JULY 1957 P/WIND TUNNEL/139

CF-105 SPARROW 2 JETTISON TESTS

.07 SCALE

N. A. E. LOW SPEED WIND TUNNEL

UNCLASSIFIED

SECRET

AVRO AIRCRAFT LIMITED

A. V. ROE CANADA LIMITED

MALTON - ONTARIO

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SUMMARY

Low speed wind tunnel jettison tests using dynamic scale models have been completed for the Sparrow II missile installation on the CF-105 for level flight conditions. The full scale Mach number range simulated was from 0.2 to 0.85. The missile models were jettisoned from simulated extended launcher units mounted underneath the missile pack of the CF-105 .07 scale model.

The jettison tests showed that the missiles can be jettisoned safely from the aircraft with the normal or emergency dampers in operation throughout the flight envelope of the aircraft with extended missiles, except for manoeuvres involving sideslip angles greater than 1° and provided that when the high missiles are jettisoned the low missiles must either have been jettisoned or are stowed in the pack. When the aircraft sideslip angle is of the order of 5°, jettisoned high missiles will interfere with the extended empty low launchers; the initial rolling motion of the missiles will result in one of the missile wings hitting its own launcher rail; and the initial rolling motion may cause the missile to jam in the launcher and fail to release. The models generally tended to move straight outboard from the aircraft as they fell, and in one configuration where the high missiles were on the side towards which the aircraft was yawed, the models moved outboard at the level of the low launchers.

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1.0 INTRODUCTION

This report presents the results of wind tunnel jettison tests that were performed using .07 scale dynamic models of the Sparrow II missile. The dynamic models were jettisoned from launchers mounted underneath the missile pack of the .07 scale CF-105 model in the 6 x 10 ft. Low Speed Wind Tunnel at the National Aeronautical Establishment, Ottawa.

The investigation was made to evaluate the proposed jettison procedure with regard to interference (missile to airframe or missile to missile), and to determine the trajectories of missiles jettisoned from the aircraft under various level flight conditions.

2.0 MODELS

2.1 Missile Model Design

The dynamic scale models used in these tests were designed and manufactured by Avro Aircraft Limited. The design data is given in the Appendix to this Report.

The design of the models was based on dynamic similarity at three altitudes. The different models were designated by letters painted on the sides of the missiles as given below:

SIMULATED ALTITUDE	DESIGNATION
Sea level	L
20,000'	M
40,000'	H

The models were constructed to scale using combinations of various metals to obtain the desired dynamic properties. The missiles were made of aluminum tubes with steel or magnesium nose pieces, steel or aluminum wings, and aluminum or magnesium tail fins, depending upon the weight case. Final balancing of the models was obtained by means of lead inserts.

The actual and desired inertia properties are compared in Table 1. The roll inertias of all the models, and the sea level models in particular, are much larger than the required values. This error occurred because the model wings and tails could not be made light enough to satisfy inertia requirements and still be strong enough to avoid excessive damage when jettisoned in the tunnel.

2.2 Description of Missile Models

The dimensional characteristics of the Sparrow II models are given in Figure 1. One of the dynamic models is shown in Figure 2. The missile model was fitted to a launcher attached to the missile pack in the fuselage of the aircraft model (see Figures 5 and 8). The missile was held on to the launcher by means of a spring loaded slide located inside the launcher rail, that engaged the slotted pins on the missile model.

2.3 Description of Model Missile Pack

A sketch of the geometry of the missile pack with launchers and missiles in the extended position is presented in Figure 3.

The model missile pack was constructed of impregnated laminated mahogany. Individual launcher units could be screwed to the bottom of the pack. A photograph of thetop of the pack showing four launcher units installed is shown in Figure 4. Two of the launcher units which simulated the extended position of the fore and aft launchers (referred to as the high and low launchers in this report), are shown in Figure 5.

The spring - loaded slide inside the launcher rail was actuated by means of the solenoid on the top of the unit, and the linkage pictured in Figure 5. The connector plugs near the aft end of the unit provided electrical contact with the wires that can be seen in Figure 4. The operation of the missile pack during the tests is described in Section 3.1.

Since the doors on the bottom of the pack close after the launchers have been extended, there was no need to simulate a missile bay in the pack. Flat plates similar to the plate on a launcher unit were used to simulate the launcher retracted case. Models that simulated the stowed position of the missiles were also available, but were not used in this series of tests.

3.0 DESCRIPTION OF TESTS

3.1 Tunnel Test Arrangements

The .07 scale model of the CF-105 Mk. 1 aircraft was mounted in the 6 x 10 ft. test section by means of a tail strut and twin wing struts. The missile pack was fitted into the bottom of the fuselage in the location shown in Figure 6. A photograph of the aircraft model with Sparrow II missiles extended is given in Figure 7.

The arrangement of the electrical release system is also shown in Figure 7. The 8 volt supply required for the operation of the solenoids which actuated the release mechanism was obtained from a 12 volt battery connected to a switch box. The switching system was designed so that any missile jettison sequence could be simulated. To release one, or all, of the missile models the corresponding toggle switch in the upper row of four on the switch box was flipped up, and then the single release switch was used to jettison the models when desired.

A small light - bulb was connected in series with the release switch and the solenoid supply to provide an indication of time zero on the test films. This light - bulb was mounted on the outboard side of the starboard wing strut (see Figure 8).

A catch - screen of chicken wire was installed across the test section about 10 ft. behind the aircraft model. Cushions of rubberized packaging material were nailed to the floor and sides of the tunnel, and taped to the leading edge of the strut fairings. These cushions were located where necessary during the tests in an attempt to protect the models from excessive damage.

