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RESEARCH MEMORANDUM

for the

U. S. Air Force

INVESTIGATION OF EJECTION RELEASE CHARACTERISTICS OF BLUFF TX-28 AND TURNABOUT TX-28 STORES FROM A 1/17-SCALE SIMULATED BOMB BAY OF THE REPUBLIC F-105 AIRPLANE AT MACH NUMBERS OF 1.39 AND 1.98

COORD. NO. AF-222

By John B. Lee

Langley Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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SUMMARY

As a continuation of an investigation of the ejection release characteristics of internally carried stores in the Republic F-105 airplane, two bluff modifications of the TX-28 store have been studied in the 27- by 27-inch preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va. The stores tested were the Turnabout TX-28 and the Bluff TX-28. Dynamically scaled models (1/17-scale) were tested at simulated altitudes of 3,400 feet at a Mach number of 1.39 and 29,000 feet at a Mach number of 1.98.

Successful releases were made with both stores at near-sea-level conditions with high ejection velocities. A decrease in ejection velocity resulted in higher pitch amplitude; the high pitch amplitudes of the Turnabout TX-28 endangered the airplane, but the Bluff TX-28 store was successfully ejected over a wide range of ejection velocities and changes in stroke ratio.

INTRODUCTION

A specific airplane may be required to perform a wide variety of missions. The type of mission, of course, dictates the store shape carried. These store shapes may vary from streamlined stores with high ratios of lift to drag, to bluff stores with low ratios of lift to drag. Investigations of the release characteristics of several store shapes from a simulated bomb bay of the Republic F-105 airplane have been reported in references 1, 2, and 3, and an investigation of similar shapes in a different bomb bay has been reported in reference 4.

At supersonic speeds, investigations have shown that adverse flow conditions in the vicinity of the airplane fuselage and bomb bay may cause poor releases. The Mk-7 store, with a high ratio of lift to drag, pitched nose-up and struck the bomb bay, but ejection releases were improved by increasing the stability of the store, changing the release point, and increasing the ejection velocity (ref. 2). The bluff stores with a low ratio of lift to drag were ejected from the bomb bay cleanly, but high pitch amplitudes resulted in some cases (ref. 3). Improvements were noted with changes in ejection velocities, stroke ratio, and ejection mechanism.

For this investigation, the Bluff TX-28 stores and the Turnabout TX-28 stores were used. The Bluff TX-28 store, with a low ratio of lift to drag, was a simple design of a straight cylinder with a flared skirt. The Turnabout TX-28 store was a modification of the one reported in reference 2. The fin area was decreased, and a ring was placed around the nose of the store.

The purpose of the present investigation was to study the effects of ejection velocity, stroke ratio, and fuselage angle of attack on the release characteristics of these two stores. One-seventeenth-scale models were tested in the preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va. The dynamically scaled stores simulated altitudes of 3,400 feet at a Mach number of 1.39 and 29,000 feet at a Mach number of 1.98 at Reynolds numbers of 8.87×10^6 and 14.63×10^6 per foot, respectively.

SYMBOLS

d	diameter, in.
g	acceleration due to gravity, ft/sec^2
h_p	simulated altitude, ft

I_Y moment of inertia of store in pitch plane, slug-in.^{2}

l store length, in.

M Mach number

p static pressure, lb/sq ft

q dynamic pressure, lb/sq ft

r radius of store, in.

t time, sec

W store weight, lb

x horizontal distance with origin at center of gravity of store at point of release, in.

z vertical distance with origin at center of gravity of store at point of release, positive downward, in.

$\dot{z}_o$ ejection velocity of store at release, ft/sec

α_f angle of attack of airplane fuselage to free-stream direction, deg

θ_s pitch angle of store in reference to undisturbed free-stream direction, deg

MODELS AND APPARATUS

Stores

The scale-model configurations of the Turnabout TX-28 and the Bluff TX-28 stores are shown in figure 1, and the ordinates of the Turnabout TX-28 store are shown in table I. The full-scale Turnabout TX-28 store, $\frac{l}{d} = 4.78$, had a ring around the nose (fig. 1(a)), and the fin area was 16 percent less that that of the Turnabout TX-28 store reported in reference 2. The center of gravity of the store was located at 38.9 percent of the store length from the nose.

The full-scale Bluff TX-28 store, $\frac{l}{d} = 4.40$ (fig. 1(b)), had a 7.6° flared skirt with a length equal to 3/4 the store diameter. The center of gravity of the store was located at 37.4 percent of the store length from the nose.

The weights and inertias of the models were scaled by the light-model method (ref. 5) to simulate the desired altitudes. The full-scale store weights were simulated within ±5 percent and the inertias, within ±10 percent. Full-scale weight of each store was 1,700 pounds, and full-scale inertias were 1,400,000 lb-in.^{2} for the Bluff TX-28 and 1,500,000 lb-in.^{2} for the Turnabout TX-28.

The store ejection pin was located in a bracket containing a spring mechanism (fig. 2) and passed through the center of gravity of the store. The pin was extended to engage the ejection mechanism rod (ref. 2), and, upon release, the spring tension forced the ejection pin to be seated in the bracket flush with the upper surface of the model.

Fuselage and Bomb Bay

The 1/17-scale model of the Republic F-105 fuselage and bomb bay used for these tests has been described previously in reference 1.

Ejection Cylinder

The modified ejection cylinder (ejection cylinder 2) described in reference 2 was used for this investigation. The ejection stroke could be varied to 1/2 and 3/4 of the full stroke length of 1.76 inches.

Photographic Apparatus

The spinning-disk method of photography (ref. 4) was used to obtain the stroboscopic photographs from which the data were obtained. The time interval between each photograph frame for each test is listed in table II.

Preflight Jet

All tests were made in the 27- by 27-inch preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va. (ref. 5). Similar test setups have been shown in references 1 and 3.

TEST CONDITIONS

The present investigation was made at test conditions of $M = 1.39$ and $M = 1.98$ with simulated altitudes of 3,400 feet and 29,000 feet, respectively. The stores were ejected over a range of ejection velocities from 10 feet per second to 33 feet per second, at stroke ratios of 1/2, 3/4, and 1. The preset incidence angle of the store was 0° in all cases. Ejections were made at fuselage angles of attack of 0° and 3°.

Table II lists the tests and the data pertinent to each test.

RESULTS AND DISCUSSION

Stroboscopic photographs of the tests, plots of time histories of the store pitch angle θ_s, and the store trajectories are shown in figures 3 to 8. The center of gravity of the store was taken as zero time and displacement. In the cases where the store struck the bomb bay or fuselage, the data symbols near impact are shaded (figs. 7(b) and 7(c)). The store incidence angle at release was not zero because the ejection rod and sway brace bent under aerodynamic loads, as previously noted in reference 1.

Bluff TX-28

The Bluff TX-28 was tested at $M = 1.39$, $h_p = 3{,}400$ feet, $\alpha_f = 3^\circ$, and $\alpha_f = 0^\circ$.

At a fuselage angle of 3°, releases were made at ejection velocities of 32, 22, and 10 feet per second (tests 1, 2, and 3, fig. 3) for stroke ratios of 1 (full stroke). A decrease in the ejection velocity caused an increase in maximum pitch angle (fig. 3(b)), and the store passed closer to the bomb bay (fig. 3(c)). As shown in reference 5, the ejection velocities for model and full-scale configurations, in the method of simulation employed, were not equal, but the trajectories were more nearly similar at higher ejection velocities. Test 3 (fig. 3(b)) indicates that high pitch angles resulted if the store passed in close proximity to the fuselage. For test 4 (fig. 3), a stroke ratio of 3/4 was used with an ejection velocity of 22 feet per second. A more favorable trajectory was obtained than for test 2 at full stroke, and the trajectory was similar to that of test 1 at full stroke with an ejection velocity of 32 feet per second. The improvement probably occurred because, for a stroke ratio of 3/4, the sway brace did not project into the airstream;

whereas for full stroke, the sway brace extends into the airstream and causes additional disturbances in the flow field (refs. 1 and 2).

A change in fuselage angle of attack from 3° to 0° showed little or no change in the store release characteristics at $\dot{z}_o = 32$ feet per second and full stroke (test 1, fig. 3, and test 5, fig. 4). Smaller pitch amplitudes resulted for a stroke ratio of 3/4 at $\alpha_f = 0°$ (test 4, fig. 3(b), and test 6, fig. 4(b)). More favorable trajectories were obtained for a stroke ratio of 3/4 at both fuselage angles of attack. The maximum store pitch angles changed from $\theta_s = 22°$ for $\dot{z}_o = 32$ feet per second, full stroke (test 5, fig. 4(b)) to $\theta_s = -22°$ for $\dot{z}_o = 15$ feet per second, stroke ratio of 1/2 (test 7, fig. 4(b)). A wide range of ejection velocities and stroke ratios can thus be used to eject the Bluff TX-28 store.

The Bluff TX-28 was also tested at $M = 1.98$, $h_p = 29{,}000$ feet, and $\alpha_f = 3°$, and favorable releases were made for all conditions. All stores pitched initially to a negative angle of attack ranging from -17° to -20° (fig. 5, tests 8, 9, and 10).

The Bluff TX-28 store can be successfully ejected at the altitudes and Mach numbers of this test. With the proper combination of ejection velocities and stroke ratios, the maximum store pitch angle can be held within ±20°.

Turnabout TX-28

The Turnabout TX-28 was tested at $M = 1.39$, $h_p = 3{,}400$ feet, $\alpha_f = 3°$, and $\alpha_f = 0°$.

At $\alpha_f = 3°$, good releases were made at full stroke with ejection velocities of 32 and 22 feet per second (tests 11 and 12, fig. 6). As the ejection velocity was decreased, the store pitch oscillations became larger, and the store gained appreciable lift. At lower ejection velocities (tests not shown), the store struck the bomb bay and fuselage. An ejection at a stroke ratio of 3/4 and $\dot{z}_o = 23$ feet per second (test 13, fig. 6(b)) resulted in a release with a maximum pitch angle of $\theta_s = 20°$, and the store trajectory passed closer to the fuselage than it did in test 12.

At $\alpha_f = 0°$, favorable ejections were made for ejection velocities of 33 and 25 feet per second at stroke ratios of 1 and 3/4, respectively (tests 14 and 15, fig. 7). For an ejection velocity of 15 feet per second and a stroke ratio of 1/2, the store pitched nose-up and struck the bomb bay (test 16, fig. 7). Excellent releases may be made, apparently with the Turnabout TX-28 store at low altitudes, provided that high ejection velocities are used. A decrease in angle of attack from 3° to 0° caused a decrease in maximum initial pitch amplitude.

The Turnabout TX-28 was also tested at $M = 1.98$, $h_p = 29,000$ feet, and $\alpha_f = 3^{\circ}$. An increase in altitude resulted in good releases with ejection velocities as low as 19 feet per second with a stroke ratio of 1/2 (fig. 8). As noted previously, however, lower ejection velocity resulted in higher pitch angles.

CONCLUSIONS

Two stores have been investigated, the Bluff TX-28 and the Turnabout TX-28, in a free jet to determine the ejection release characteristics and flight behavior in the close vicinity of a fuselage. The tests were made at Mach numbers of 1.39 and 1.98 for simulated altitudes of 3,400 and 29,000 feet, respectively. Ejections were made over a range of ejection velocities from 10 to 33 feet per second. Favorable release conditions were obtained with both store shapes.

