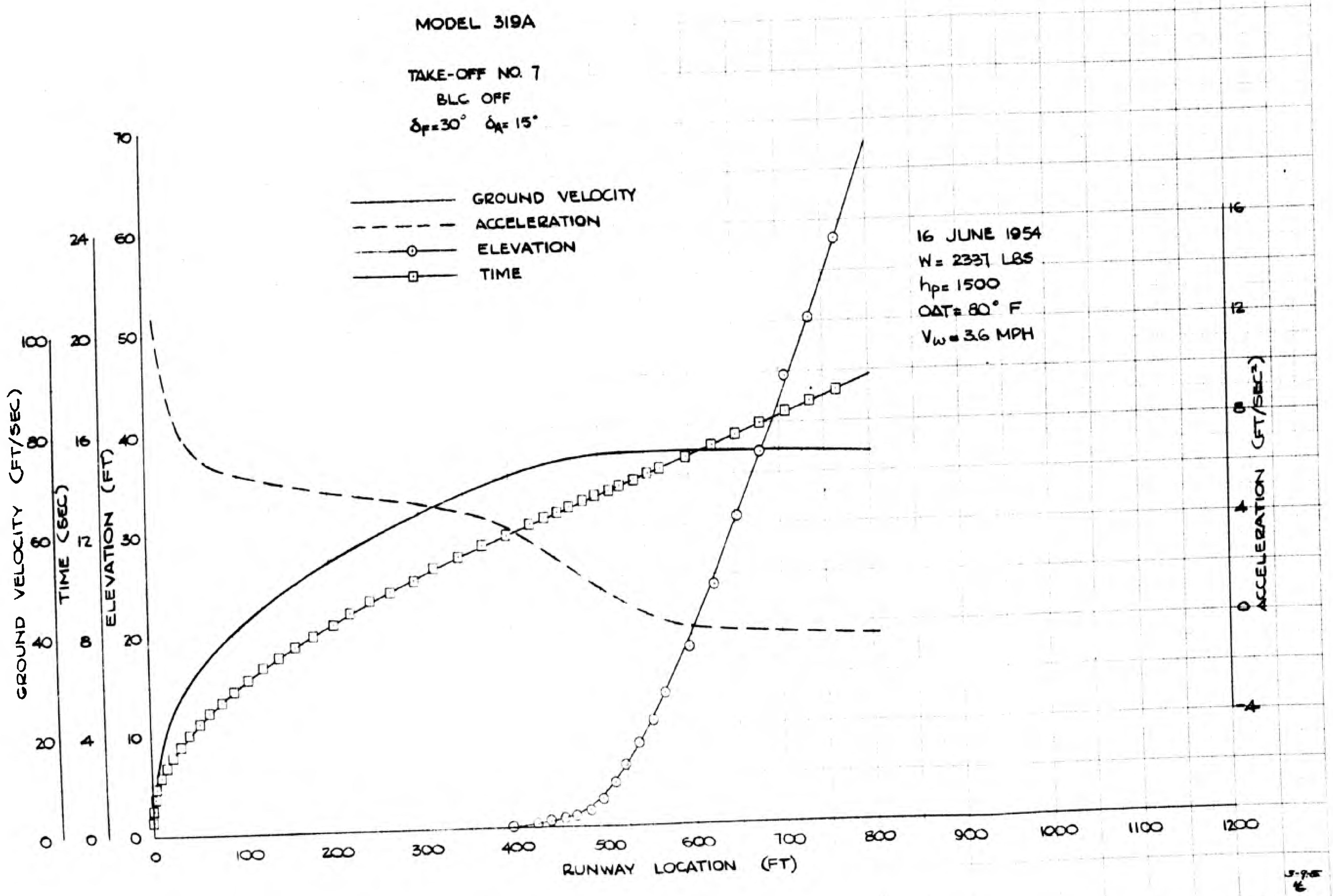

MODEL 319A
TAKE-OFF NO. 7
BLC OFF
$\delta_F = 30°$ $\delta_A = 15°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2337 LBS
h_p = 1500
OAT = 80° F
V_W = 3.6 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

FIG. 37

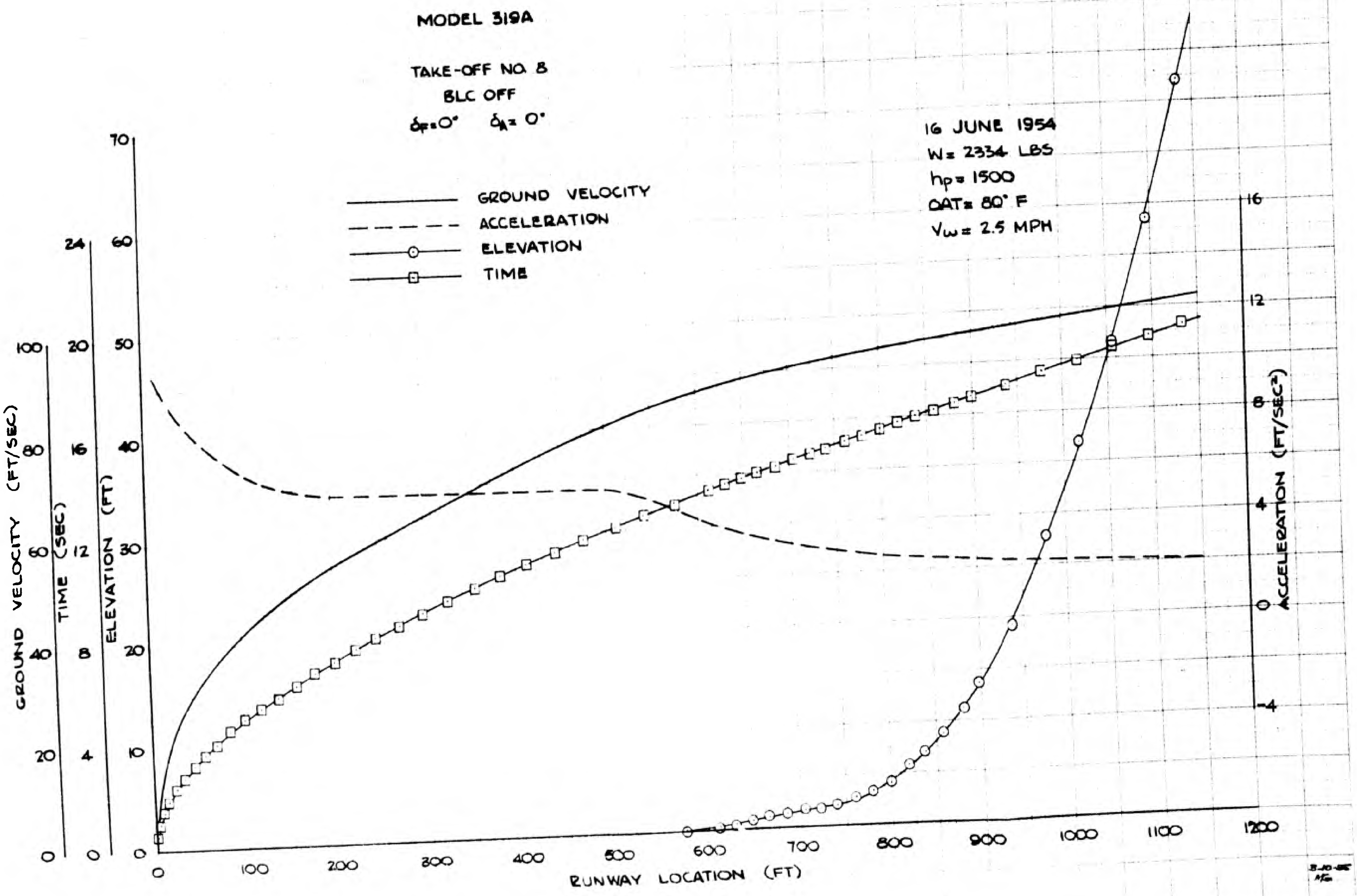
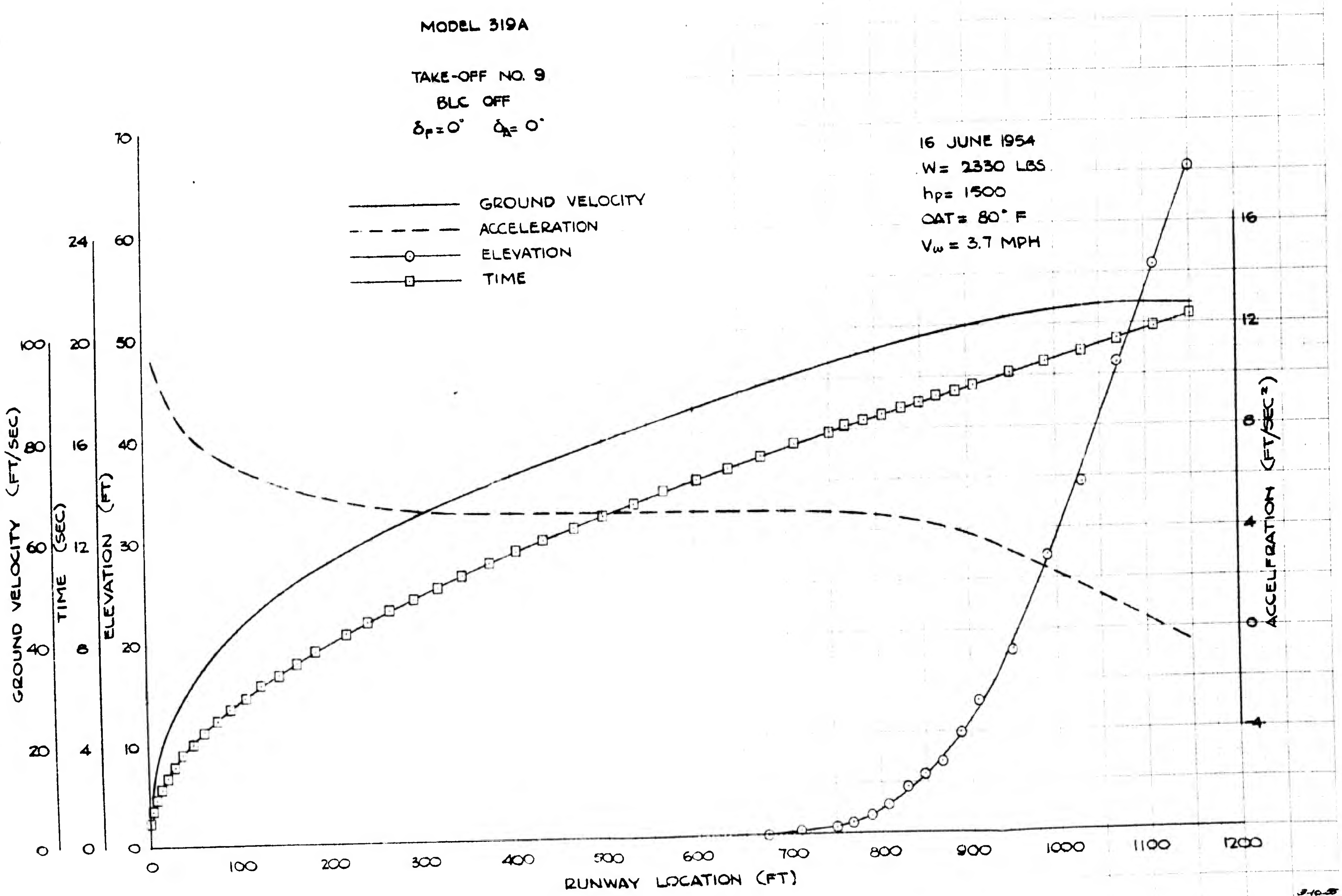