Two fastax high - speed cine - cameras were used to record each jettison test. One camera was set up outside of the test section on a line perpendicular to the longitudinal axis of the CF-105 model. Model motion was photographed through the windows of the large test section door on the starboard side of the aircraft. The second camera was placed on the tunnel floor at the entrance to the test section about 10 ft. from the missile models. The front camera was located on the longitudinal axis of the aircraft model for each case of yaw in the test program.

The film speed was set at approximately 850 frames per second for all of the tests. At this film speed the motion of the models at high tunnel speed was slowed down sufficiently to facilitete film analysis, and the motion at lower speeds was not reduced too much. The fastax timing unit operates from a 120 volt, 60 cycle a.c. supply which results in 120 timing marks on the film per second. The time between the beginning of one mark and the starting point of the next will be 0.00833 seconds.

At the beginning of a test run the cameras were started and allowed to run for two seconds in order to reach the desired film speed before the photographic lighting system was turned on. The release switch was flipped up just after the lights came on, and the cameras were stopped when the models hit the catch - screen.

The missile models were always checked for wind off free fall before proceding with a test run. Models that could not be made to fall satisfactorily or that were too loose, were not used.

3.2 Tunnel Operating Conditions

The tunnel operating conditions are given in the Appendix. The basic parameter for tunnel operation is the indicated dynamic pressure,

$$q_{dial} = 1.069\ q_{true}$$

4.0 TEST PROGRAM

4.1 Configurations Tested

The missile-launcher combinations were arranged in the following configurations for these tests:

(1) Four missiles down, low missiles jettisoned.

(2) Low launchers down, high missiles down and jettisoned.

(3) High missiles down and jettisoned.

The three configurations are illustrated in Figures 8, 9 and 10.

Configurations (1) and (2) were arranged to simulate the proposed jettison sequence. With all missiles down, the low missiles are jettisoned first. As the low launchers start to retract, or at some time before they are fully retracted, the high missiles are jettisoned. The third configuration was included to simulate jettison of the high missiles after the low launchers have been retracted.

4.2 Outline of Program

The maximum tunnel test section true dynamic pressure that could be obtained during this test program was 70 psf. This limited the maximum full scale Mach Number that could be simulated for the three altitudes in the program.

Ten level flight conditions were simulated including:-

Sea Level at M = .80, .70, .50, .20,
20,000 ft. at M = .85, .70, .50,
40,000 ft. at M = .85, .70, .50.

The three configurations were tested according to the following basic program:

(a) 0° yaw at the ten flight conditions.

(b) $\pm 5^{\circ}$ of yaw at the following flight conditions:

Sea Level at M = .80, .50.
20,000 ft. at M = .85, .50.
40,000 ft. at M = .85, .50.

5.0 TEST RESULTS

The jettison tests performed in this series are listed in the schedule of test films given in Table 2. The high speed test films were studied by projecting them at 16 frames per second and also by means of a frame by frameanalysis using a film viewer giving about twenty times magnification. The results of this analysis, with particular emphasis on initial motions and specific cases of interference, are summarized in Table 3.

5.1 Discussion

The test results provided two main points of interest for consideration: the rolling motion of the missile models just after release and the effects of this rotation, and the lateral motion of the missiles.

The initial rolling and yawing motion of the Sparrow missile models summarized in Table 3 resulted from local cross-flow components of the flow field underneath the missile pack. This flow field is illustrated in Figure 11 by wool tufts attached to the lower surface of the missile pack. The initial rolling, yawing and lateral motion of the missiles could be predicted from these flow patterns, and the test show that the models performed as would be expected.

When the initial rolling rate was high and the missiles rolled through 45° before falling a missile wing semi-span below the level of the launchers, the fins of the models came into contact with the launcher rail. The actual cases of this type of missile to airframe interference are listed in Table 3. The models appeared to roll into their launchers in a random manner for the configurations tested, except that contact generally occurred when the missile was initially in a strong cross-flow field. Since the missile models rolling moment of inertias were high, the full scale missiles will roll faster than the model missiles. Thus it may be assumed that the full scale missiles will always interfere with the launchers in the presence of a strong cross-flow field.

Film strip reproductions of some of the better high speed film records for Configurations (1) and (2) are given in Figures 12, 13, and 14. The conditions described above occurred for the starboard inboard model in Figure 12(a) (in this case the model just brushed past the launcher), and for the starboard outboard model in Figure 14(a).

In five of the runs one of the missiles failed to release (Runs 34, 38, 42, 53, 60). In two of these cases the test films clearly showed that the release did not operate (Runs 34 and 60). The three remaining cases involved the port inboard model and the release mechanism appeared to have operated in each case. During the test program considerable difficulty was encountered in getting models to stay up in the port inboard launcher; they had to be firmly fitted to the launcher. It will be noted that these tests were always successful when they were repeated - an attempt had been made not to force the missiles into the launchers the second time. On this basis, the failure to jettison could be accounted for by excessive mechanical interference.

In one test however, (Run 38), the model rolled slightly after the release operated and then hung up. This suggests that the pins on the missile actually jammed in the launcher. There were also other cases (see Table 3(c), (e), (h), (i)), where the model hesitated before it fell free of the launcher suggesting that the pins tended to jam in the launcher rail. Thus it appears that the missiles may fail to release especially if the missile is in a strong cross-flow field such as occurs in the outboard positions when the aircraft is yawed towards that side.