The Bluff TX-28 store can be released over a wide range of ejection velocities and stroke ratios. Decreasing the stroke length improved the release characteristics; however, the proper combination of the ejection velocity and stroke length is necessary.

Low pitch amplitudes were obtained with the Turnabout TX-28 store. Successful ejections were limited, however, to high ejection velocities. No improvement was noted by decreasing the length of the ejection stroke. A decrease in fuselage angle of attack from 3° to 0° improved the initial pitch amplitude.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., January 22, 1957.

John B. Lee
Aeronautical Research Engineer

Approved:
Joseph A. Shortal
for Chief of Pilotless Aircraft Research Division

bcc

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2. Lee, John B.: Investigation of Ejection Release Characteristics of Four Dynamically Scaled Internal-Store Shapes From a 1/17-Scale Simulated Bomb Bay of the Republic F-105 Airplane at Mach Numbers of 1.39 and 1.98 - COORD. NO. AF-222. NACA RM SL56I28a, U. S. Air Force, 1956.

3. Carter, Howard S., and Lee, John B.: Investigation of the Ejection Release of Several Dynamically Scaled Bluff Internal Stores at Mach Numbers of 0.8, 1.39, and 1.98. NACA RM L56H28, 1956.

4. Lee, John B., and Carter, Howard S.: An Investigation of Ejection Releases of Submerged and Semisubmerged Dynamically Scaled Stores From a Simulated Bomb Bay of a Fighter-Bomber Airplane at Supersonic Speeds. NACA RM L56I10, 1956.

5. Sandahl, Carl A.; and Faget, Maxime A.: Similitude Relations for Free-Model Wind-Tunnel Studies of Store-Dropping Problems. NACA TN 3907, 1957.

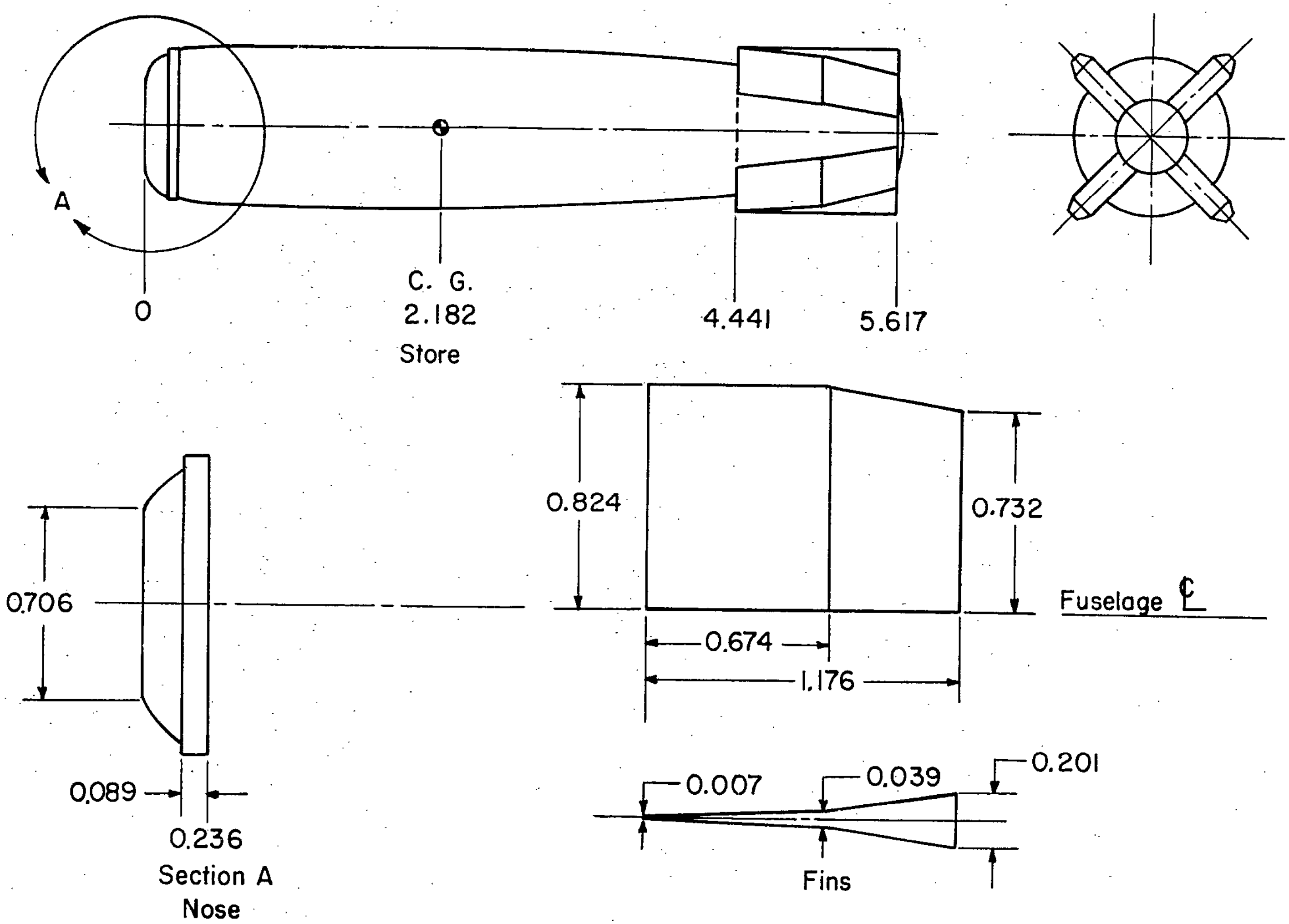
TABLE I.- ORDINATES OF

TURNABOUT TX-28

x, in.	r, in.
0	0.353
.147	.526
.408	.565
.529	.570
.765	.579
1.335	.588
2.747	.588
2.924	.586
2.955	.586
3.261	.574
3.610	.553
3.735	.544
3.859	.535
4.441	.482
4.706	.453
5.000	.399
5.617	.293
5.706	0

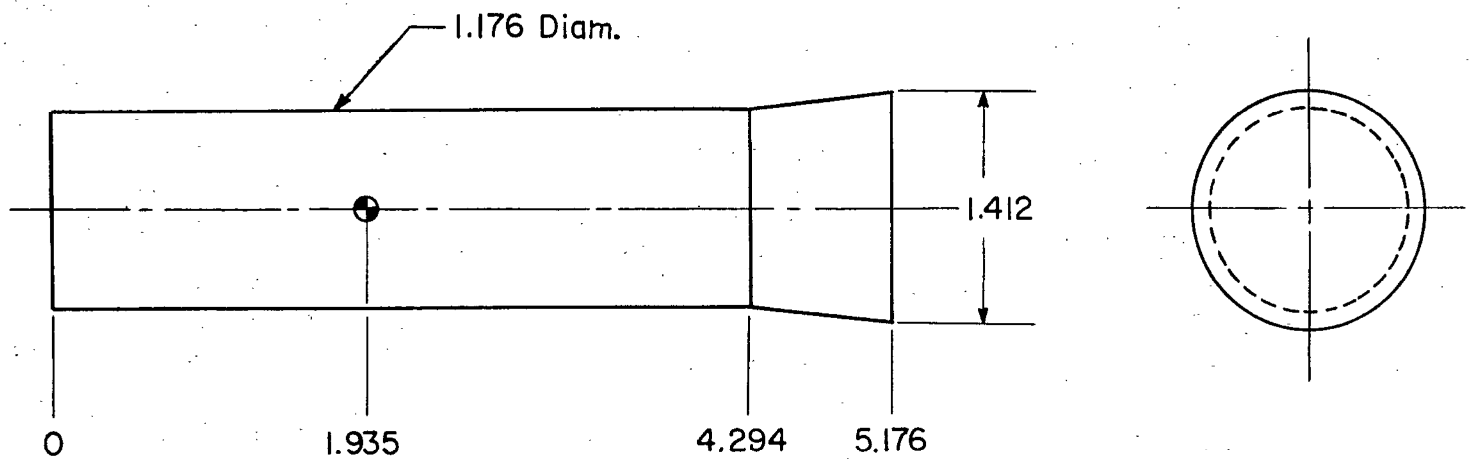
TABLE II.- SUMMARY OF PRETEST DATA

Test	Figure	Store	Tunnel conditions		Release conditions			Model conditions				Time interval of frames, milliseconds
			M	h_p, ft	α_f, deg	$\dot{z}_o$, ft/sec	Stroke ratio	W, lb	I_{Yg}, lb-in.^{2}	Center of gravity station, in.	Center of gravity station, Percent l	
1	3	Bluff TX-28	1.39	3,400	3	32	1	0.380	0.724	1.964	37.94	2.03
2	3	Bluff TX-28	1.39	3,400	3	22	1	.390	.717	1.926	37.19	2.02
3	3	Bluff TX-28	1.39	3,400	3	10	1	.402	.745	1.937	37.38	2.08
4	3	Bluff TX-28	1.39	3,400	3	22	3/4	.399	.730	1.934	37.35	2.03
5	4	Bluff TX-28	1.39	3,400	0	32	1	.398	.755	1.934	37.35	1.97
6	4	Bluff TX-28	1.39	3,400	0	25	3/4	.402	.744	1.930	37.27	1.99
7	4	Bluff TX-28	1.39	3,400	0	15	1/2	.402	.744	1.931	37.31	1.95
8	5	Bluff TX-28	1.98	29,000	3	30	1	1.120	2.075	1.960	37.87	1.95
9	5	Bluff TX-28	1.98	29,000	3	20	3/4	1.123	2.125	1.955	37.78	1.95
10	5	Bluff TX-28	1.98	29,000	3	11.5	1/2	1.125	2.040	1.965	37.95	2.00
11	6	Turnabout TX-28	1.39	3,400	3	32	1	.400	.790	2.184	38.89	2.05
12	6	Turnabout TX-28	1.39	3,400	3	22	1	.394	.775	2.176	38.78	2.08
13	6	Turnabout Tx-28	1.39	3,400	3	23	3/4	.395	.761	2.182	38.85	2.08
14	7	Turnabout TX-28	1.39	3,400	0	33	1	.395	.761	2.167	38.59	1.97
15	7	Turnabout TX-28	1.39	3,400	0	25	3/4	.396	.725	2.167	38.59	1.97
16	7	Turnabout TX-28	1.39	3,400	0	15	1/2	.397	.797	2.197	39.11	2.06
17	8	Turnabout TX-28	1.98	29,000	3	30	1	1.117	2.035	2.193	39.04	2.19
18	8	Turnabout TX-28	1.98	29,000	3	21	3/4	1.112	2.035	2.200	39.17	2.00
19	8	Turnabout TX-28	1.98	29,000	3	19	1/2	1.103	2.035	2.186	38.92	2.03



(a) Turnabout TX-28. $l/d = 4.78$.

Figure 1.- One-seventeenth-scale models of Republic F-105 stores. All dimensions are in inches.



(b) Bluff TX-28. $l/d = 4.40$; length of flare equal to 3/4 store diameter.

Figure 1.- Concluded.