MODEL 319A
TAKE-OFF NO. 8
BLC OFF
$\delta_F = 0°$ $\delta_A = 0°$
16 JUNE 1954
W = 2334 LBS
hp = 1500
OAT = 80° F
V_w = 2.5 MPH
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
4
8
12
16
20
24
10
30
50
70
200
300
400
500
600
700
800
900
1000
1100
1200
-4

FIG. 38


MODEL 319A
TAKE-OFF NO. 9
BLC OFF
$\delta_F = 0°$ $\delta_A = 0°$
16 JUNE 1954
W = 2330 LBS
hp = 1500
OAT = 80° F
V_w = 3.7 MPH
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

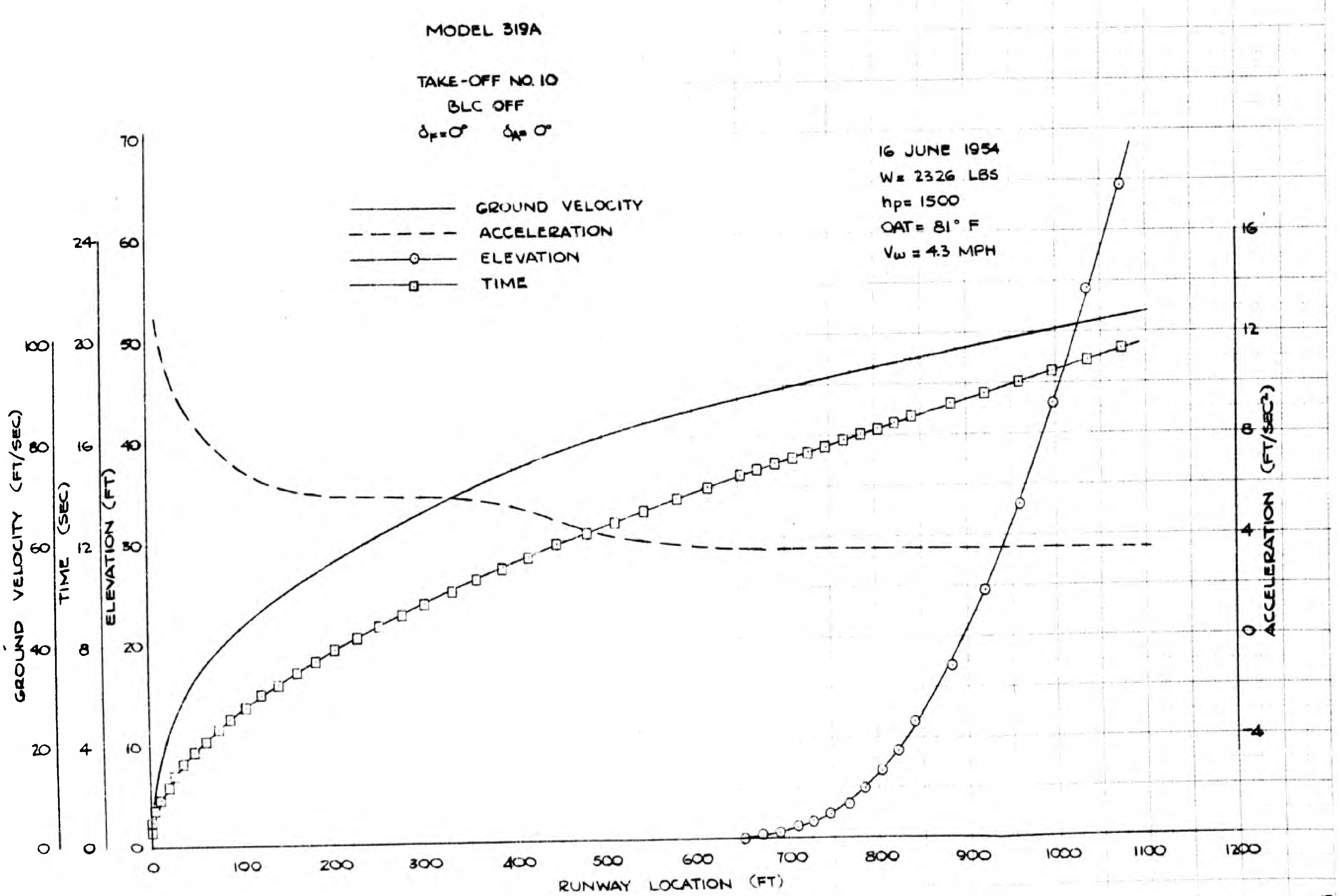
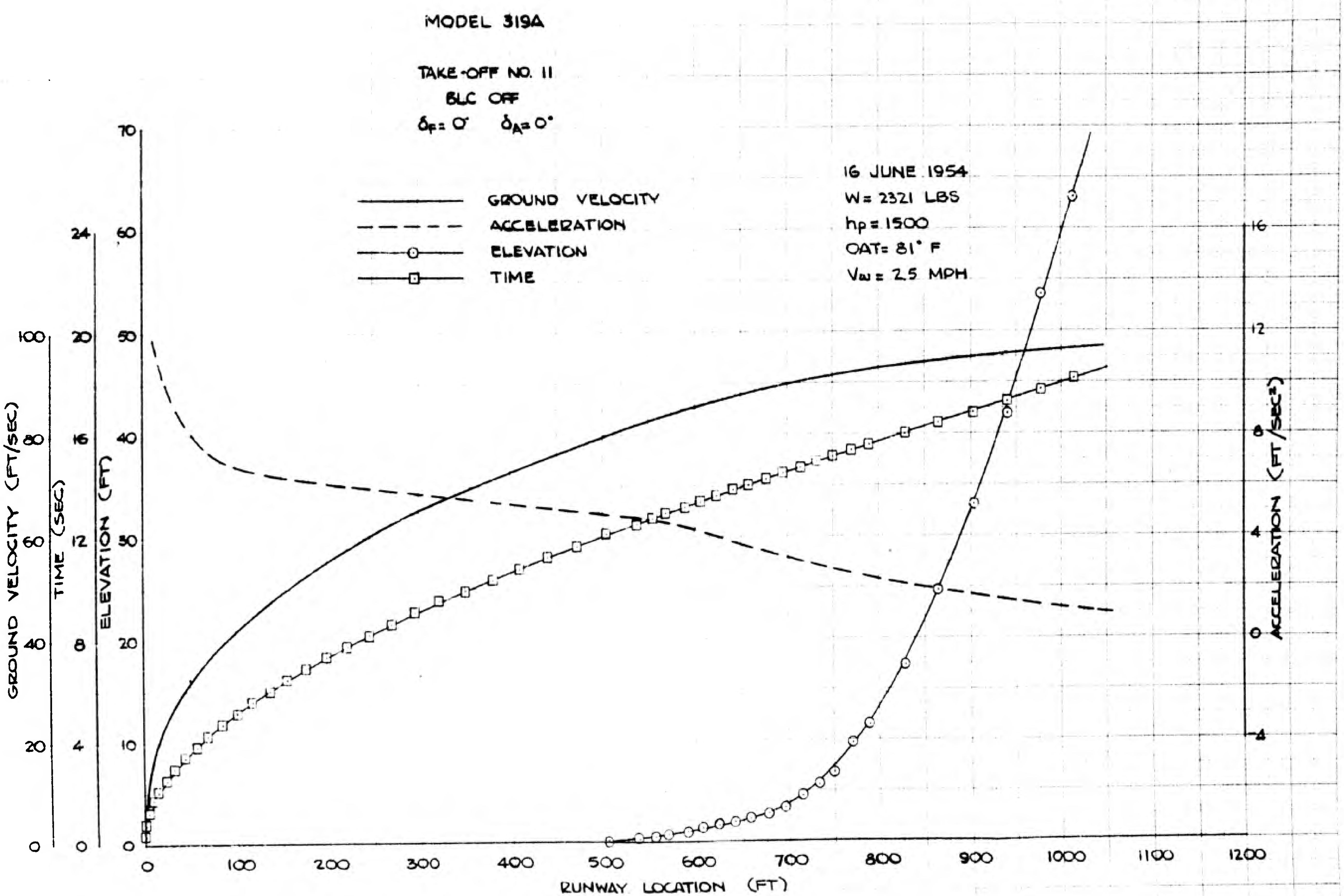

MODEL 319A
TAKE-OFF NO. 10
BLC OFF
$\delta_F = 0°$ $\delta_A = 0°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2326 LBS
hp = 1500
OAT = 81° F
V_ω = 4.3 MPH
GROUND VELOCITY (FT/SEC)
0
20
40
60
80
100
TIME (SEC)
0
4
8
12
16
20
24
ELEVATION (FT)
0
10
20
30
40
50
60
70
ACCELERATION (FT/SEC²)
-4
0
4
8
12
16
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