For the two tests in Configuration (3) (Runs 34 and 60) where one of the missiles failed to jettison, the aircraft was yawed in the direction which caused the jettisoned missile to move laterally toward the aborted missile and hit it.

In Configuration (2) where the high missiles were jettisoned with the low launchers down, the jettisoned missiles interfered with the low launchers when the aircraft was yawed, especially when the aircraft was yawed to port. This effect is illustrated by the film records reproduced in Figure 13 (aircraft yawed 5° port) where both jettisoned missiles appear to interfere with the low launchers (the lower port fins of the missiles hit the low launchers). The actual contact can best be noted when the films are projected. In Figure 14(a) (aircraft yawed 5° starboard) the contact between the port inner missile model and the starboard inner launcher is very clear.

There was no definite pattern to this missile to airframe interference with respect to Mach number, altitude or angle of attack. It may be assumed for the full scale case that the high missiles will interfere with the extended empty low launchers when jettisoning occurs with the aircraft yawed to angles of the order of 5°. If the high missiles were jettisoned in this configuration from the aircraft and the low launchers were starting to retract, there could be rather disasterous results. In this case, the low launchers should be fully retracted before the high missiles can be safely jettisoned.

5.2 Model Trajectories

At zero yaw in the three configurations the models generally moved slightly outboard towards the nearest side of the aircraft as they fell away from it. In some cases the models just fell straight down below the aircraft. The high missiles tended to move further outboard than the low missiles. With the aircraft yawed both missiles moved in the direction of yaw and were swept well outboard of the aircraft. In Configuration (2) and (3), with the aircraft yawed 5° starboard, the starboard outer, high missile moved outboard either at or just below the level of the low launchers.

The outboard motion of the models was predominant; they only moved slightly aft of their original position. The initial rolling motion usually stabilized or slowed up as the models moved clear of the aircraft.

Typical trajectories after the release are shown in Figures 12, 13, and 14. The three runs reproduced are for the same altitude and Mach number so that they can be compared. In the front views the models disappear from view at a distance approximately nine inches (.2b) below the aircraft model. In Figure 14, the worst case of the severe outboard movement of the starboard outer missile is illustrated.

In the tunnel, the models shown in Figure 12 hit the floor at about a half aircraft model wing semi-span outboard and slightly aft of the missile pack; for Figure 13 the models hit the floor below the aircraft, slightly outboard of the side of the fuselage; and for Figure 14 the starboard outer model hit the tunnel wall two feet off the floor at a point behind the wing struts. The yawed models usually hit the tunnel wall a few inches from the floor at the wing strut position ($.27\bar{c}$).

None of the models jettisoned interfered with the aircraft in any other way than the missile launcher interference already discussed. The models which came closest to the aircraft wing were the high, starboard outer models.

6.0 CONCLUSIONS

Based on the dynamic tests of .07 scale models, the following conclusions for the jettison characteristics of the Sparrow II missile from a full scale CF-105 can be made:-

1. For flight conditions with zero sideslip ($\pm 1^0$):

   (a) The missiles will roll as soon as they are free from the launchers and will tend to interfere with their own launcher rail, especially for an outboard position where a cross flow exists with increasing angle of attack. If a missile rolls thru more than 45^o before falling a missile wing span below the level of its launcher, one set of the upper fins will come into contact with the launcher rail. The severity of this contact is difficult to determine from the jettison tests.

   (b) The high missiles will not interfere with the extended empty low launchers when they are jettisoned in this configuration.

2. For flight conditions with 5^o sideslip:

   (a) The missiles will interfere with their own launchers as described above.

   (b) The jettison tests indicated that jettisoned high missiles will interfere with the extended empty low launchers with the aircraft yawed, especially to port for this configuration.

   (c) Assuming that the mechanical release mechanism on the models reasonably simulated the full scale design, the jettison tests showed that the initial rolling motion may cause the missiles to jam in the launchers and fail to release for those positions where there is a strong cross-flow. This condition would occur for an outboard position when the aircraft is yawed towards that side.

6.0 CONCLUSIONS Cont'd.

3. The jettisoned missiles will not interfere with the aircraft in any way other than outlined above for the configurations tested. The configuration in which the high missiles would be jettisoned before the low missiles was not tested because the geometry of the extended missile arrangement is such that there would be excessive missile-to-missile interference.

4. The missiles will, in general, tend to move straight outboard from the missile pack as they fall below the aircraft. If the aircraft is yawed to starboard when the high missiles are jettisoned, the starboard outer missile will move almost straight outboard at the level of the low launchers.

Based on the above jettison characteristics, the following recommendations for the Sparrow II missile jettison procedure for the CF-105 are presented:

1. For flight conditions with zero sideslip ($\pm 1^\circ$):

   (a) The missiles can be jettisoned safely from the aircraft (assuming that the missiles' rolling contact with their own launchers is not damaging), with the normal or emergency dampers in operation throughout the flight envelope of the aircraft with extended missiles, provided that when the high missiles are jettisoned the low missiles either have been jettisoned, or are stowed in the pack.

2. For flight conditions with 5° sideslip:

   (a) The missiles can be safely jettisoned in this case provided that the jettison sequence is such that the empty low launchers have been fully retracted before the high missiles are jettisoned.