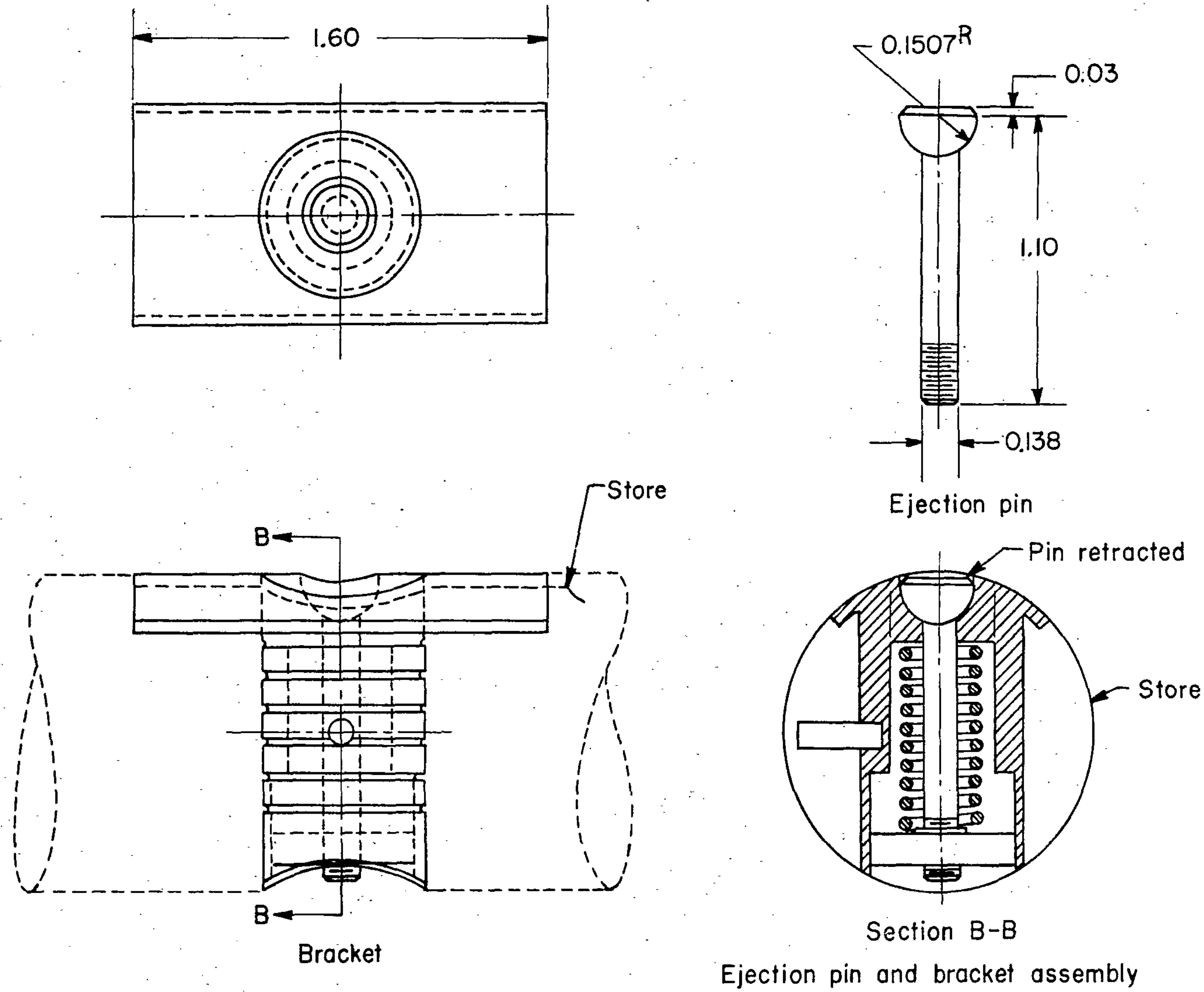
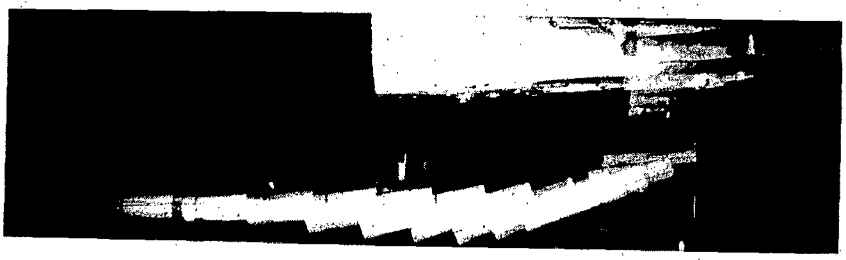


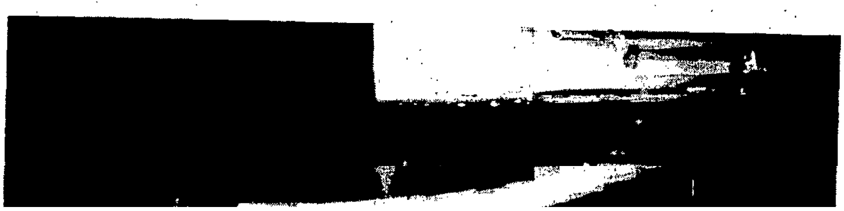
Figure 2.- Ejection pin and bracket.

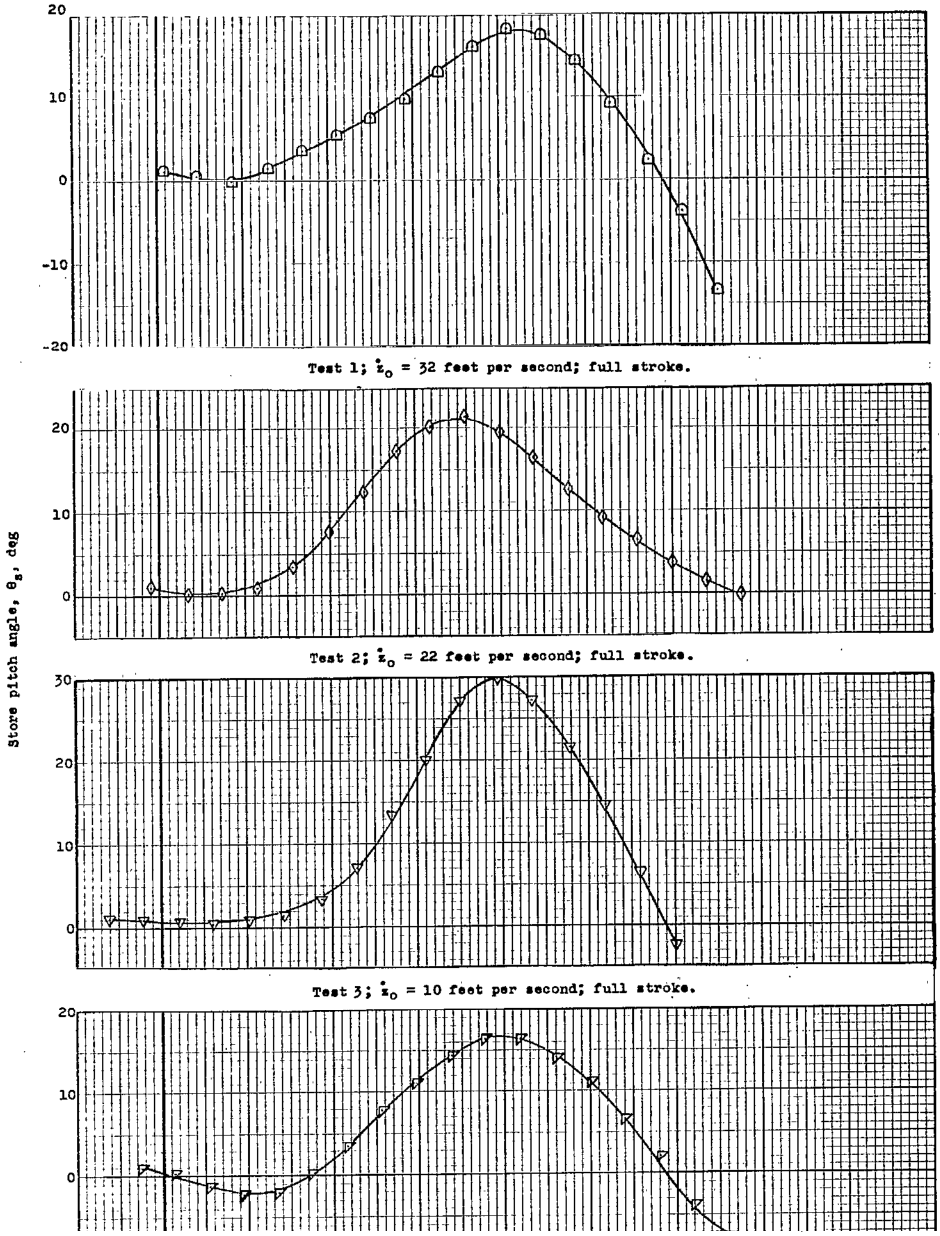
Test 1; $\dot{z}_o$ = 32 feet per second; full stroke. L-95685