FIG. 40


MODEL 319A
TAKE-OFF NO. 11
BLC OFF
$\delta_F = 0°$ $\delta_A = 0°$
GROUND VELOCITY
ACCELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2321 LBS
hp = 1500
OAT = 81° F
V_w = 2.5 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
ACCELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
10
20
30
40
50
60
70
4
8
12
16
20
24
80
-4

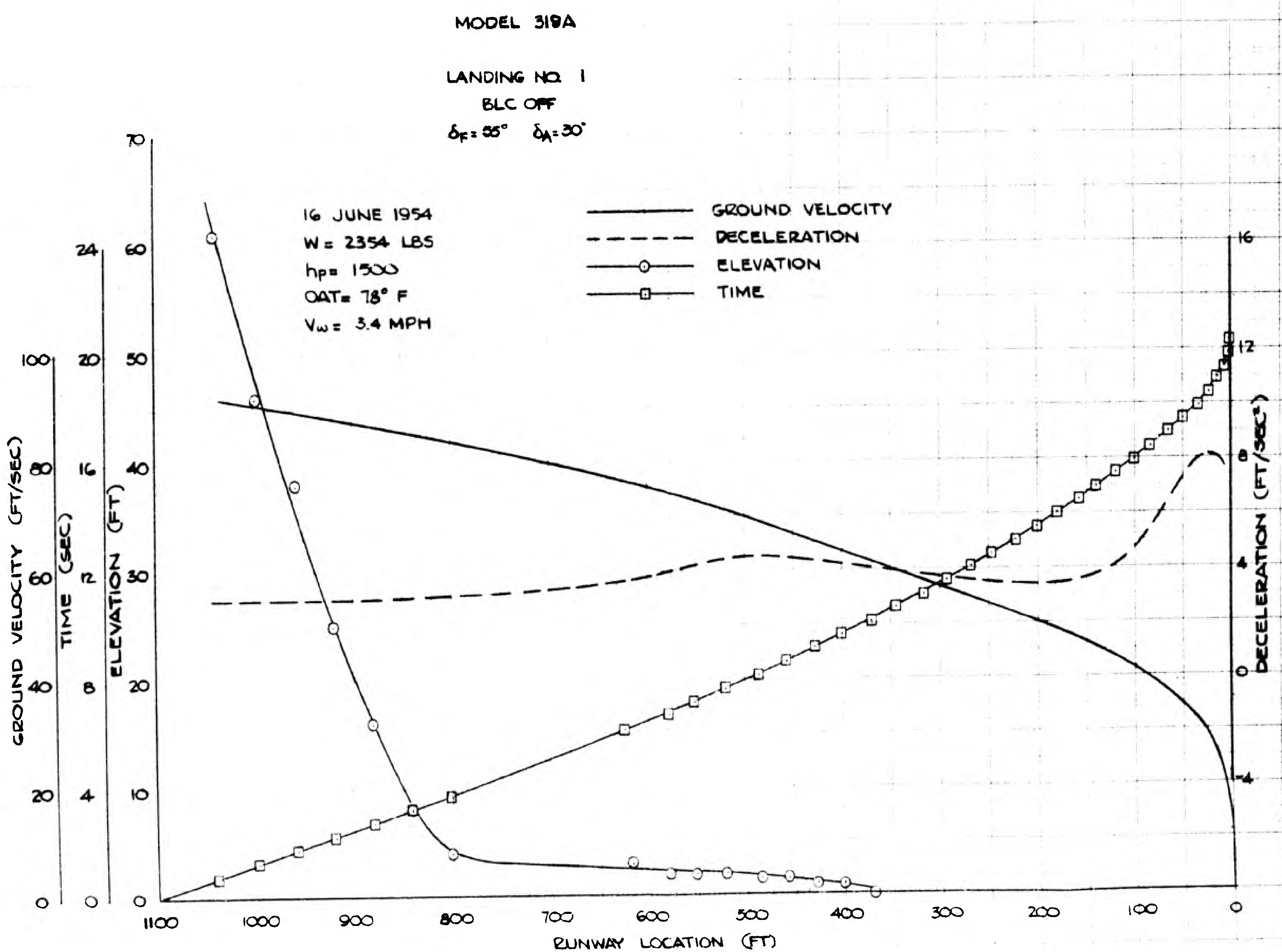
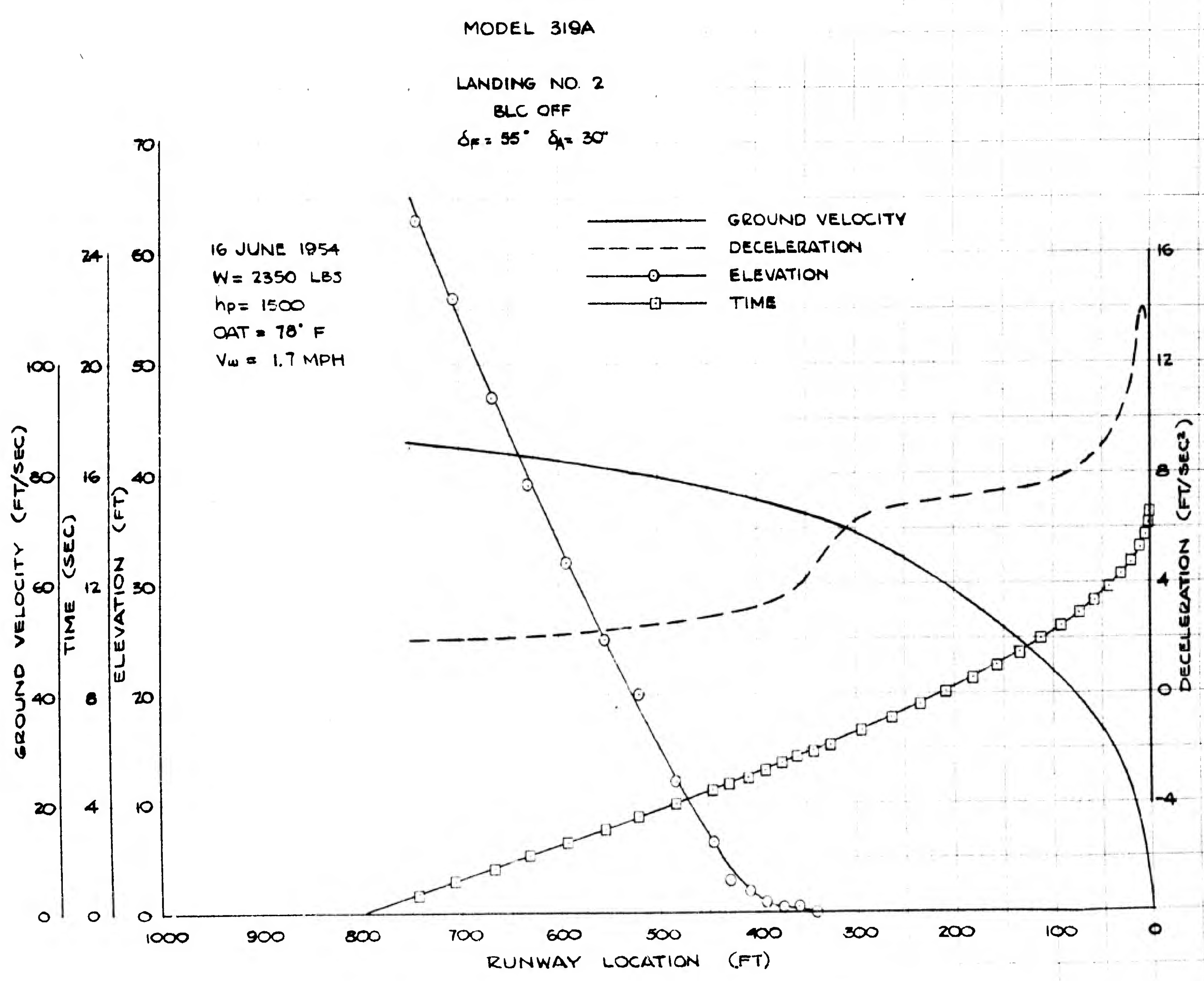
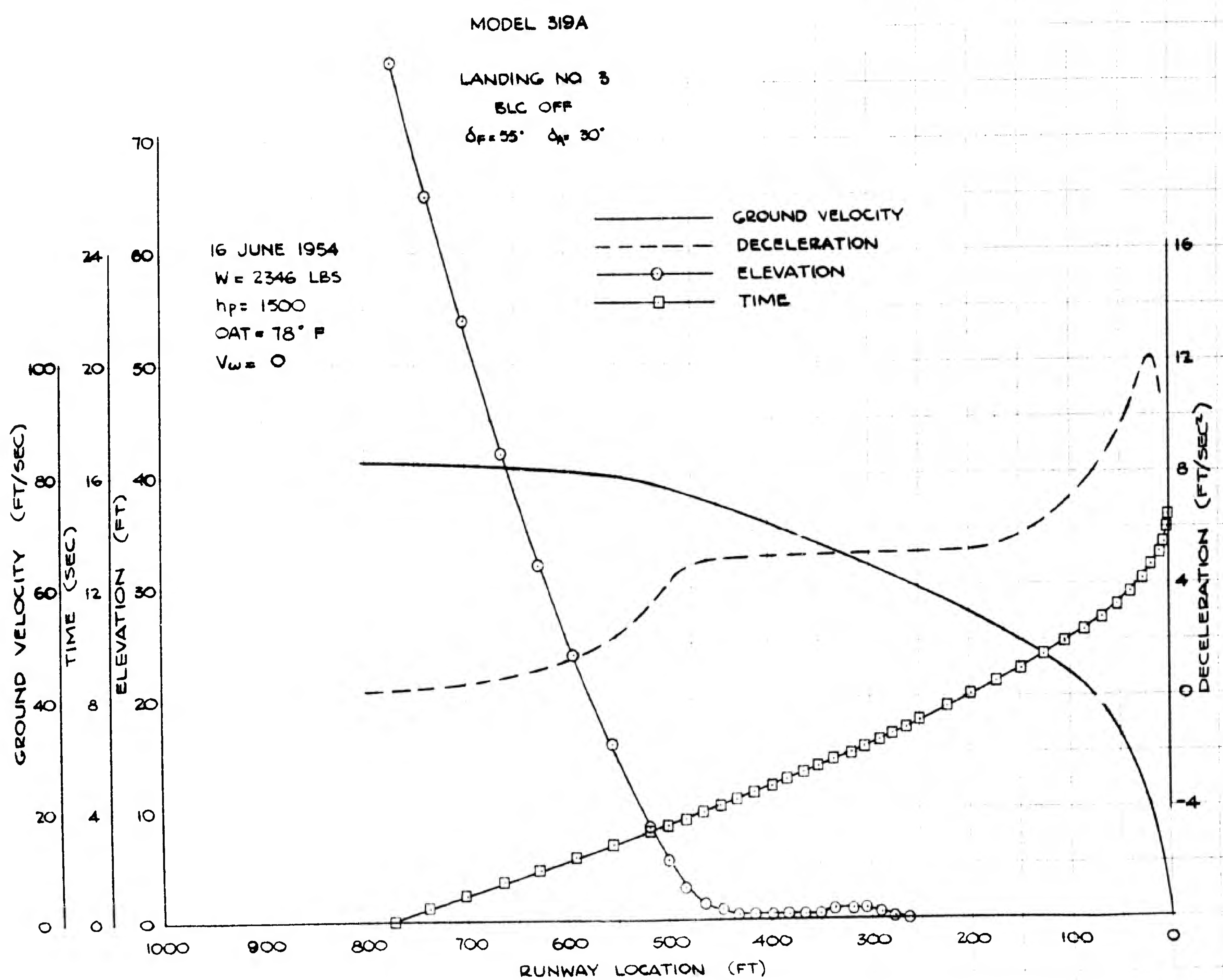