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APPENDIX

DESIGN AND TEST DATA FOR SPARROW II

JETTISON TESTS

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DESIGN AND TEST DATA FOR SPARROW II JETTISON TESTS

MODEL SCALE: $\ell_m = .07\ \ell_{fs}$

DESIGN AND TEST DATA:

SIMULATED ALTITUDE Ft.	FULL SCALE MACH NUMBER	FULL SCALE T.A.S. Kts.	TUNNEL T.A.S. f.p.s.	TUNNEL DYNAMIC PRESSURE q_{dial} p.s.f.	AIRPLANE ANGLE OF ATTACK degrees	SPARROW MODEL WEIGHT lbs.
S.L.	.2	132	59	4.4	12.8	.148
	.5	331	148	27.7	2.3	
	.7	463	207	54.4	1.3	
	.85	562	251	80.0	.9	
20,000	.5	307	137	23.9	5.4	.278
	.7	430	192	46.9	2.6	
	.85	522	233	69.1	1.8	
40,000	.5	287	128	20.8	13.7	.606
	.7	401	179	40.9	6.7	
	.85	487	218	60.3	4.4	

DESIGN AND TEST DATA: (Continued)

Model radii of gyration, with reference to model C.G. position:

k_x = .25 in.

k_y = 2.60 in.

k_z = 2.60 in.

Model C.G. to be in the same positions as for the full scale body.

Models to be geometrically similar to full scale bodies except for small details.

Model time intervals along a trajectory will be = $\sqrt{.07}$ full scale values.

NOTE:

(1) Sparrow model weights were based on a full scale weight of 432 lbs.

(2) Airplane angle of attack taken as angle to trim at T.A.S. (level flight with C.G. at .31 $\bar{c}$).

(3) $q_{true} = .936\ q_{dial}$

TABLES.

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REPORT NO.	P/WIND TUNNEL/139
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TABLE I

DYNAMIC PROPERTIES OF MODELS

SIMULATED ALTITUDE	PROPERTY	REQUIRED VALUE	ACTUAL VALUE	% ERROR
Sea Level	Weight, W	.148 lb.	.148 lb.	
	Roll Inertia, Ixx	.00925 lb.in^2	.02212 lb.in^2	139
	Pitch Inertia, Iyy	1.0005	1.0004	
	Yaw Inertia, Izz	1.0005	1.0004	
20,000	W	.278	.278	
	Ixx	.01738	.02776	59.8
	Iyy = Izz	1.879	1.875	
40,000	W	.606	.606	
	Ixx	.03787	.06021	60.5
	Iyy = Izz	4.096	4.087	

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TABLE II

.07 SCALE SPARROW II JETTISON TESTS

SCHEDULE OF TEST FILMS

In the complete film of the tests, the test films will appear in the same numerical order as the film numbers given below. The Avro reference number for the CF-105 Sparrow jettison film is - 20-6

1.0 CONFIGURATION

Four missiles down
Low missiles jettisoned

1.1 Aircraft at Zero Yaw ($\psi = 0^{\circ}$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
1	Sea Level	.20
2		.50
3		.70
4		.80
5	20,000'	.50
6		.70
7		.85
8	40,000'	.50
9		.70
10		.85

1.2 Aircraft Yawed 5° Starboard ($\psi = 5^{\circ}$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
46	Sea Level	.50
47		.80
48	20,000'	.50
49		.85
50	40,000'	.50
51		.85

1.3 Aircraft Yawed 5° Port ($\psi = -5°$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
66	Sea Level	.80
67	20,000'	.85
68	40,000'	.85

2.0 CONFIGURATION

Low launchers down
High missiles down and jettisoned

2.1 Aircraft at Zero Yaw ($\psi = 0°$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
11	Sea Level	.20
12		.50
13		.70
14		.80
15	20,000'	.50
16		.70
17		.85
18	40,000'	.50
19		.70
20		.85

2.2 Aircraft Yawed 5° Port ($\psi = -5°$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
38, 39	Sea Level	.50
40		.80
41	20,000'	.50
42, 43		.85
44	40,000'	.50
45		.85

2.3 Aircraft Yawed 5° Starboard ($\Psi = 5^\circ$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
52	Sea Level	.50
53, 54		.80
55	20,000'	.50
56		.85
57	40,000'	.50
58		.85

3.0 CONFIGURATION

High missiles down
and Jettisoned.

3.1 Aircraft at Zero Yaw ($\Psi = 0^\circ$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
21	Sea Level	.20
22		.50
23		.70
24		.80
25	20,000'	.50
26		.70
27		.85
28	40,000'	.50
29		.70
30		.85

3.2 Aircraft Yawed 5° Port ($\Psi = -5^\circ$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
31	Sea Level	.50
32		.80
33	20,000'	.50
34, 35		.85
36	40,000'	.50
37		.85

3.3 Aircraft Yawed 5° Starboard ($\Psi = 5^{\circ}$)

FILM NO.	SIMULATED ALTITUDE	FULL SCALE MACH NO.
59	Sea Level	.50
60, 61		.80
62	20,000'	.50
63		.85
64	40,000'	.50
65		.85