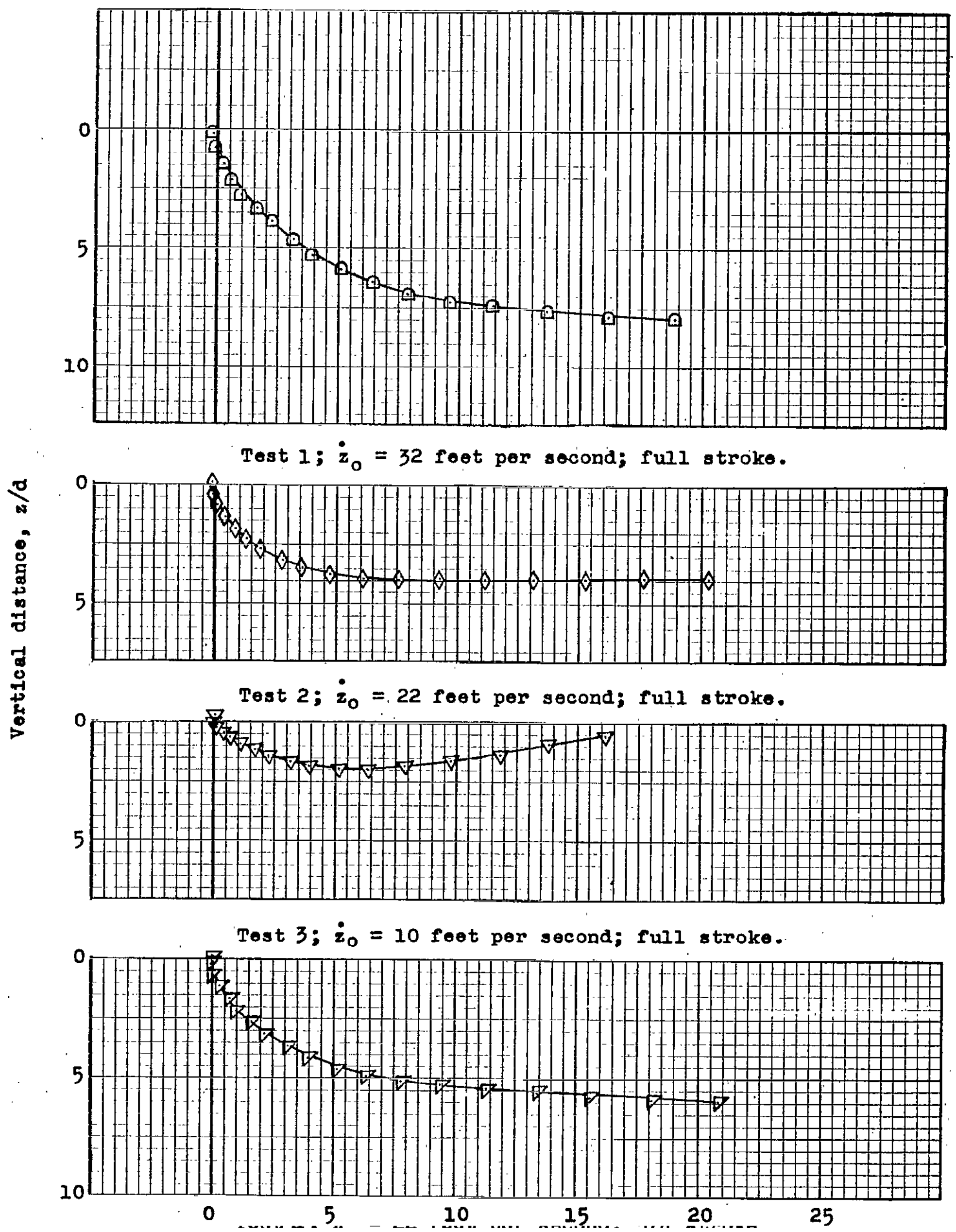


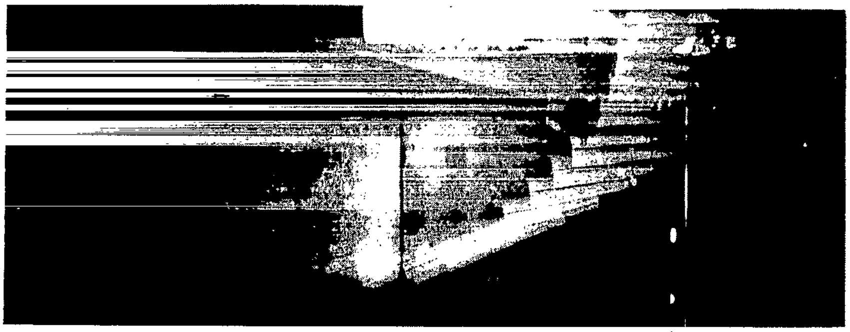
Test 2; $\dot{z}_o$ = 22 feet per second; full stroke. L-95687

Test 3; $\dot{z}_o$ = 10 feet per second; full stroke. L-95689

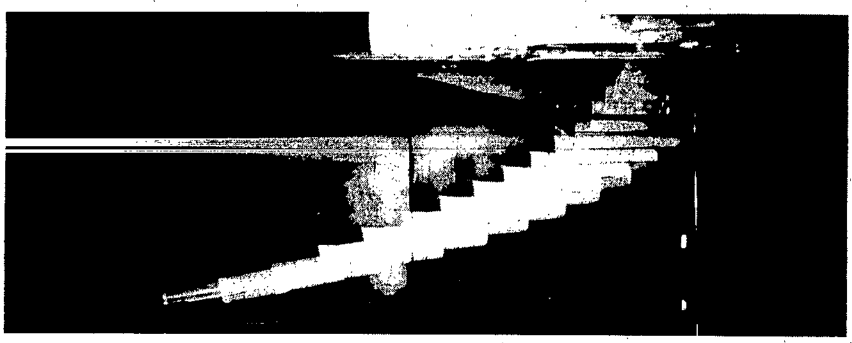



Store pitch angle, θ_s, deg
Test 1; $\dot{z}_o$ = 32 feet per second; full stroke.
Test 2; $\dot{z}_o$ = 22 feet per second; full stroke.
Test 3; $\dot{z}_o$ = 10 feet per second; full stroke.

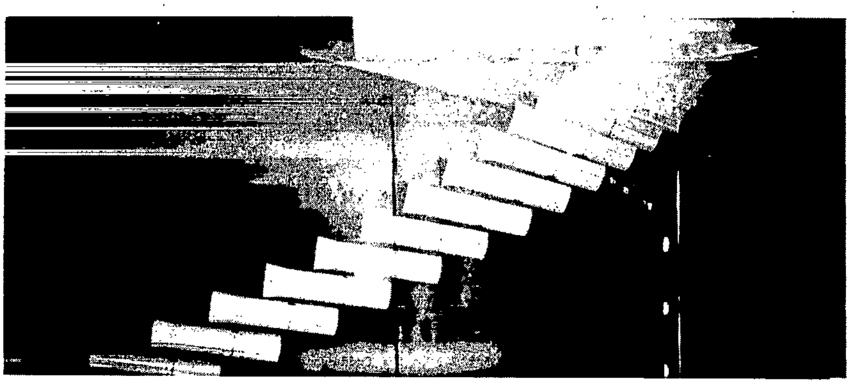

Vertical distance, z/d
0
5
10
Test 1; $\dot{z}_o$ = 32 feet per second; full stroke.
Test 2; $\dot{z}_o$ = 22 feet per second; full stroke.
Test 3; $\dot{z}_o$ = 10 feet per second; full stroke.
0
5
10
15
20
25

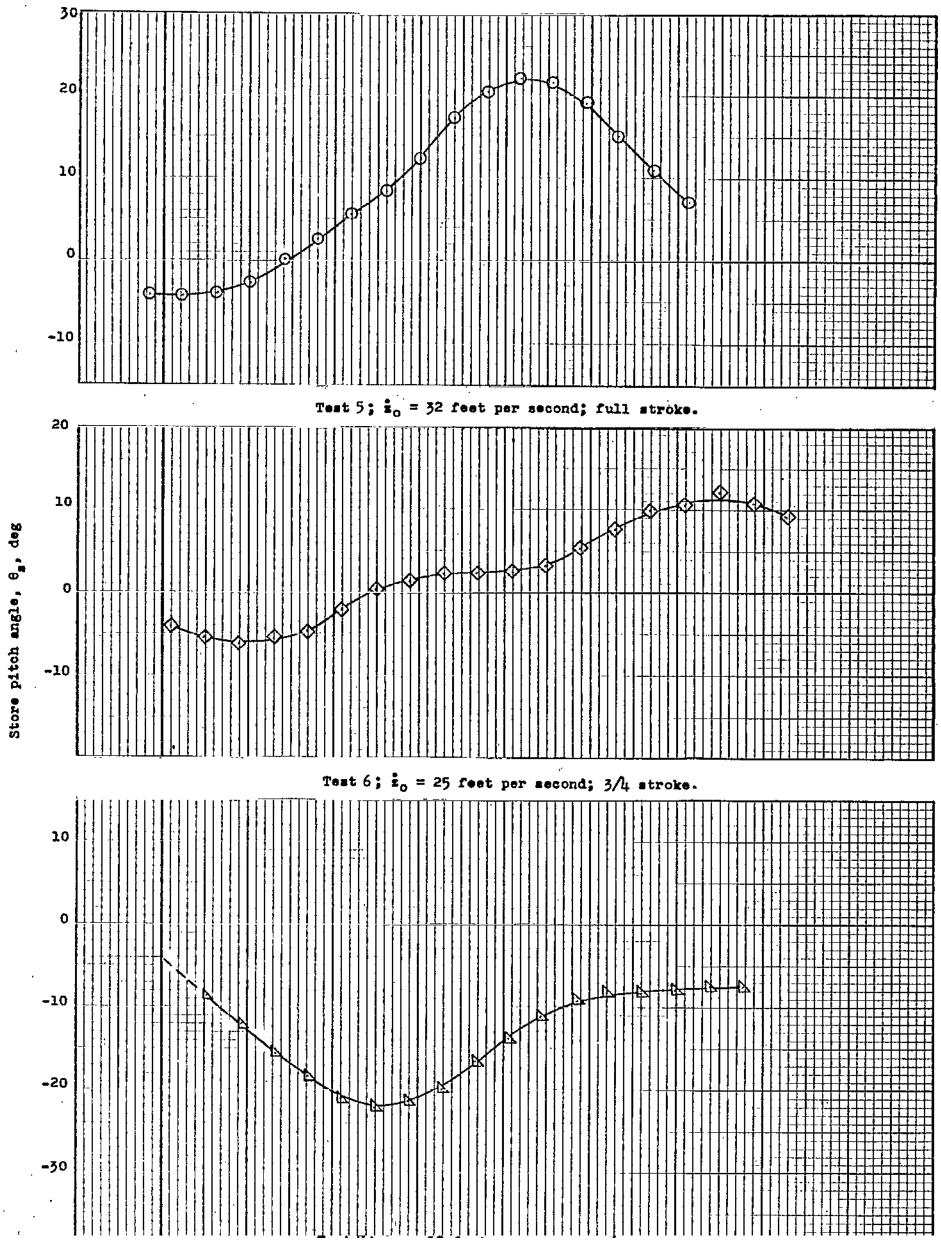


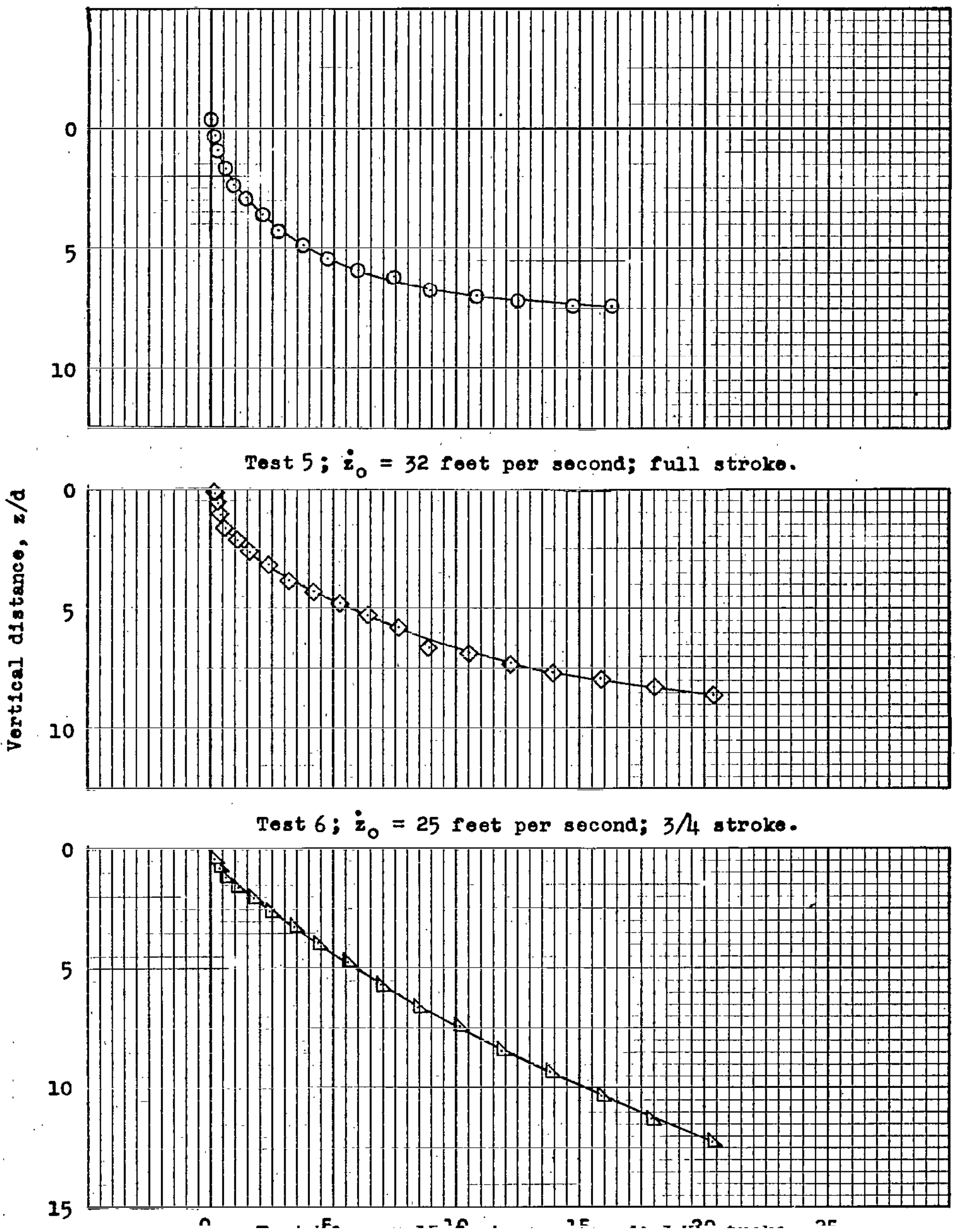
Test 5; $\dot{z}_o$ = 32 feet per second; full stroke. L-95679