MODEL 319A
LANDING NO. 1
BLC OFF
$\delta_F = 55°$ $\delta_A = 30°$
16 JUNE 1954
W = 2354 LBS
hp = 1500
OAT = 78° F
V_ω = 3.4 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
0
4
8
12
16
20
24
0
10
20
30
40
50
60
70
-4
0
4
8
12
16
1100
1000
900
800
700
600
500
400
300
200
100
0

FIG. 42


MODEL 319A
LANDING NO. 2
BLC OFF
δF = 55° δA = 30°
16 JUNE 1954
W = 2350 LBS
hp = 1500
OAT = 78° F
Vw = 1.7 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
1000
900
800
700
600
500
400
300
200
100
0


MODEL 319A
LANDING NO 3
BLC OFF
$\delta_F = 55°$ $\delta_A = 30°$
16 JUNE 1954
W = 2346 LBS
hp = 1500
OAT = 78° F
V_w = 0
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0 20 40 60 80 100
0 4 8 12 16 20 24
0 10 20 30 40 50 60 70
-4 0 4 8 12 16
1000 900 800 700 600 500 400 300 200 100 0

3-14-55

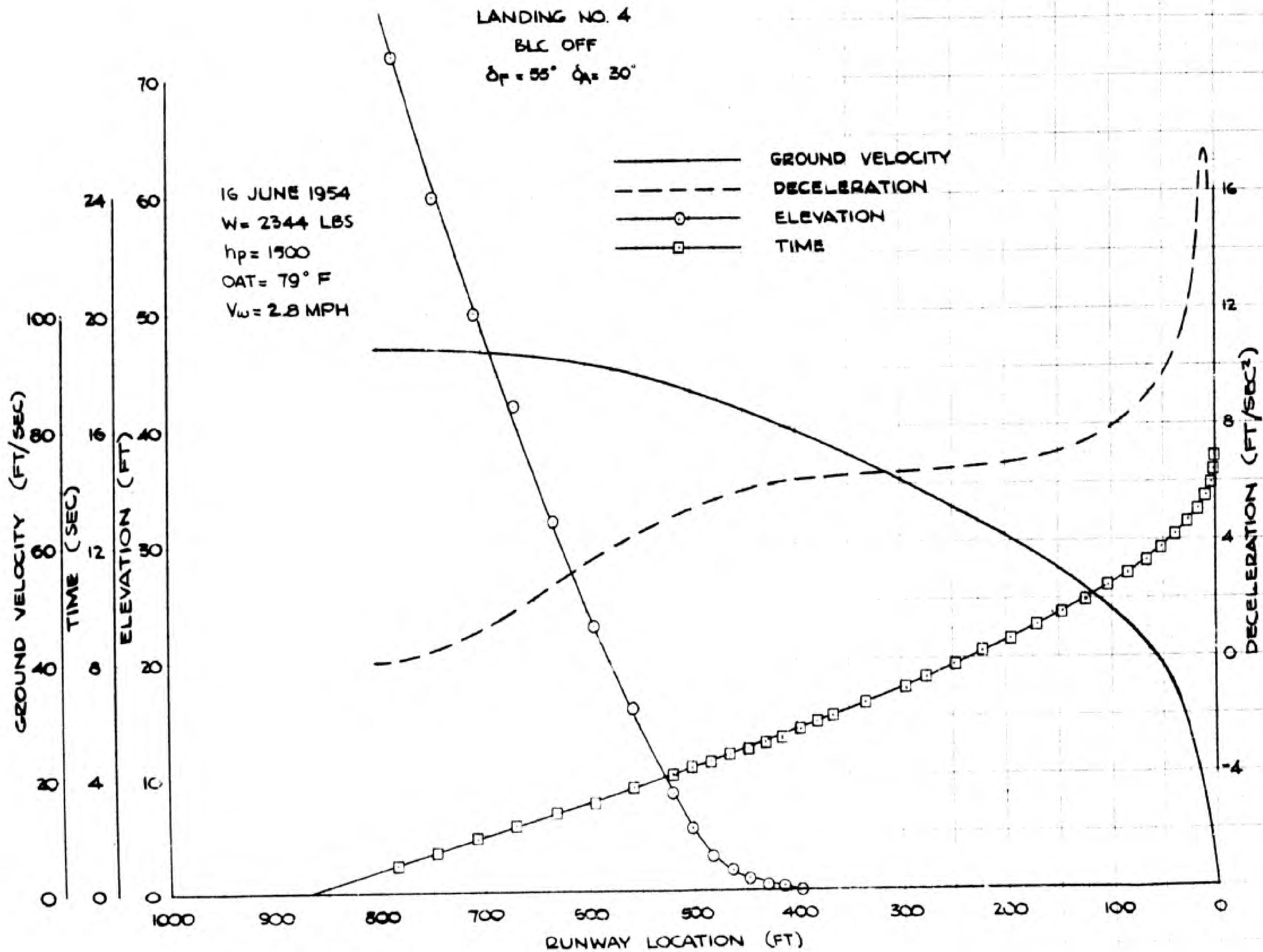

MODEL 319A
LANDING NO. 4
BLC OFF
δF = 55° δA = 30°
16 JUNE 1954
W = 2344 LBS
hp = 1500
OAT = 79° F
Vω = 2.8 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

FIG. 45

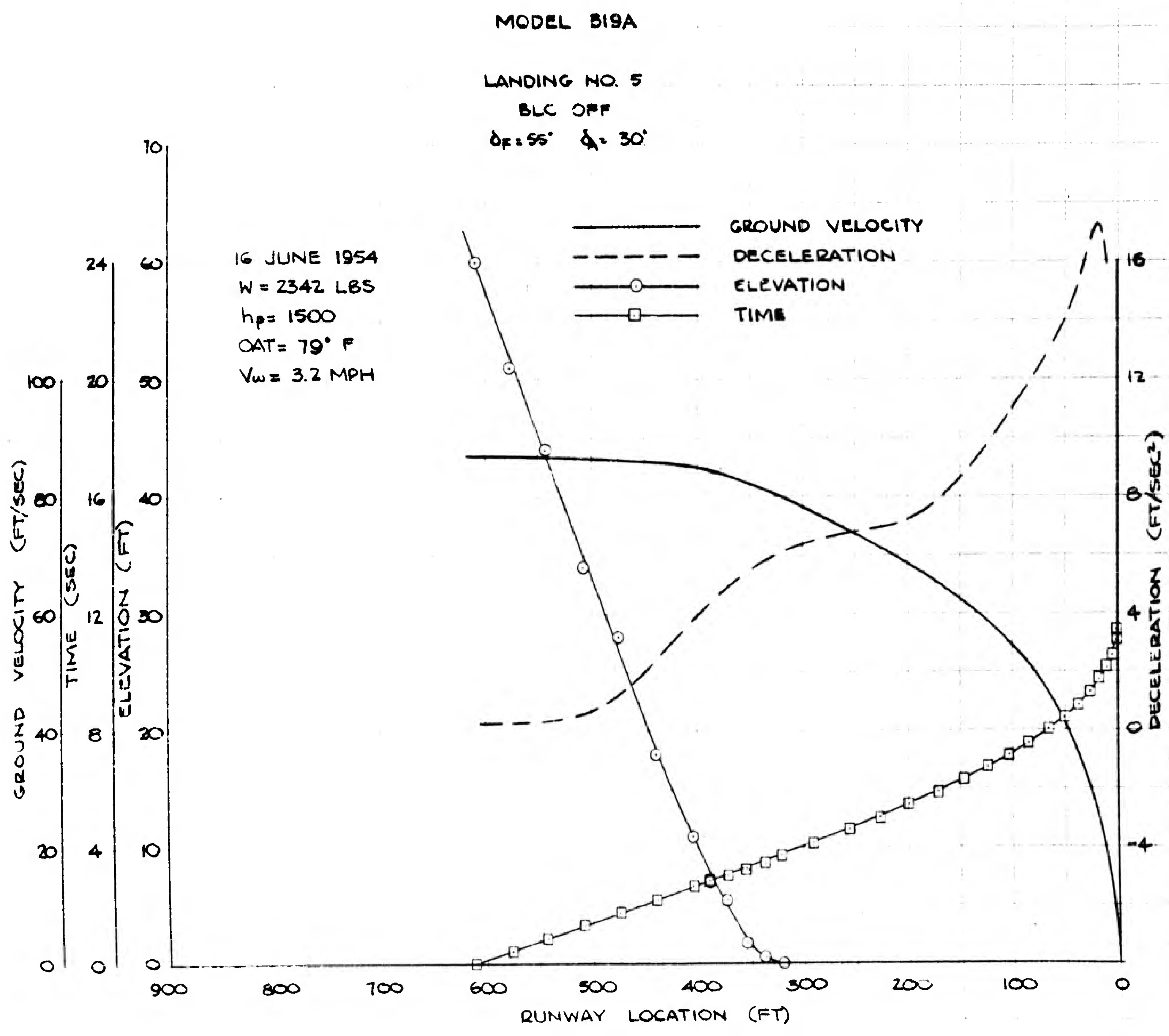

MODEL 819A
LANDING NO. 5
BLC OFF
$\delta_F = 55°$ $\delta_A = 30°$
16 JUNE 1954
W = 2342 LBS
h_p = 1500
OAT = 79° F
V_w = 3.2 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
0
4
8
12
16
20
24
0
10
20
30
40
50
60
70
-4
0
4
8
12
16
900
800
700
600
500
400
300
200
100
0