TABLE 3(a) - SUMMARY OF FILM ANALYSIS OF JETTISON TESTS

CONFIGURATION 1. Four missiles down, low missiles jettisoned

Aircraft at zero yaw

RUN NO.	ALT	M	α^{o}	INITIAL ROLL	INITIAL YAW	MISSILE IN CONTACT WITH LAUNCHER	REMARKS
1	S.L.	.2	12.8	SI - P very slightly(< 5°) PO - S (15° to 40°)	SI - none PO - P slightly(5 to 10°)	no	No pitching motion
2	↓	.5	2.3	SI - none PO - S slightly(5 to 10°)	SI - S slightly PO - P " "	↓	Slight nose down pitching (10°). SI fell faster than PO
3	↓	.7	1.3	SI - S very slightly PO - S slightly	SI - none PO - P slightly	↓	Slight nose down pitching, SI fell faster than PO.
4	↓	.8	1.0	SI - S very slightly PO - none	SI - none PO - P slightly	↓	Slight nose down pitching.
5	20000	.5	5.4	SI - P PO - S	SI - S slightly PO - P (15° or >)	↓	Little pitching motion(< 5°)Rolling motion tended to stabilize as models fell well clear of launchers
6	↓	.7	2.6	SI - P PO - S	SI - S PO - P	PO tail came close	Little pitching
7	↓	.85	1.8	SI - P PO - S	SI - S PO - P	PO tail came close	Slight nose down pitching SI fell faster than PO
8	40000	.5	13.7	SI - P slightly PO - S	SI - S slightly PO - P " "	no	No pitching motion
9	↓	.7	6.7	SI - P slightly PO - S	SI - S slightly PO - P	↓	Rolling motion tended to stabilize as models moved away from aircraft
10	↓	.85	4.4	SI - P slightly PO - S	SI - S slightly PO - P	↓	Slight nose down pitching

SI = Starboard inboard model
PO = Port outboard model

Roll to starboard = positive roll angle
Roll to port = negative roll angle

S = to starboard
P = to port

NOTE: The initial roll and yaw angles were estimated for the period in which the models fell a missile wing semi-span below the launchers. These angles are approximate and only serve to indicate rates of angular rotation.

The missiles contact the launcher from which they were jettisoned unless otherwise noted.

TABLE 3(b) - SUMMARY OF FILM ANALYSIS OF JETTISON TESTS

CONFIGURATION 1. Four missiles down, low missiles jettisoned

Aircraft yawed 5° starboard

RUN NO.	ALT	M	α°	INITIAL ROLL	INITIAL YAW	MISSILE IN CONTACT WITH LAUNCHER	REMARKS
46	S.L.	.5	2.3	Both P, 45°	SI - S PO - none	no	Both models rolled thru 45 just below launchers.
47	↓	.8	1.0	Both P, 45°	SI - S slightly PO - none	SI PO came close	Slight nose down pitching SI rolled faster than PO
48	20000	.5	5.4	SI - P, 45° PO - P	SI - S PO - P slightly	SI came close	Nose down pitching. SI rolled farther than PO
49	↓	.85	1.8	SI - P, > 45° PO - P	SI - S PO - P slightly	SI and PO	Nose down pitching. SI Rolled farther than PO
50	40000	.5	13.7	SI - P PO - P slightly	SI - S slightly PO - P slightly	no	SI rolled faster than PO
51	↓	.85	4.4	Both P, > 45°	SI - S PO - S slightly	SI PO came close	Both models moved outboard initially, SI stopped rolling after hitting launcher.

TABLE 3(c) Aircraft yawed 5° port

RUN NO.	ALT	M	α°	INITIAL ROLL	INITIAL YAW	MISSILE IN CONTACT WITH LAUNCHER	REMARKS
66	S.L.	.80	1.0	SI - S PO - S slightly	SI - P PO - P slightly	SI came close PO came close at tail	PO hesitated, came free as SI passed below it
67	20000	.85	1.8	SI - S, 45° PO - S	Both to P	SI	PO hesitated, SI rolled faster than PO, rolling motion tended to stabilize below aircraft.
68	40000	.85	4.4	Both S, > 45°	Both to P	SI PO came close	PO rolled faster than SI, rolling motion stabilized rapidly below aircraft

SI = Starboard inboard model
PO = Port outboard model

S = to starboard
P = to port

Roll to starboard = positive roll angle
Roll to port = negative roll angle

(For the numerical range of some of the angles indicated see Table 3(a)).

TABLE 3(d) - SUMMARY OF FILM ANALYSIS OF JETTISON TESTS

CONFIGURATION 2. Low launchers down, high missiles down and jettisoned

Aircraft at zero yaw

RUN NO.	ALT	M	α°	INITIAL ROLL	INITIAL YAW	MISSILE IN CONTACT WITH LAUNCHER	REMARKS
11	S.L.	.2	12.8	SO - P PI - S slightly	SO - S PI - P slightly	no	No pitching motion
12	↓	.5	2.3	SO - P PI - S	SO - S PI - P	SO tail came close	Slight nose down pitching
13	↓	.7	1.3	SO - P PI - S	SO - S PI - P	SO tail came close	Nose down pitching
14	↓	.8	1.0	SO - P, 45° PI - S	SO - S PI - P	PI tail came close	Nose down pitching, PI fell faster than SO.
15	20000	.5	5.4	SO - P, 45° PI - S slightly	SO - S slightly PI - P " "	SO came close	SO moved outboard as wing passed thru 45° near launcher.
16	↓	.7	2.6	SO - P, >45° PI - S	SO - S slightly PI - P	SO PI came close	PI fell faster than SO
17	↓	.85	1.8	SO - P, >45° PI - S	SO - S PI - P	SO	Nose down pitching
18	40000	.5	13.7	SO - P PI - S	SO - S slightly PI - P " "	no	No pitching motion
19	↓	.7	6.7	SO - P, 45 PI - S slightly	SO - S PI - P very slightly	SO came close	SO wing passed just below launcher as model moved outboard, rolling motion continued. PI rolled to Port after falling clear.
20	↓	.85	4.4	SO - P, 45 PI - S	SO - S slightly PI - P " "	SO came close	PI fell faster than SO. SO moving outboard as wing passed thru 45°