Test 6; $\dot{z}_o$ = 25 feet per second; 3/4 stroke. L-95681

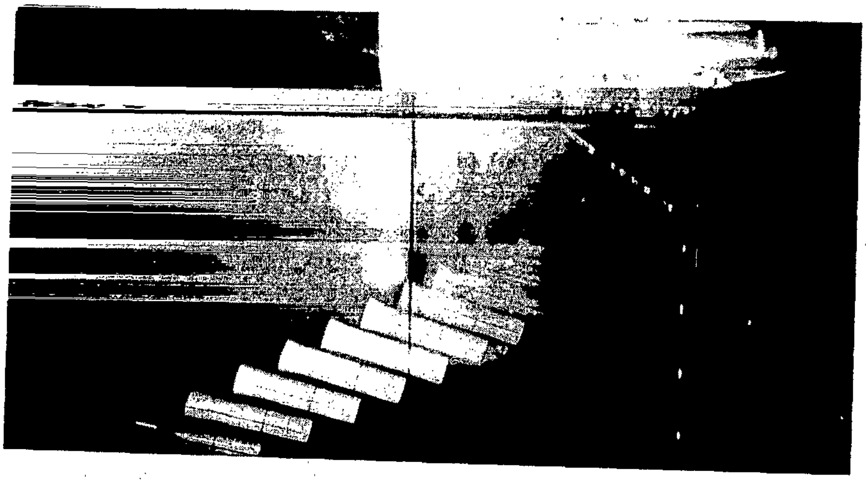



30
20
10
0
-10
Test 5; $\dot{z}_o$ = 32 feet per second; full stroke.
20
10
0
-10
Store pitch angle, θ_s, deg
Test 6; $\dot{z}_o$ = 25 feet per second; 3/4 stroke.
10
0
-10
-20
-30

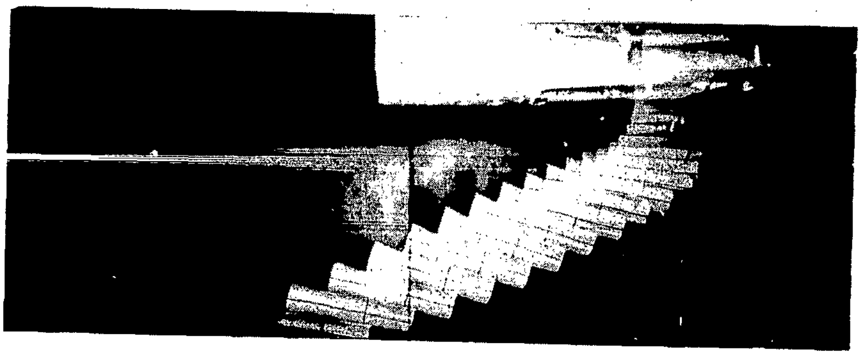


Test 5; $\dot{z}_o$ = 32 feet per second; full stroke.

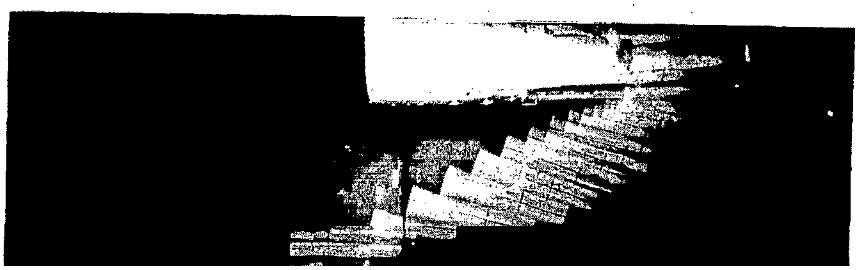
Test 6; $\dot{z}_o$ = 25 feet per second; 3/4 stroke.

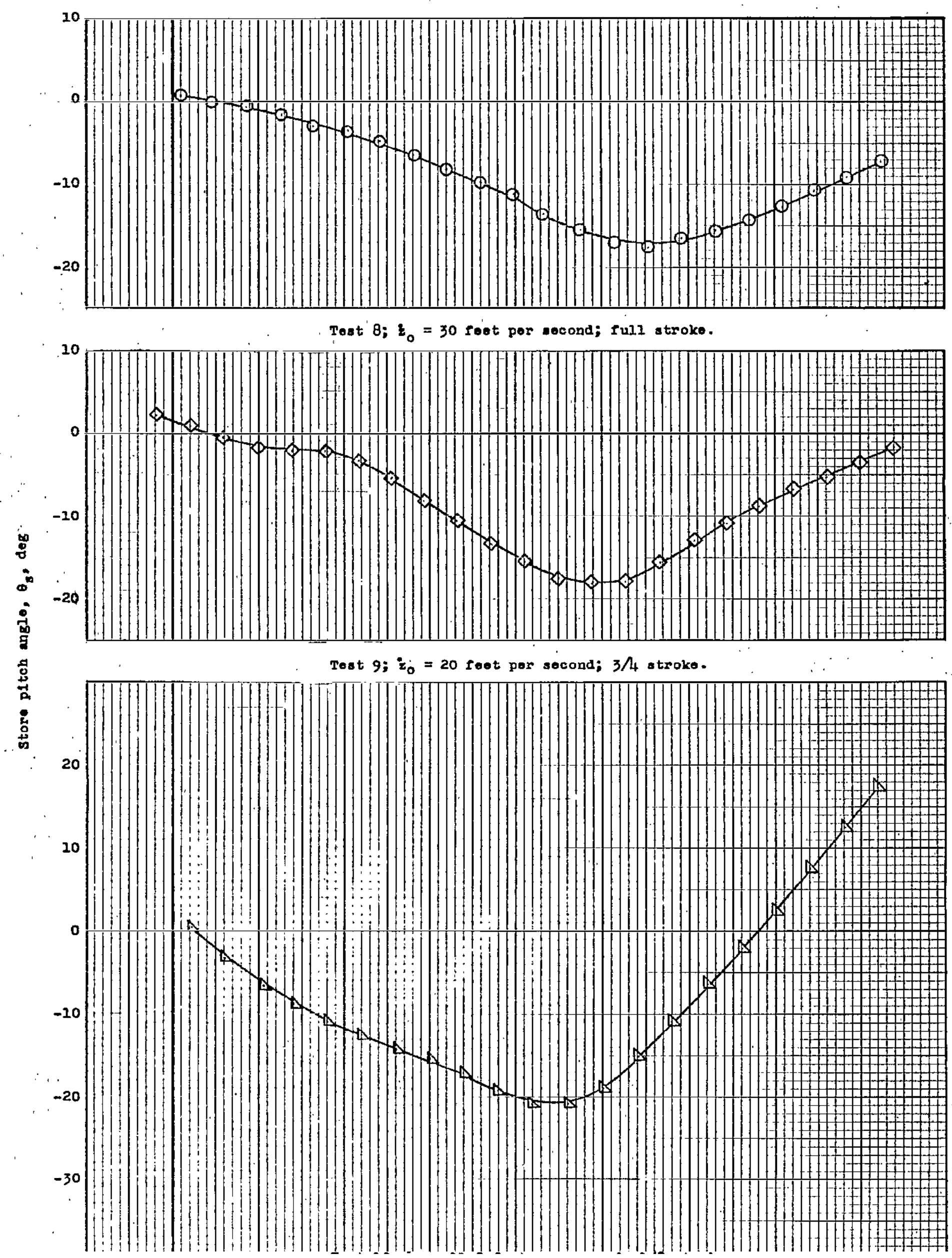


Test 8; $\dot{z}_o$ = 30 feet per second; full stroke. L-95692



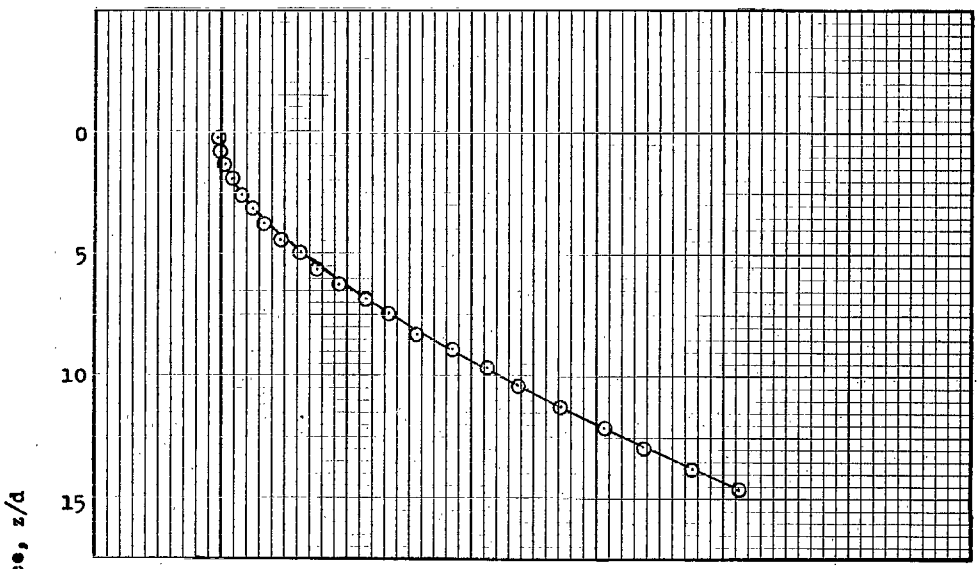
Test 9; $\dot{z}_o$ = 20 feet per second; 3/4 stroke. L-95694



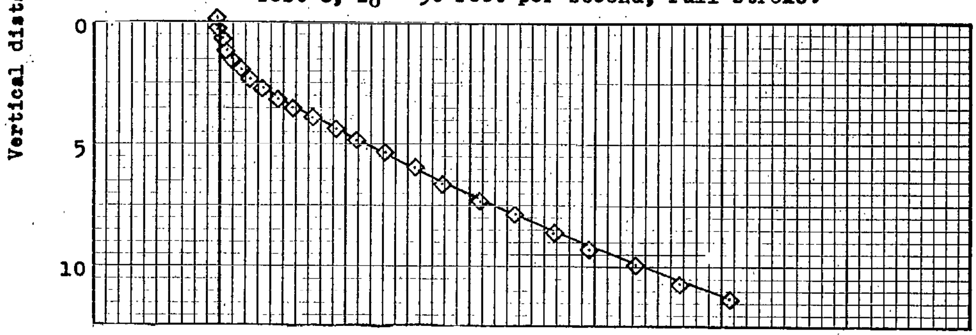


Test 8; $\dot{z}_o$ = 30 feet per second; full stroke.