FIG. 46

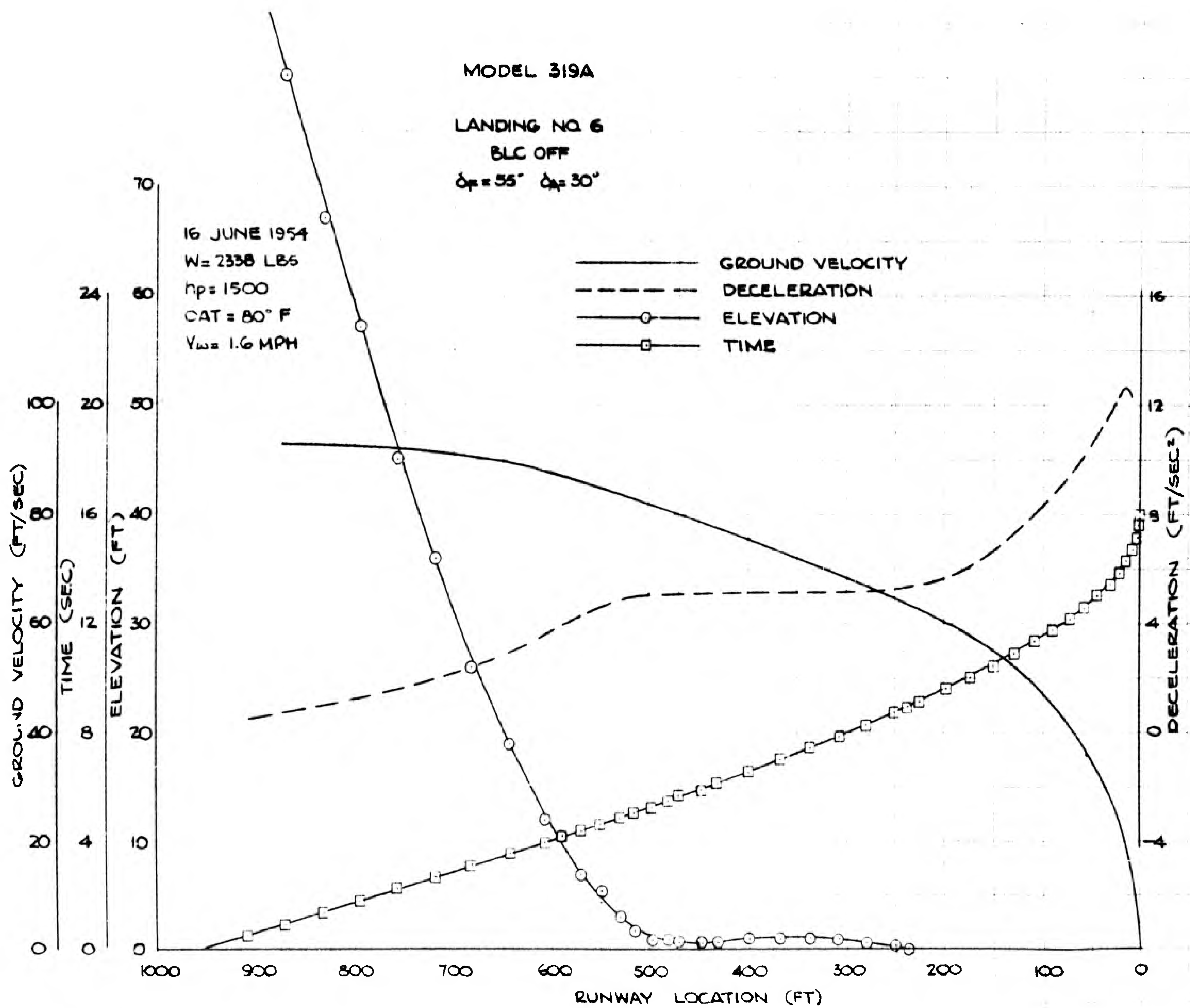
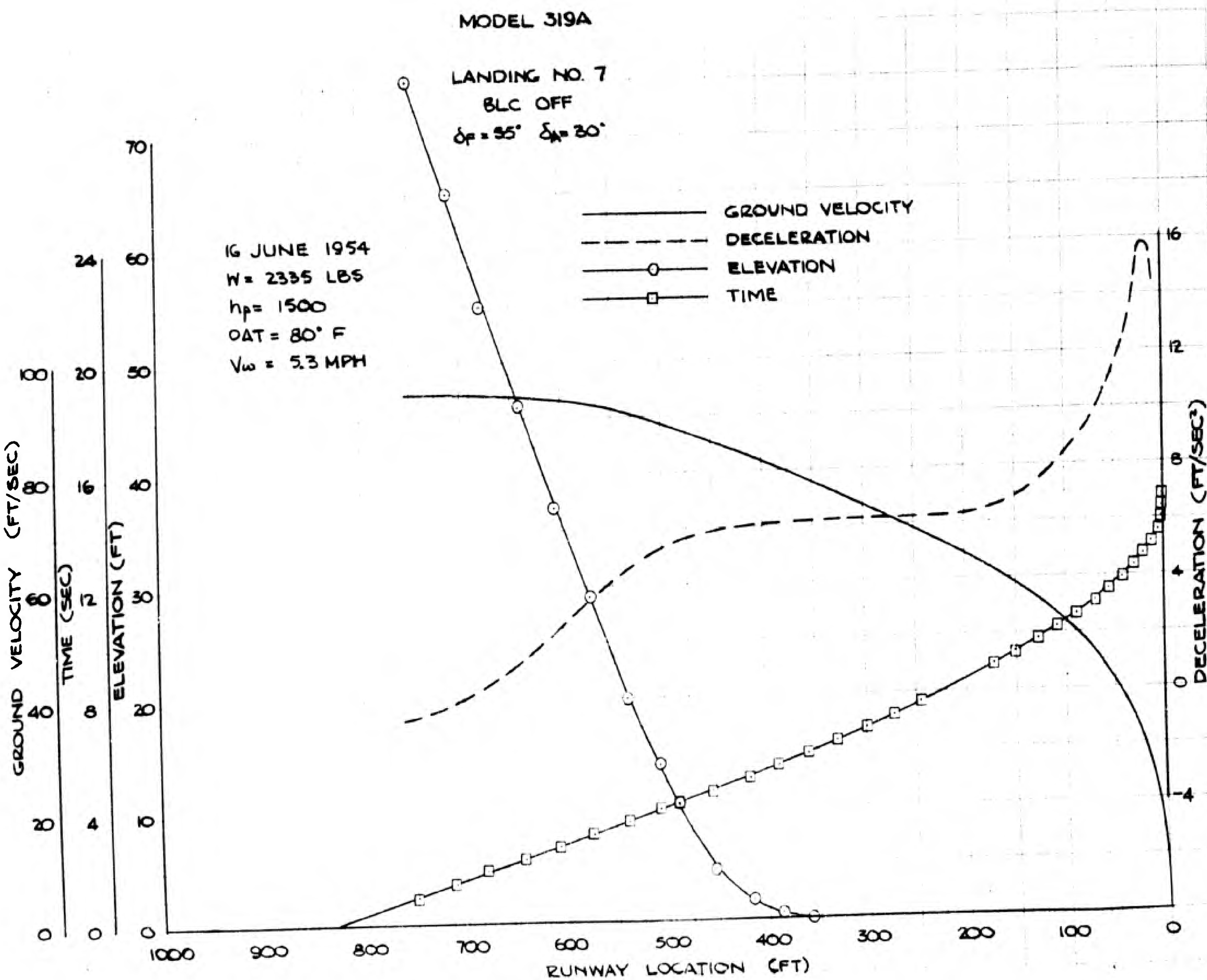
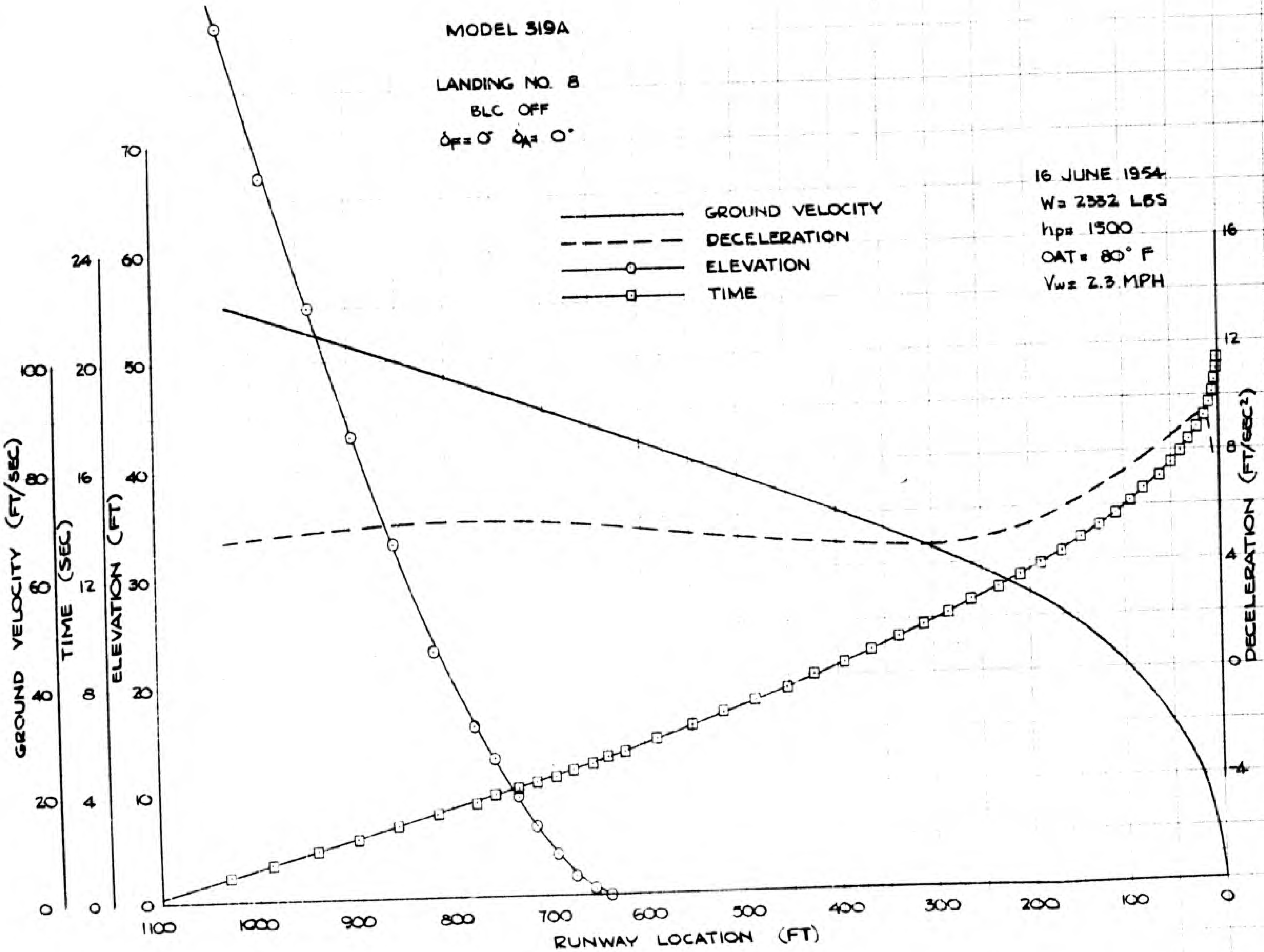