SO = Starboard outboard model
PI = Port inboard model

Roll to starboard = positive roll angle
Roll to port = negative roll angle

S = to starboard
P = to port

(For the numerical range of some of the angles indicated see Table 3(a))

TABLE 3(e) - SUMMARY OF FILM ANALYSIS OF JETTISON TESTS

CONFIGURATION 2. Low launchers down, high missiles down and jettisoned

Aircraft yawed 5^{o} port

RUN NO.	ALT	M	α^{o}	INITIAL ROLL	INITIAL YAW	MISSILE IN CONTACT WITH LAUNCHER	REMARKS
38	S.L.	.5	2.3	SO - S PI - S very slightly	SO - S	SO hit SI	SO hesitated. PI release operated, PI rolled slightly then hung up.
39	↓	.5	2.3	SO - S PI - S	SO - S PI - S slightly	SO hit SI PI hit PO	PI rolled faster than SO. PI hit PO launcher twice, with upper and lower wings as it fell down and moved outboard.
40	↓	.8	1.0	↓	SO - S PI - P	SO hit SI PI hit PO	Nose down pitching
41	20000	.5	5.4	↓	SO - S PI - P slightly	PI hit PO	PI rolled faster than SO- Rolling motion stabilized as model fell free
42	↓	.85	1.8	SO - S PI - none	SO - S	no	SO hesitated. PI release operated, but PI did not jettison, did not appear to roll initially
43	↓	.85	1.8	SO - S PI - S	SO - S PI - none	SO hit SI PI hit PO	PI initially rolled before release. PI hit PO launcher twice, nose down pitching.
44	40000	.5	13.7	↓	SO - S slightly PI - none	no	No pitching motion. PI rolled farther than SO
45	↓	.85	4.4	↓	SO - S PI - S slightly	PI hit PO	

SO = Starboard outboard model
PI = Port inner model
SI = Starboard inner launcher
PO = Port outer launcher

S = to starboard
P = to port

Roll to starboard = positive roll angle
Roll to port = negative roll angle

(For the numerical range of some of the angles indicated see Table 3(a)).

TABLE 3(f) - SUMMARY OF FILM ANALYSIS OF JETTISON TESTS

CONFIGURATION 2. Low launchers down, high missiles down and jettisoned

Aircraft yawed 5° starboard

RUN NO.	ALT	M	α°	INITIAL ROLL	INITIAL YAW	MISSILE IN CONTACT WITH LAUNCHER	REMARKS
52	S.L.	.5	2.3	Both P	SO - none PI - S very slightly	SO	PI pitched nosed down. SO leveled out, moved outboard at level of low launchers.
53	↓	.8	1.0	SO - P, $> 45^{\circ}$	SO - S slightly	SO	PI hung up, did not roll - cannot determine if release operated or not. SO hesitated before falling free.
54	↓	.8	1.0	SO - P, $> 45^{\circ}$ PI - P	SO - none PI - P very slightly	SO PI hit SI	PI rolled faster than SO initially, stabilized then started rolling again after hitting SI. SO moved outboard on same level as low launchers.
55	20000	.5	5.4	SO - P, $> 45^{\circ}$ PI - P	SO - none PI - S slightly	SO	SO rolled faster than PI initially, pitched up slightly
56	↓	.85	1.8	SO - P, $> 45^{\circ}$ PI - P	SO - S PI - P slightly	SO	SO rolled faster than PI initially, hesitated before falling free.
57	40000	.5	13.7	SO - P, 45 PI - P	SO - S PI - P	no	No pitching motion
58	↓	.85	4.4	SO - P, 45 PI - P	SO - none PI - P, slightly	SO and PI	

SO = Starboard outboard model
PI = Port inboard model

SI = Starboard inboard launcher

S = to starboard
P = to port

Roll to starboard = positive roll angle
Roll to port = negative roll angle

(For the numerical range of some of the angles indicated see Table 3(a)).

FIGURES.