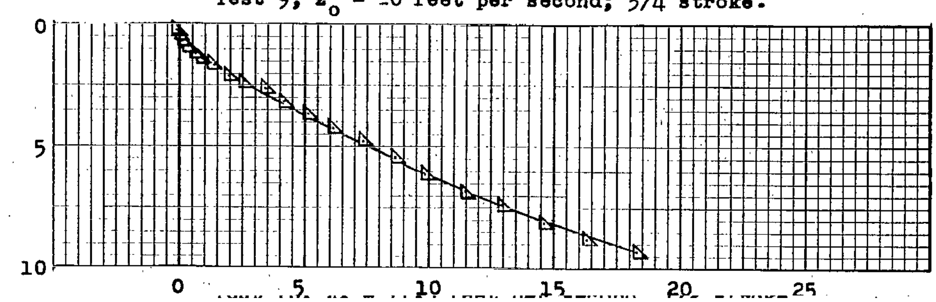
Test 9; $\dot{z}_o$ = 20 feet per second; 3/4 stroke.

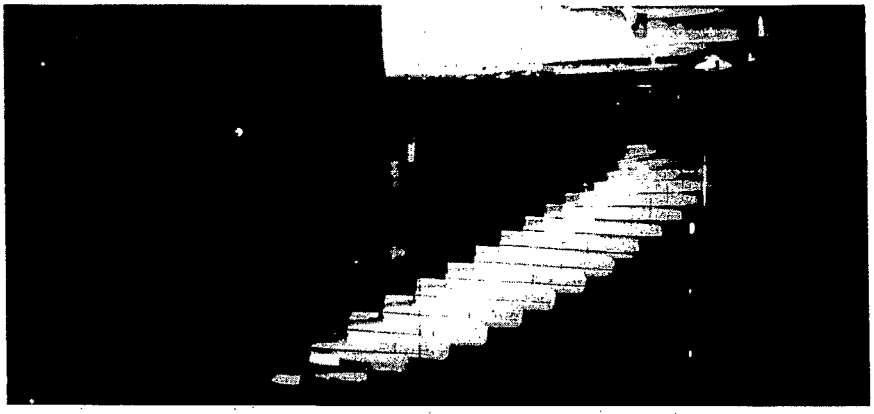


Test 8; $\dot{z}_o$ = 30 feet per second; full stroke.

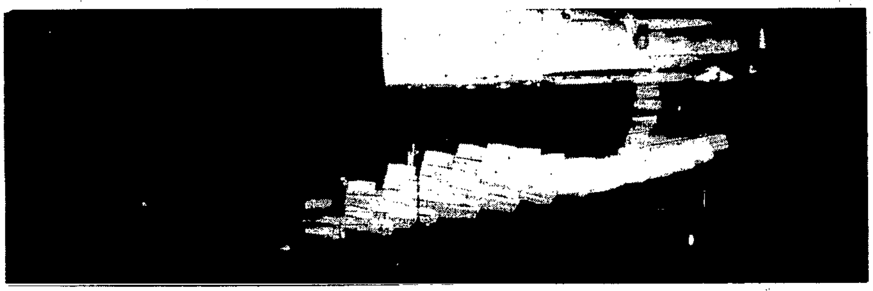


Test 9; $\dot{z}_o$ = 20 feet per second; 3/4 stroke.

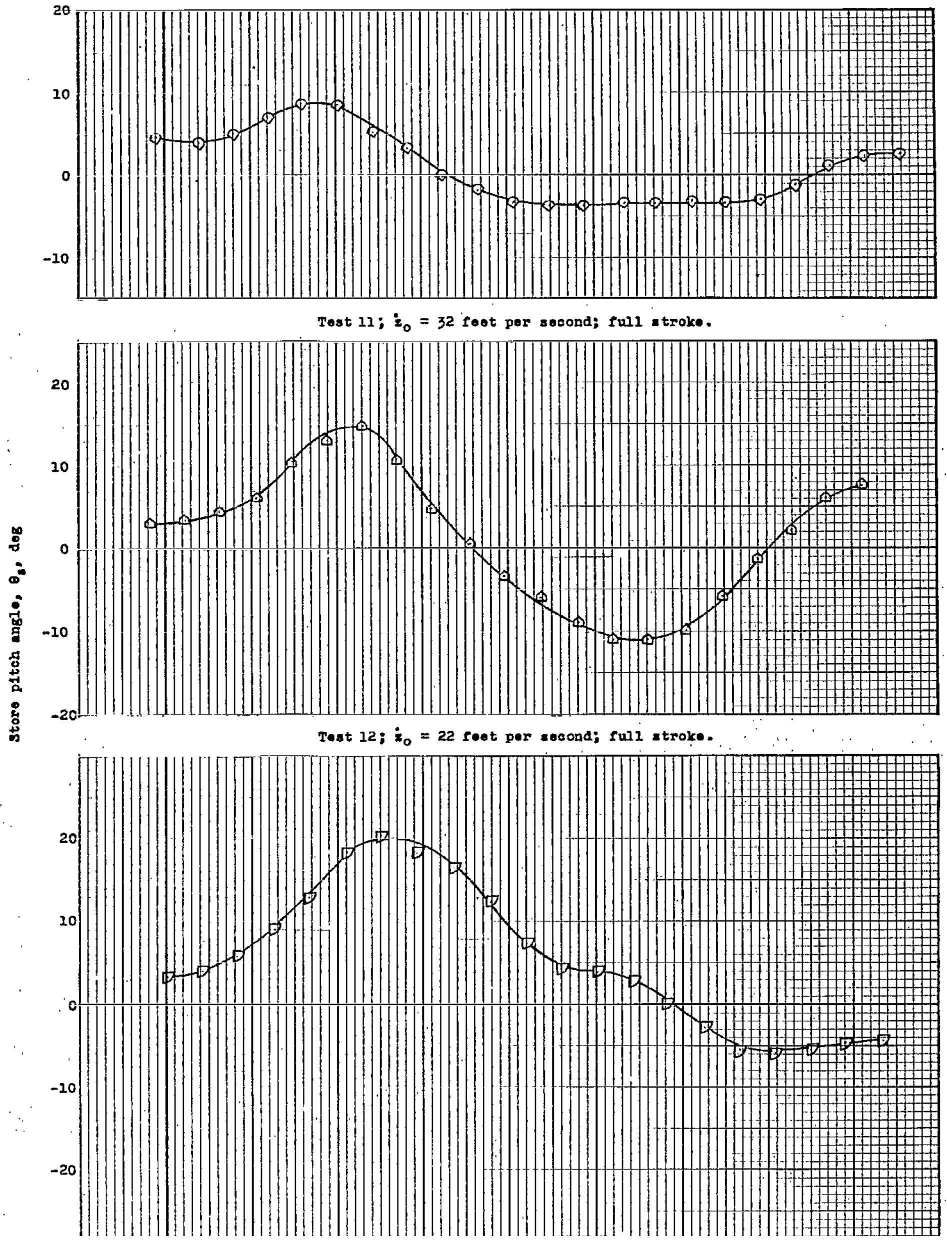


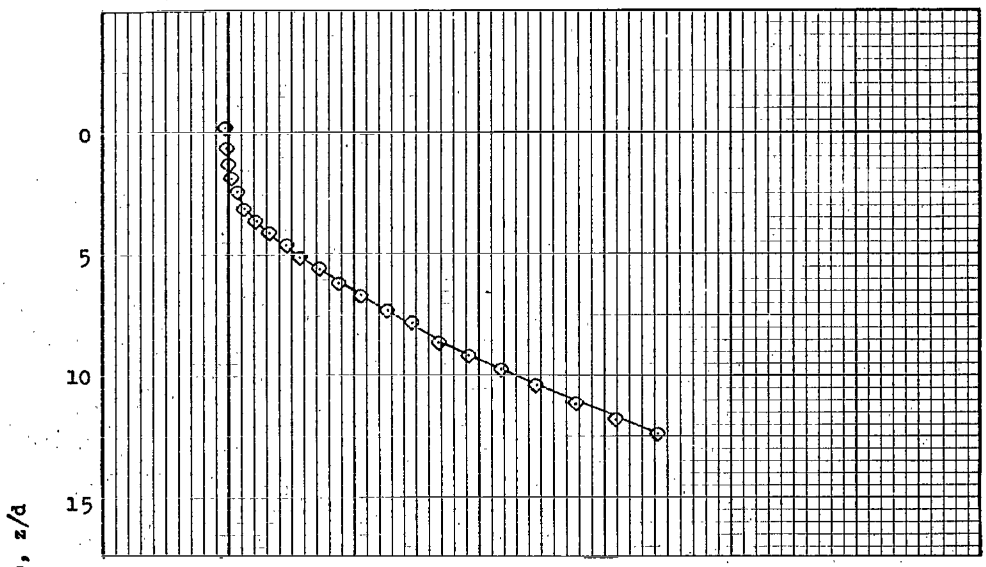


Test 11; $\dot{z}_o$ = 32 feet per second; full stroke. L-95686

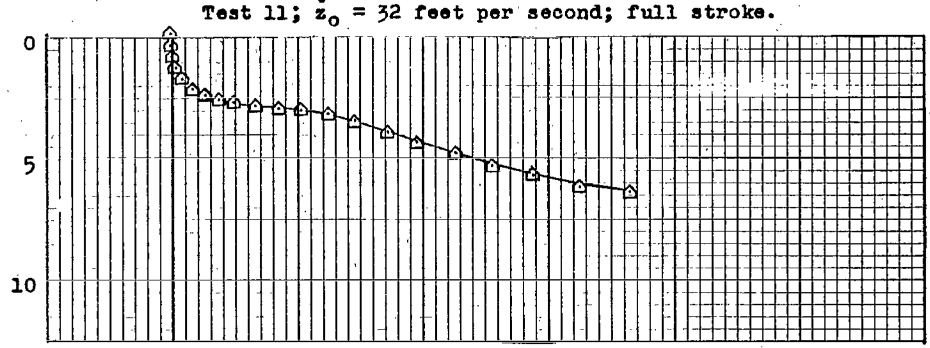


Test 12; $\dot{z}_o$ = 22 feet per second; full stroke. L-95688

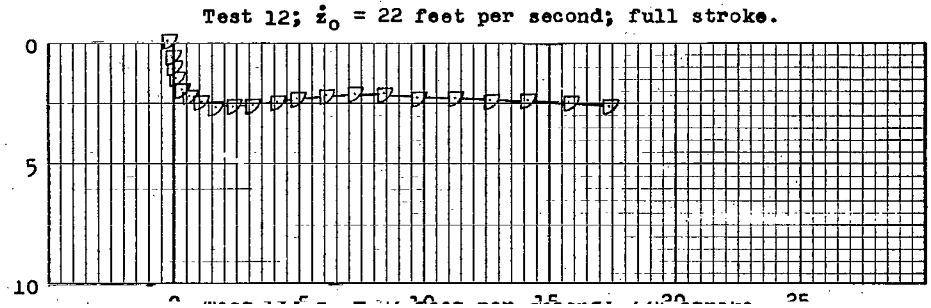

20
10
0
-10
Test 11; $\dot{z}_o$ = 32 feet per second; full stroke.
20
10
0
-10
-20
Store pitch angle, θ_s, deg
Test 12; $\dot{z}_o$ = 22 feet per second; full stroke.
20
10
0
-10
-20