MODEL 319A
LANDING NO. 6
BLC OFF
$\delta_F = 55°$ $\delta_A = 30°$
16 JUNE 1954
W= 2338 LBS
hp= 1500
CAT = 80° F
V_W = 1.6 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
1000
900
800
700
600
500
400
300
200
100
0

FIG. 47



MODEL 319A
LANDING NO. 7
BLC OFF
δ_F = 35° δ_A = 30°
16 JUNE 1954
W = 2335 LBS
h_p = 1500
OAT = 80° F
V_ω = 5.3 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)

5-23-55


MODEL 319A
LANDING NO. 8
BLC OFF
δF = 0° δA = 0°
16 JUNE 1954
W = 2332 LBS
hp = 1500
OAT = 80° F
Vw = 2.3 MPH
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
DECELERATION (FT/SEC²)
RUNWAY LOCATION (FT)
0
20
40
60
80
100
4
8
12
16
24
10
30
50
70
-4
1100
1000
900
800
700
600
500
400
300
200
0

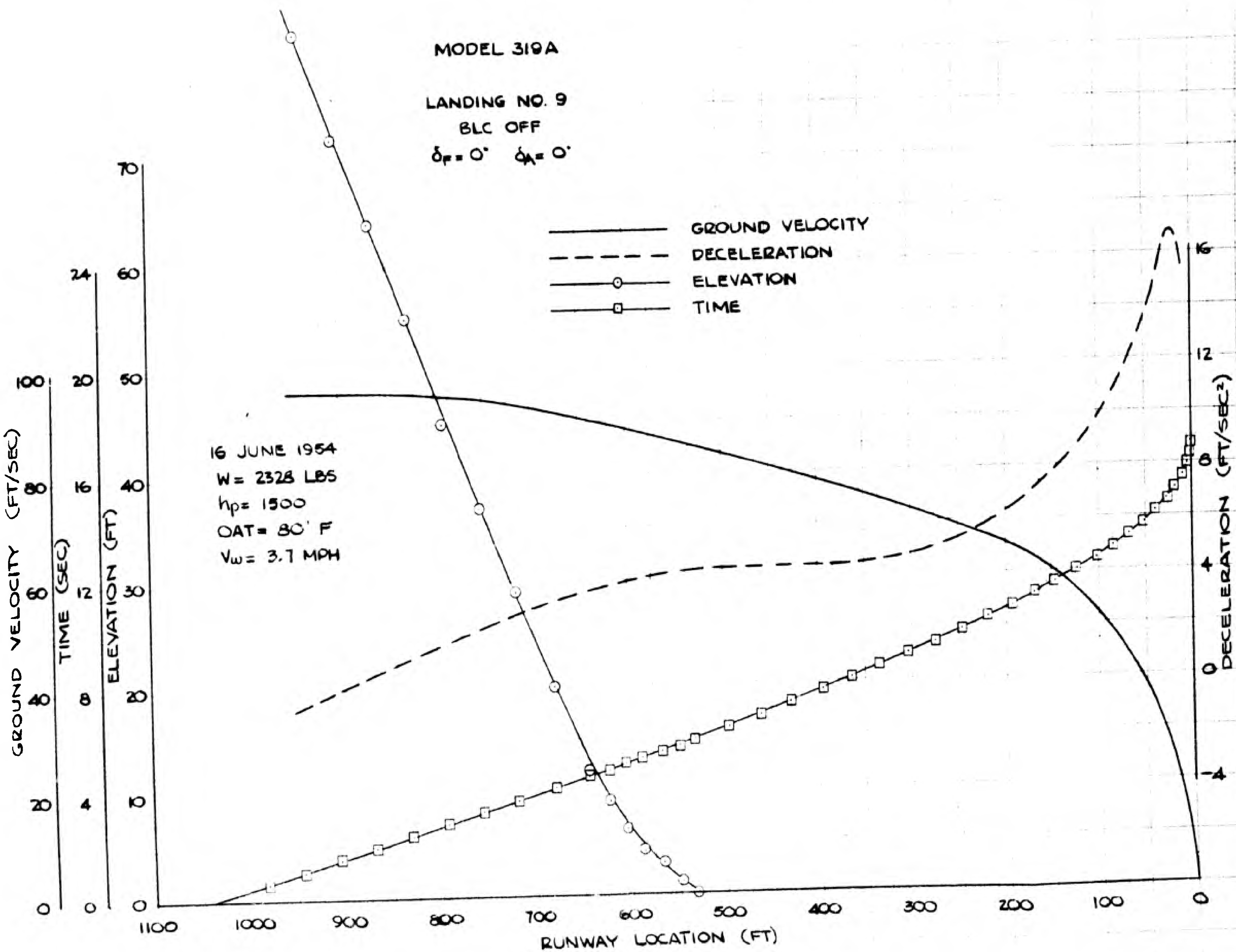
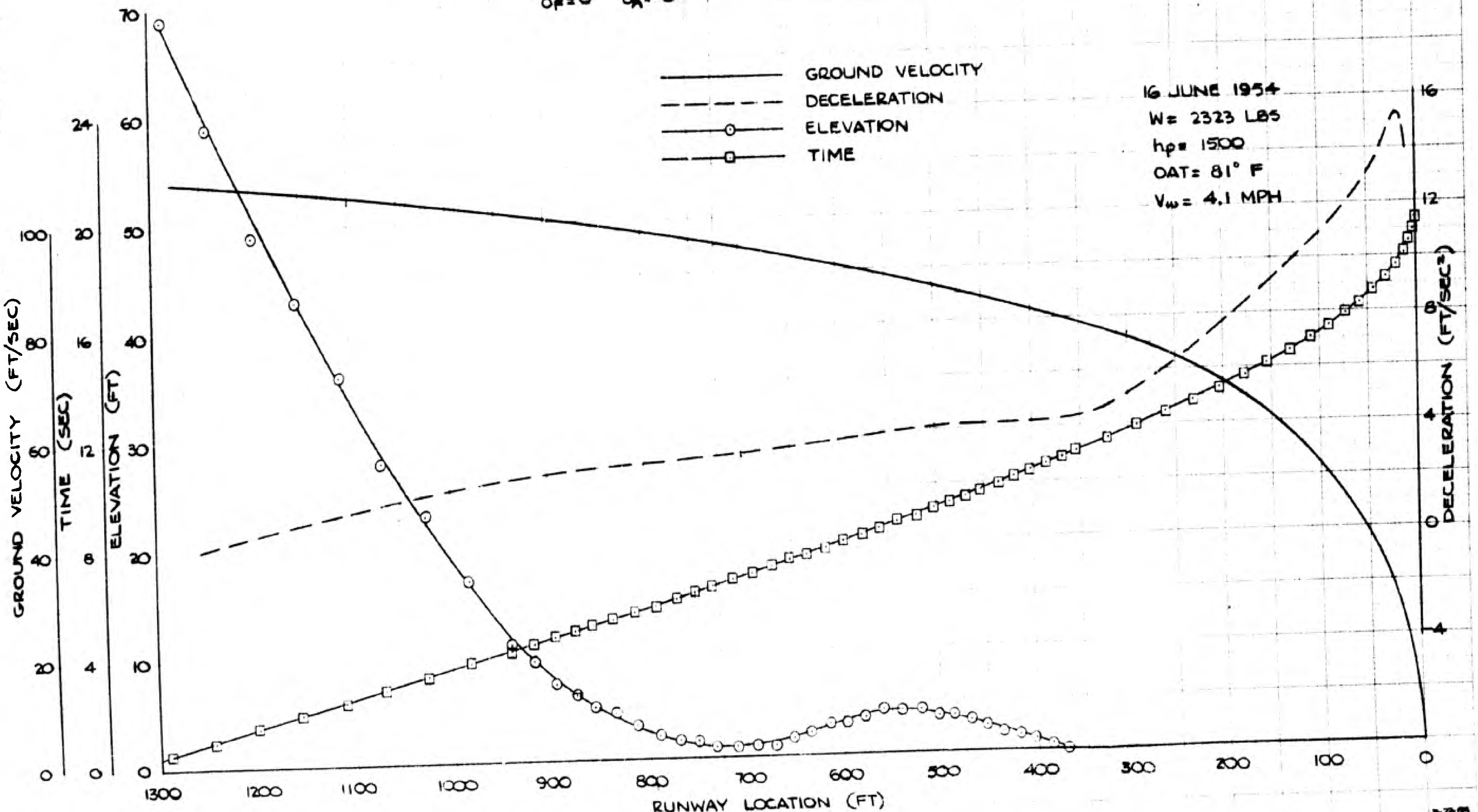