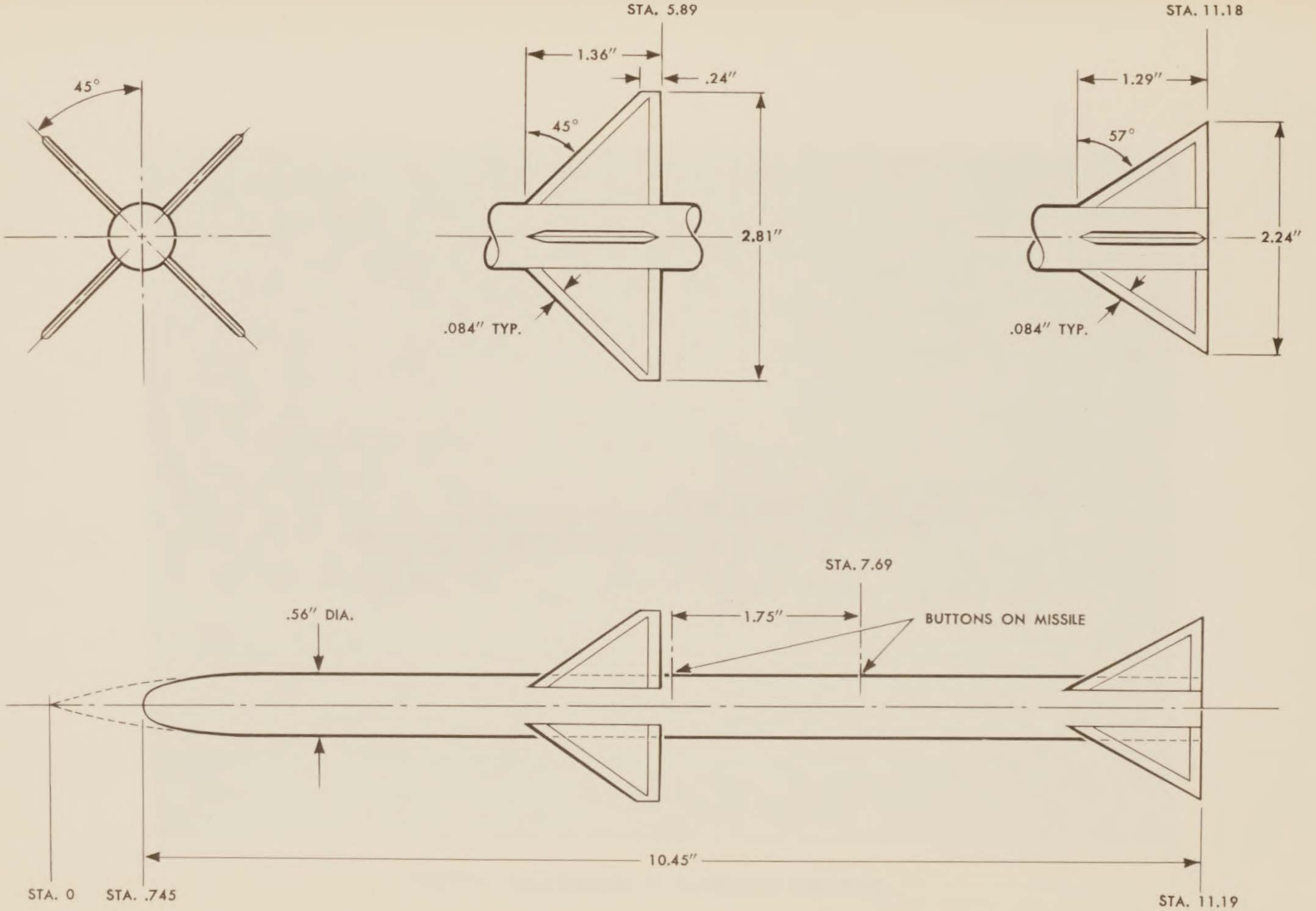


FIG. 1 C105 .07 SCALE SPARROW 2 MISSILE

2579-105-1

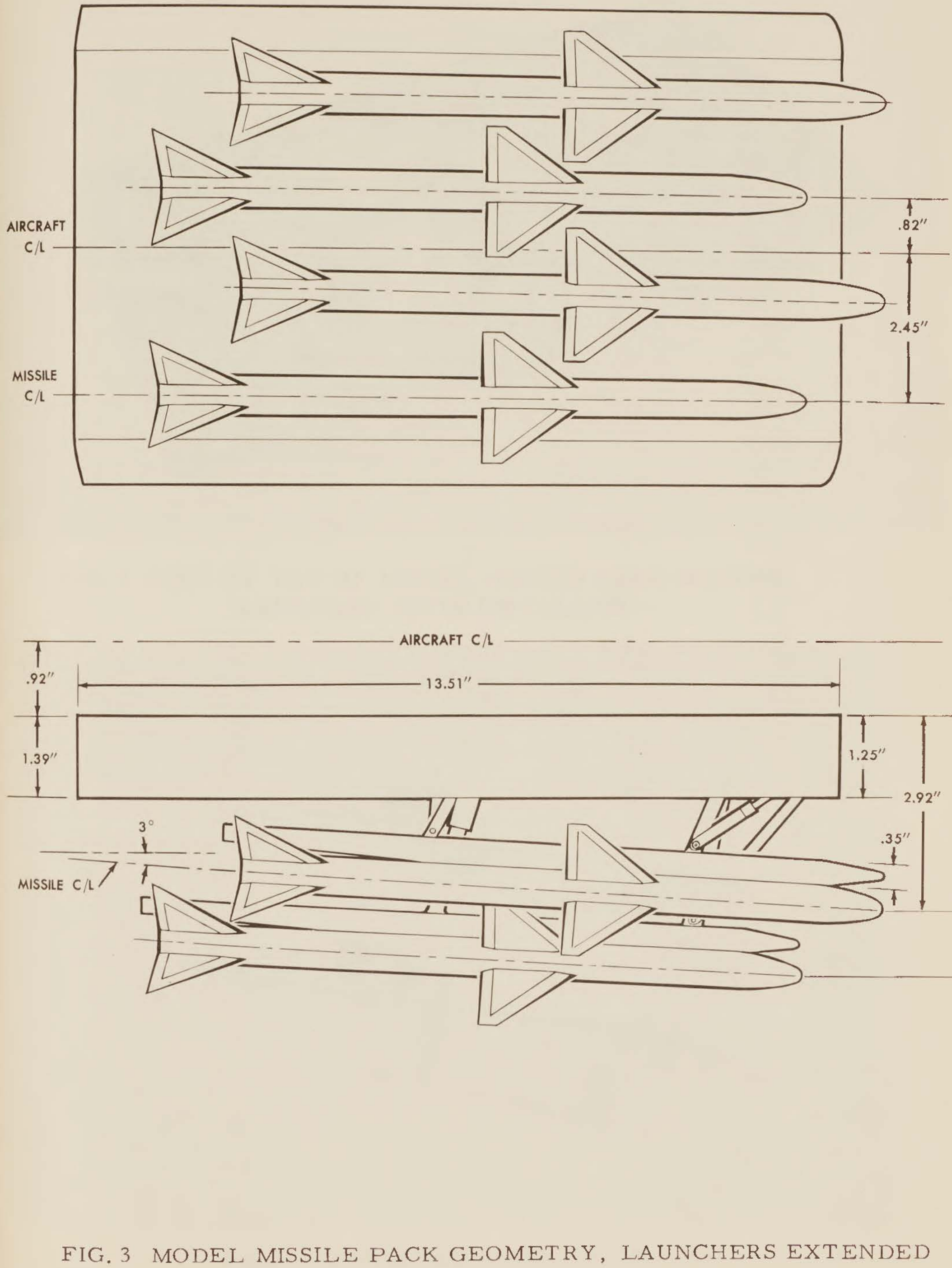


FIG. 3 MODEL MISSILE PACK GEOMETRY, LAUNCHERS EXTENDED