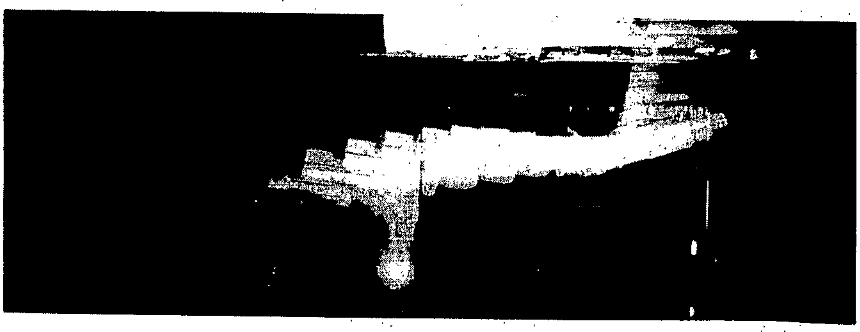
Test 11; $\dot{z}_o$ = 32 feet per second; full stroke.



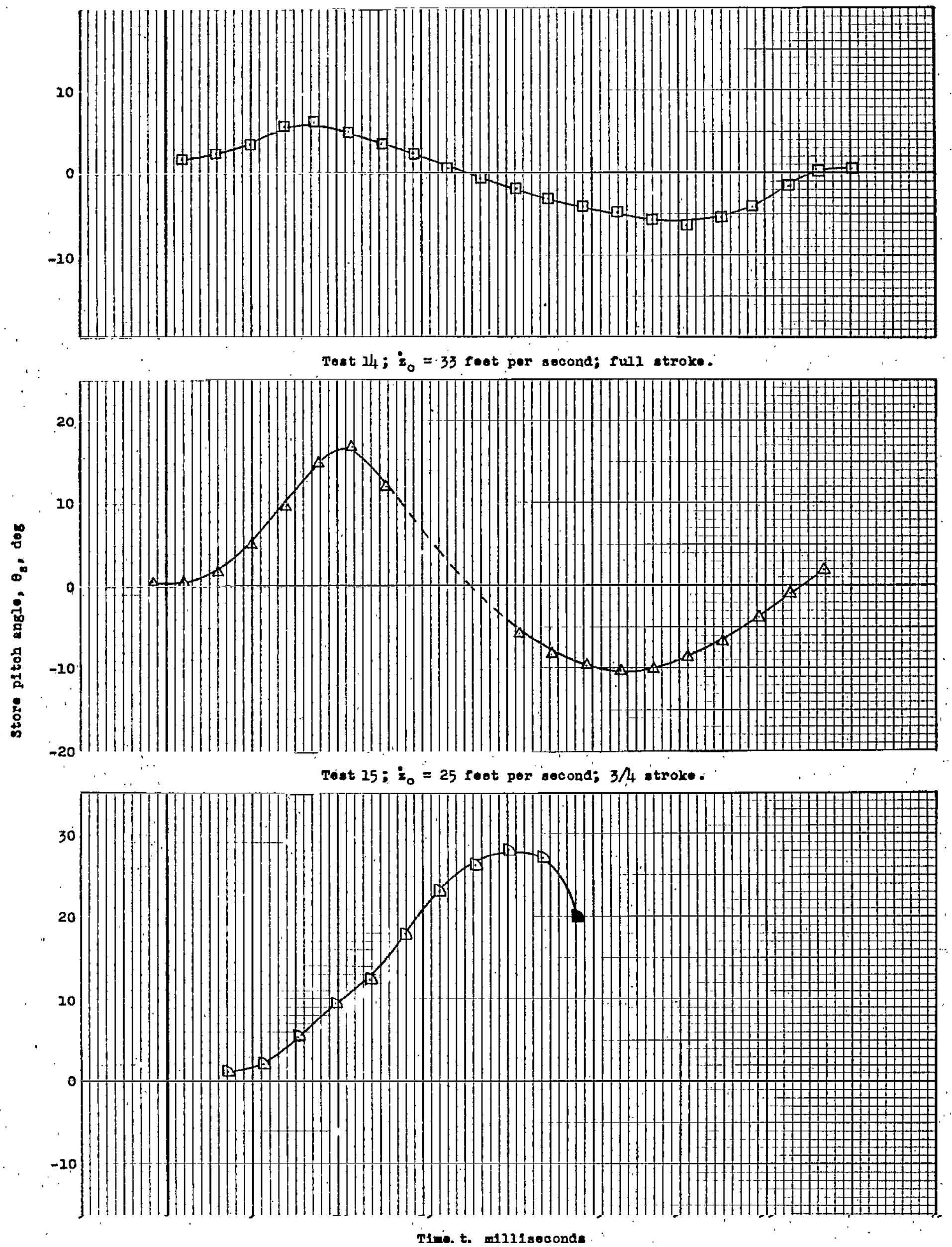
Test 12; $\dot{z}_o$ = 22 feet per second; full stroke.

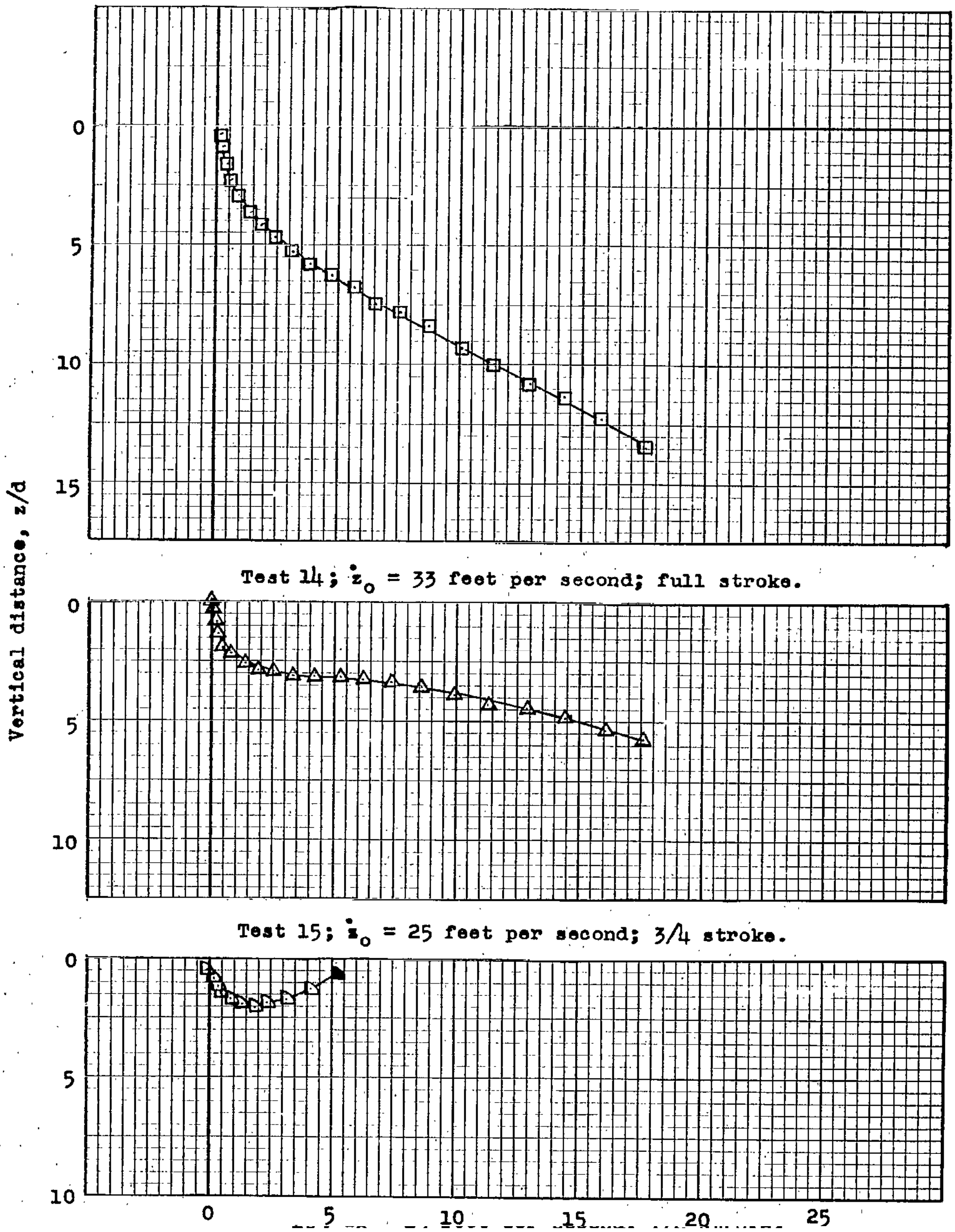


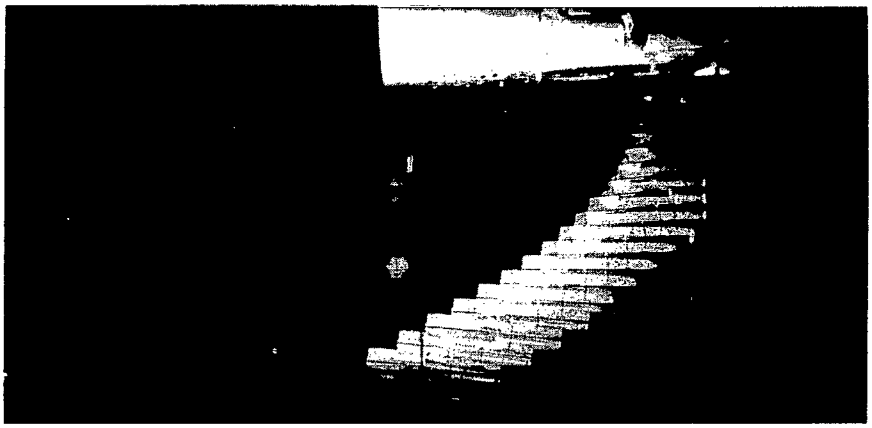
Test 14; $\dot{z}_o$ = 33 feet per second; full stroke. L-95680