MODEL 319A
LANDING NO. 9
BLC OFF
$\delta_F = 0°$ $\delta_A = 0°$
GROUND VELOCITY
DECELERATION
ELEVATION
TIME
16 JUNE 1954
W = 2328 LBS
h_p = 1500
OAT = 80° F
V_w = 3.7 MPH
GROUND VELOCITY (FT/SEC)
TIME (SEC)
ELEVATION (FT)
RUNWAY LOCATION (FT)
DECELERATION (FT/SEC²)

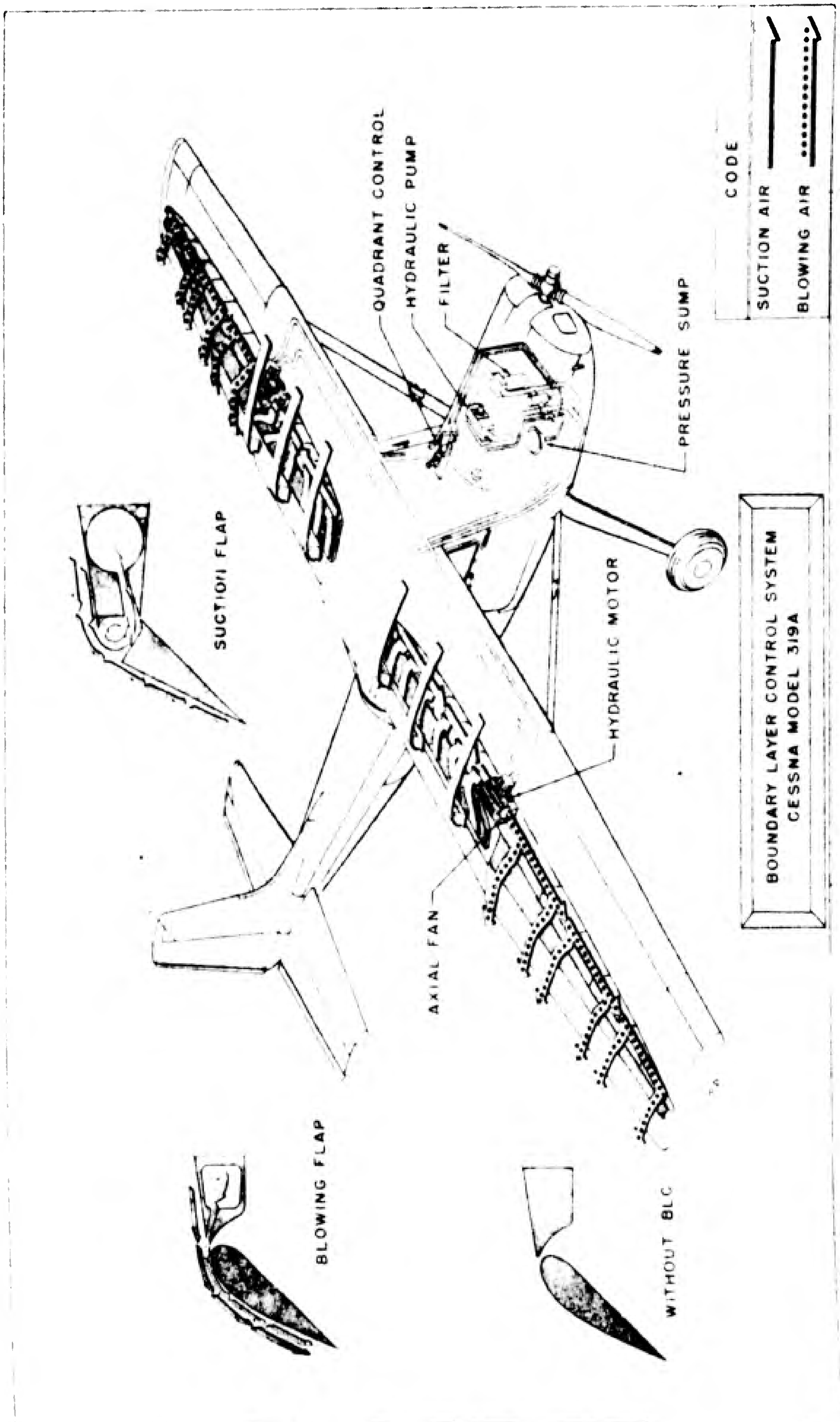
FIG. 49

3-23-65

MODEL 319A

LANDING NO. 10
BLC OFF
$\delta_F = 0°$ $\delta_A = 0°$





BOUNDARY LAYER CONTROL SYSTEM
CESSNA MODEL 319A

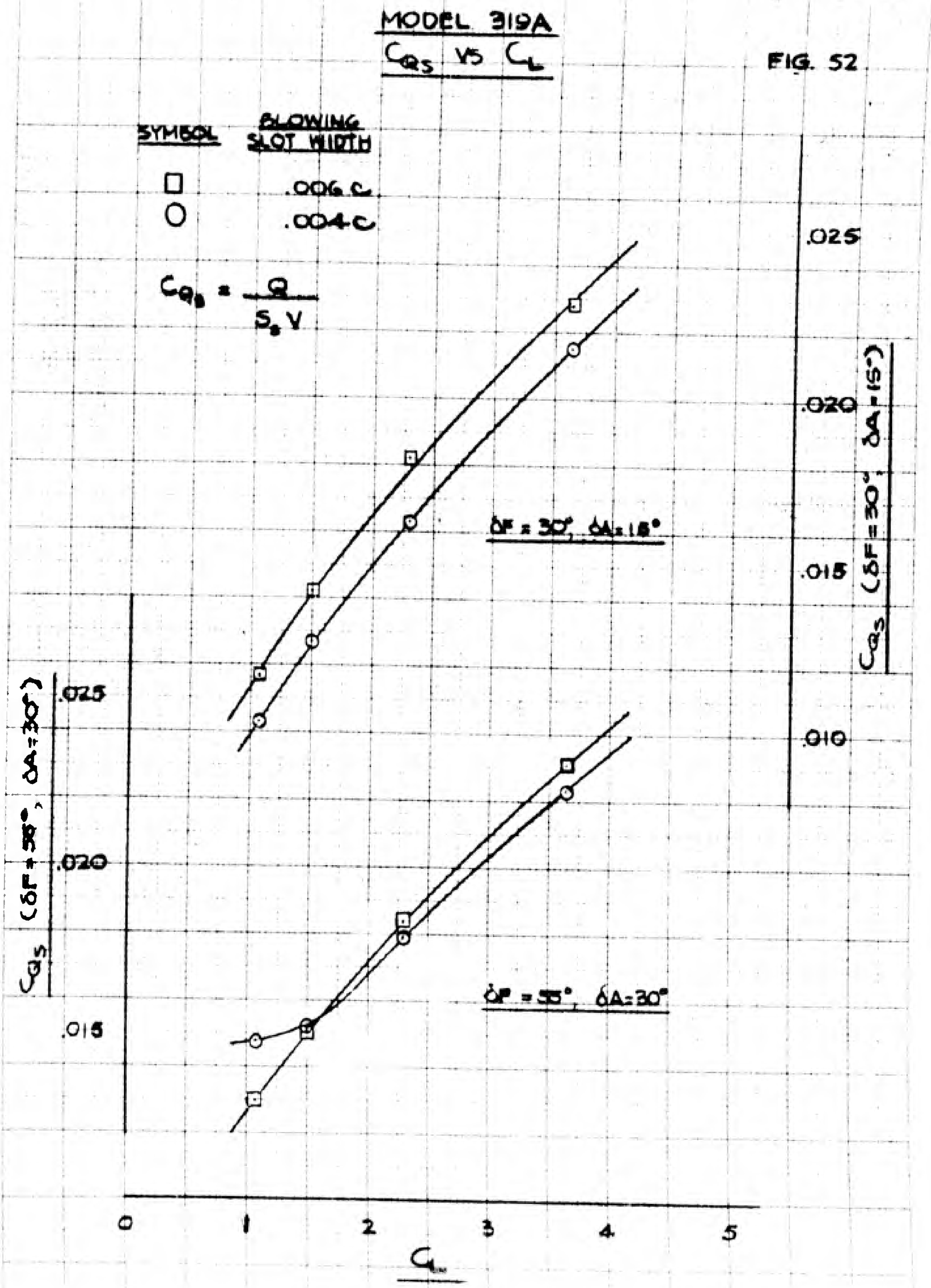
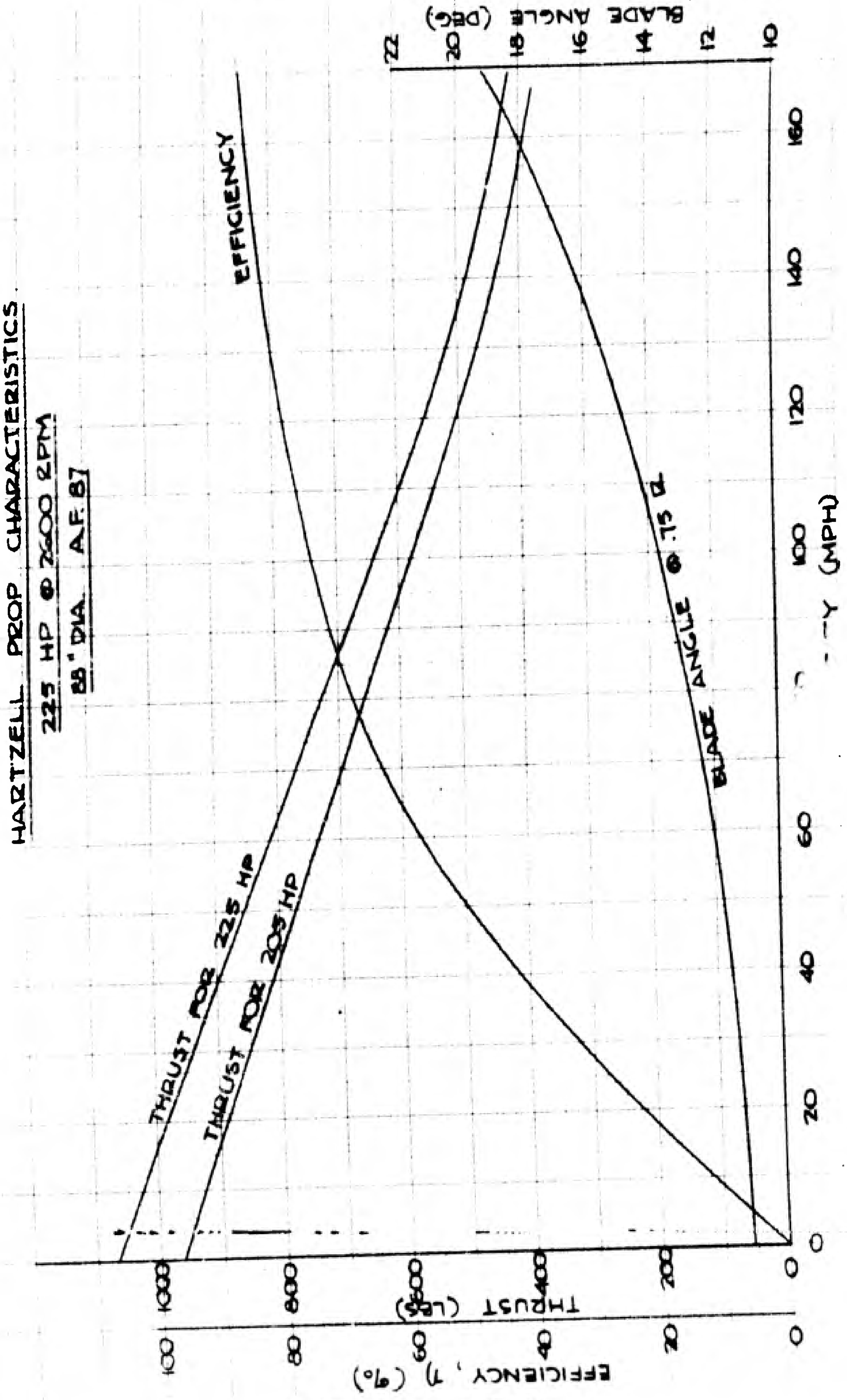