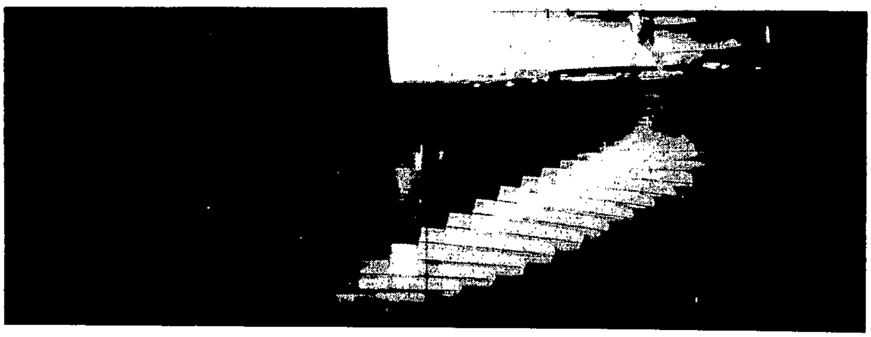
Test 15; $\dot{z}_o$ = 25 feet per second; 3/4 stroke. L-95682


10
0
-10
Test 14; ż$_o$ = 33 feet per second; full stroke.
20
10
0
-10
-20
Store pitch angle, θ$_s$, deg
Test 15; ż$_o$ = 25 feet per second; 3/4 stroke.
30
20
10
0
-10
Time, t, milliseconds

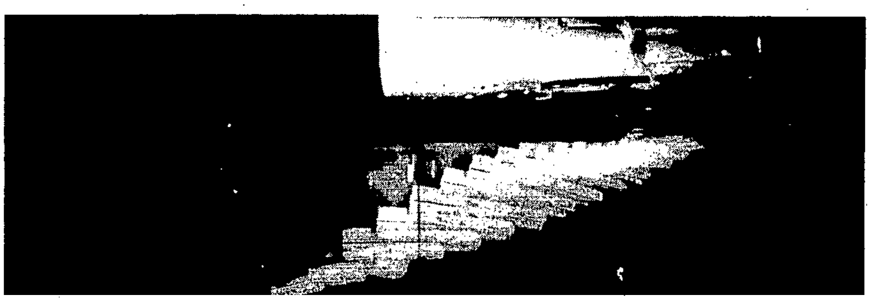

Vertical distance, z/d
0
5
10
15
Test 14; $\dot{z}_o$ = 33 feet per second; full stroke.
0
5
10
Test 15; $\dot{z}_o$ = 25 feet per second; 3/4 stroke.
0
5
10
0
5
10
15
20
25

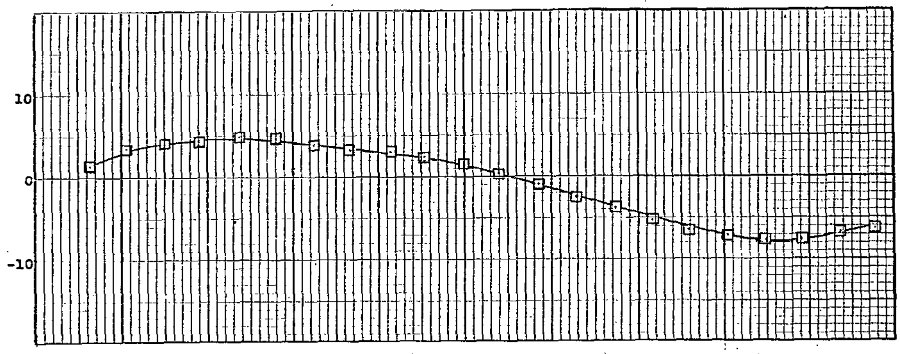


Test 17; $\dot{z}_o$ = 30 feet per second; full stroke. L-95693

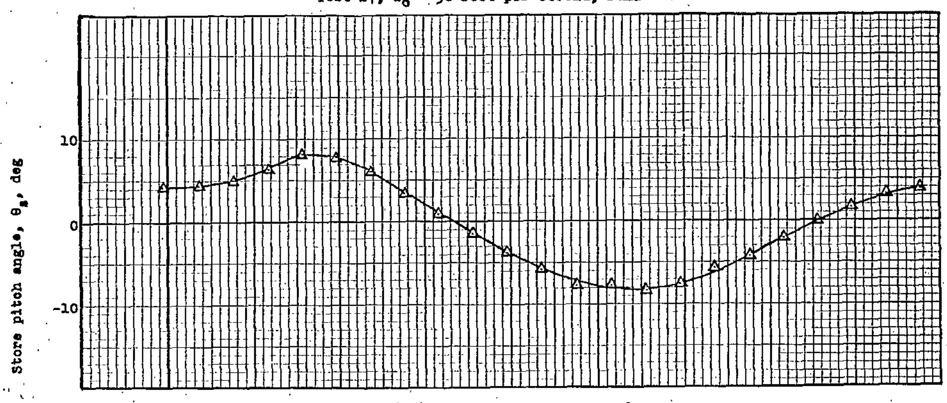


Test 18; $\dot{z}_o$ = 21 feet per second; 3/4 stroke. L-95695

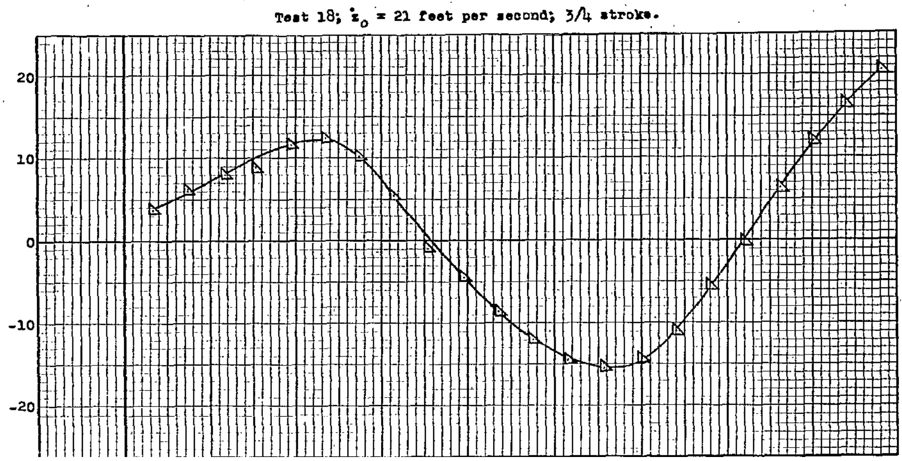


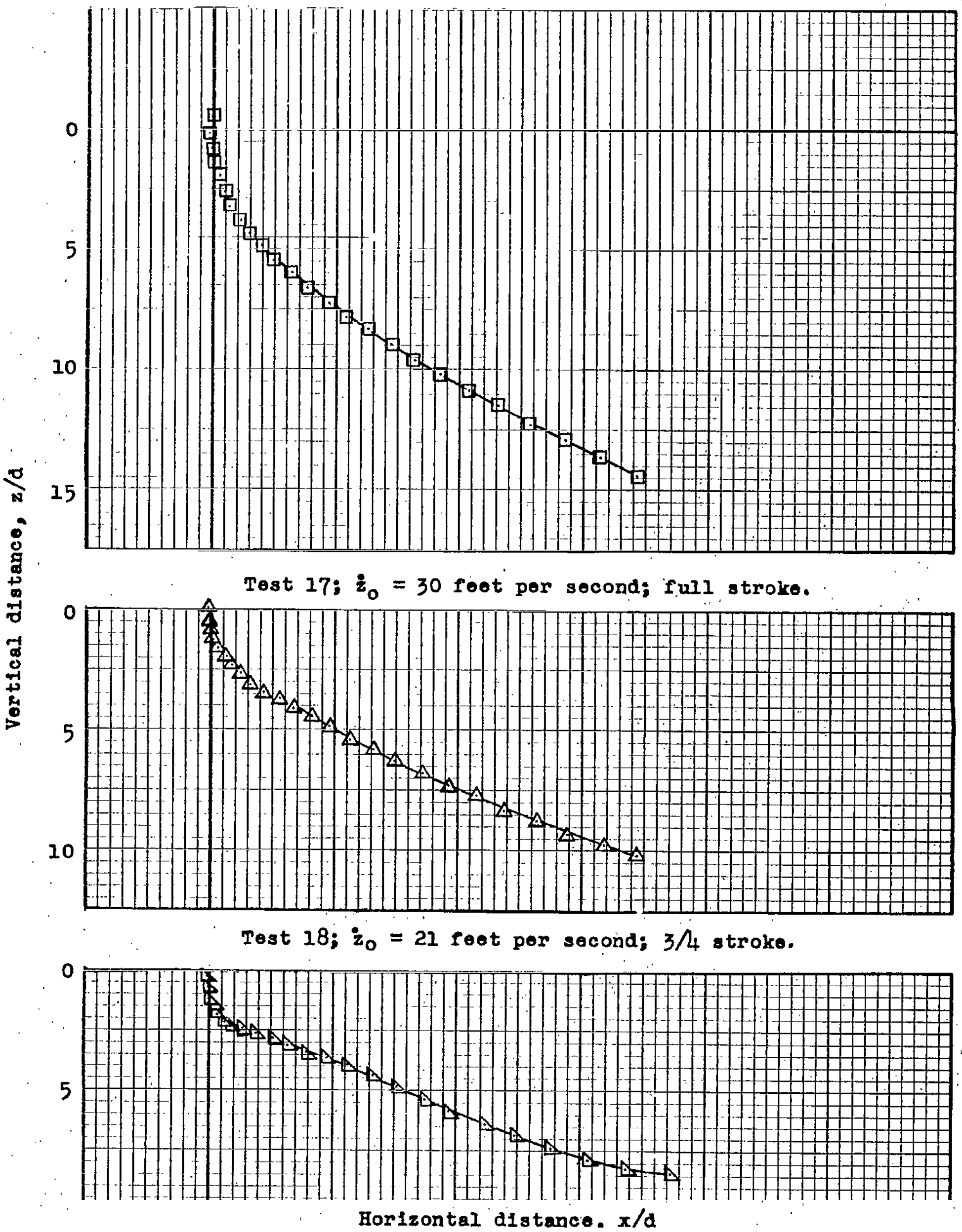


Test 17; $\dot{z}_o$ = 30 feet per second; full stroke.



Test 18; $\dot{z}_o$ = 21 feet per second; 3/4 stroke.




0
5
10
15
Vertical distance, z/d
Test 17; $\dot{z}_o$ = 30 feet per second; full stroke.
0
5
10
Test 18; $\dot{z}_o$ = 21 feet per second; 3/4 stroke.
0
5
Horizontal distance. x/d

 [redacted]

INVESTIGATION OF EJECTION RELEASE CHARACTERISTICS OF BLUFF TX-28 AND TURNABOUT TX-28 STORES FROM A 1/17-SCALE SIMULATED BOMB BAY OF THE REPUBLIC F-105 AIRPLANE AT MACH NUMBERS OF 1.39 AND 1.98

COORD. NO. AF-222

By John B. Lee

ABSTRACT

An investigation of ejection release characteristics of the Bluff TX-28 and the Turnabout TX-28 stores from a 1/17-scale bomb bay of the Republic F-105 airplane has been conducted in the 27- by 27-inch preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Va., at Mach numbers of 1.39 and 1.98. Ejections were made over a range of ejection velocities from 10 to 33 feet per second. The purpose of the investigation was to determine the conditions that affect these store ejections.

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