FIG. 52

MC
8-16-54

FIG. 53

[redacted]TIAL



[redacted]

FIG. 54

CONTINENTAL MOTORS CORPORATION

0-470-A-27X TEST
WITH VICKERS HYDRAULIC PUMP NO. AA 35500L
Hyd. Fluid - Vitrea No. 27
Hyd. Pump Inlet Pressure - 34 psi
Aug. 20, 1953

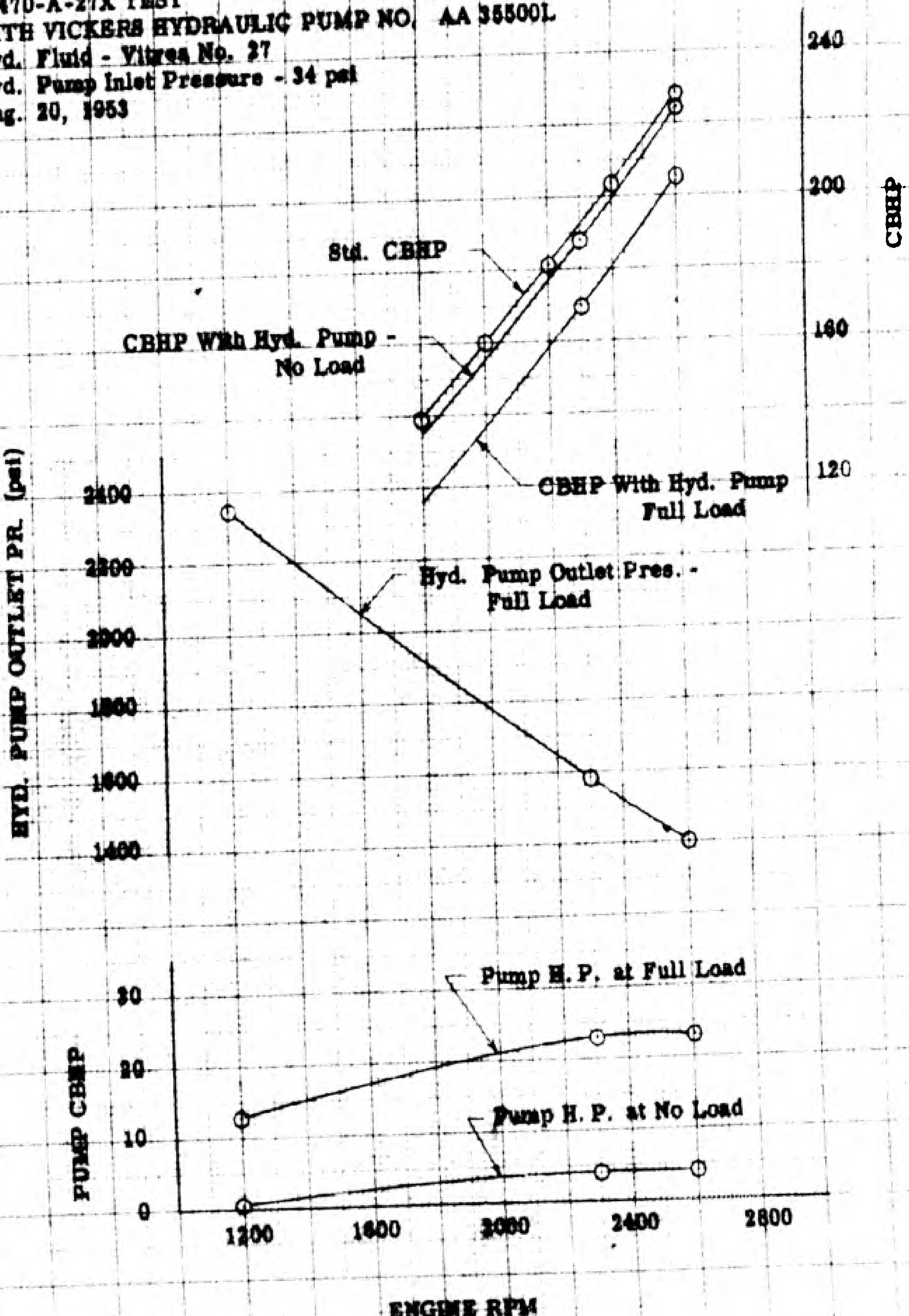
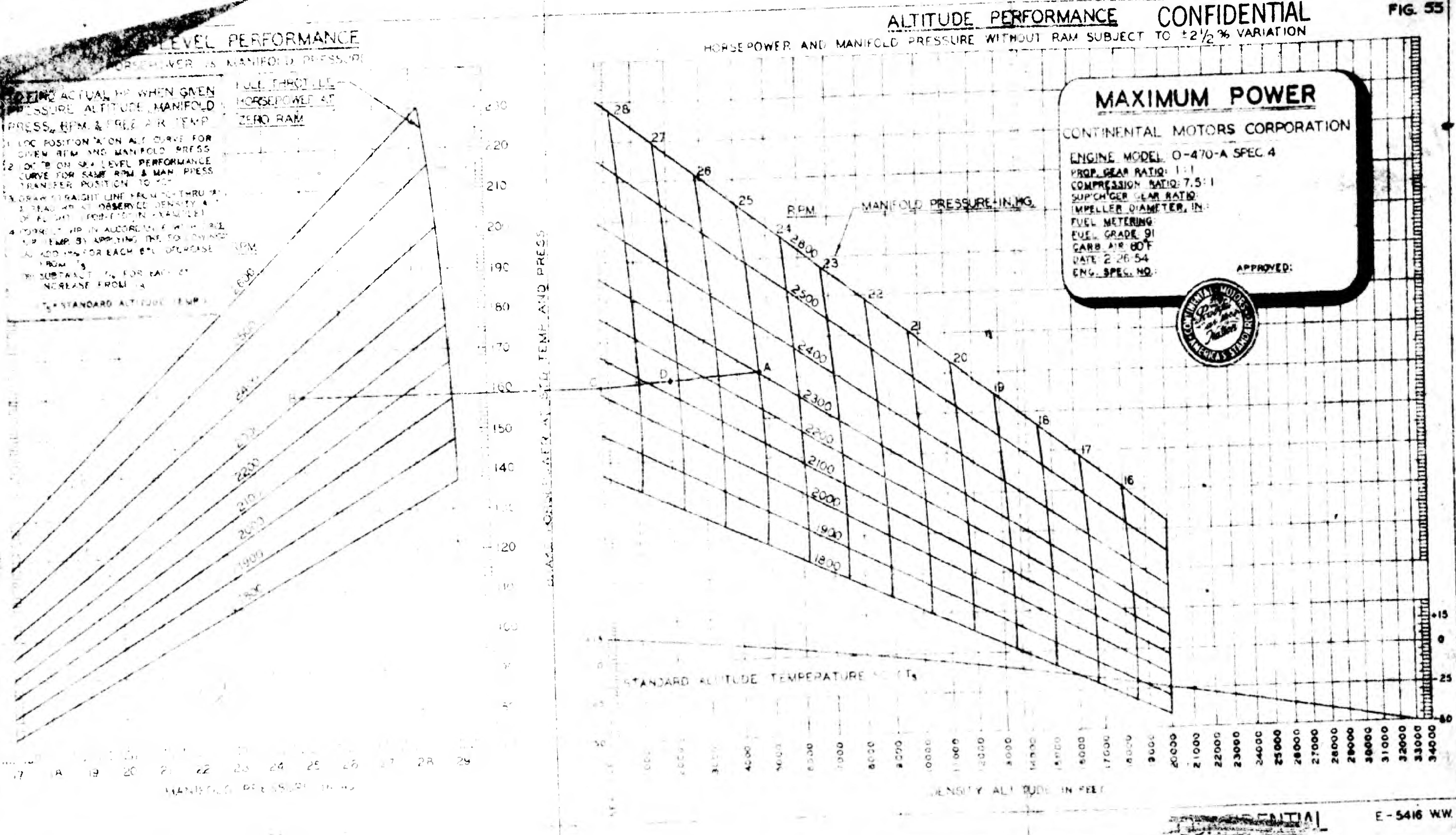


FIG. 55



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