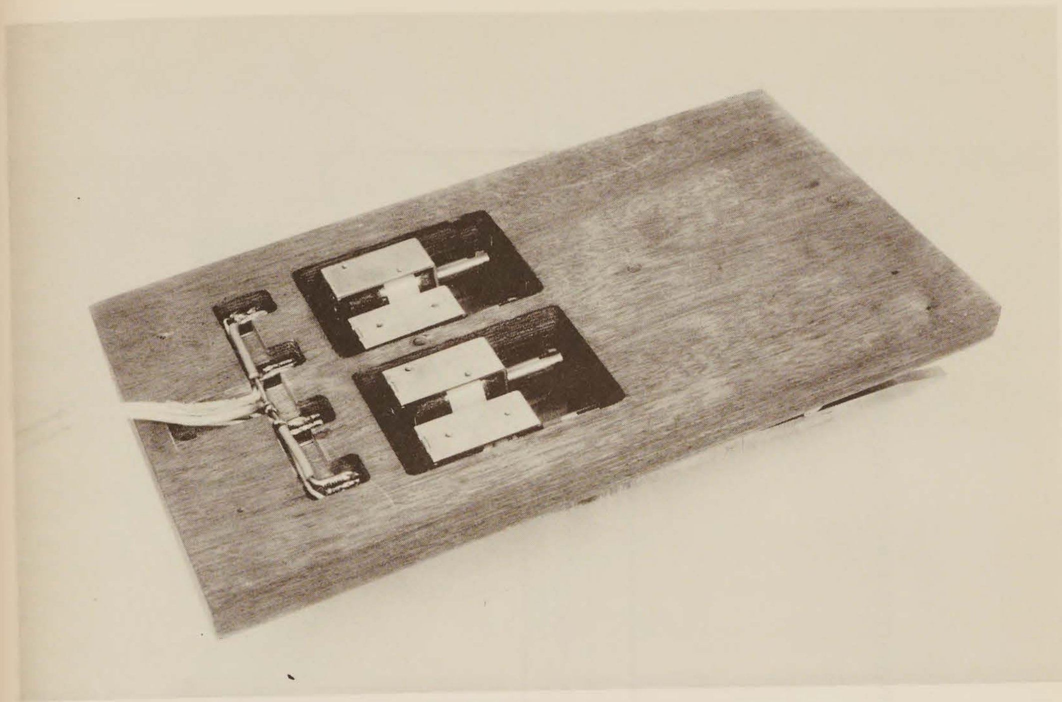


FIG. 4 VIEW OF TOP OF MODEL MISSILE PACK SHOWING LAUNCHER UNITS INSTALLED

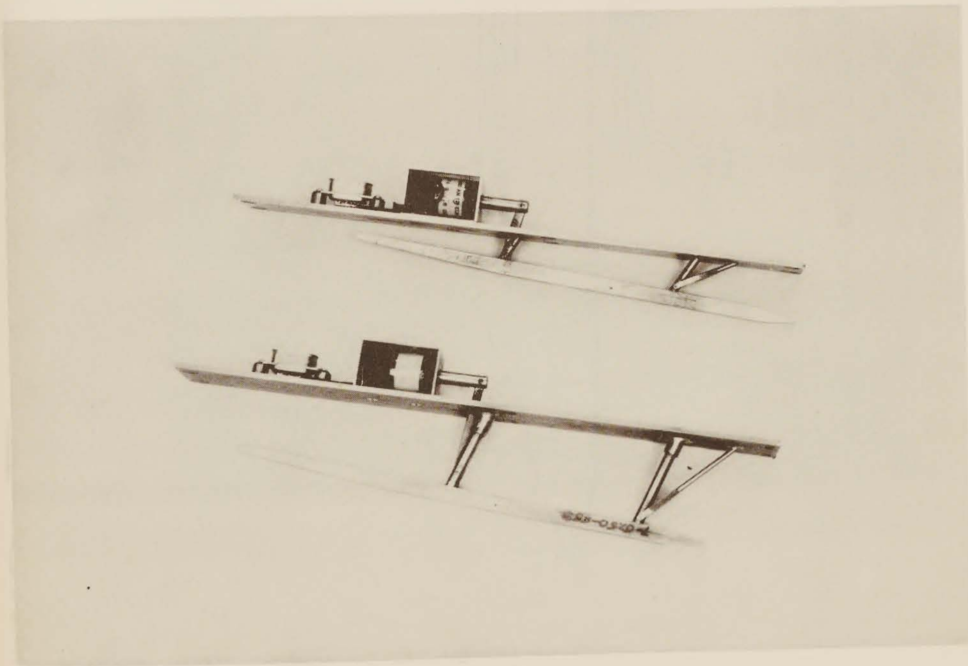


FIG. 5 MODEL LAUNCHER UNITS

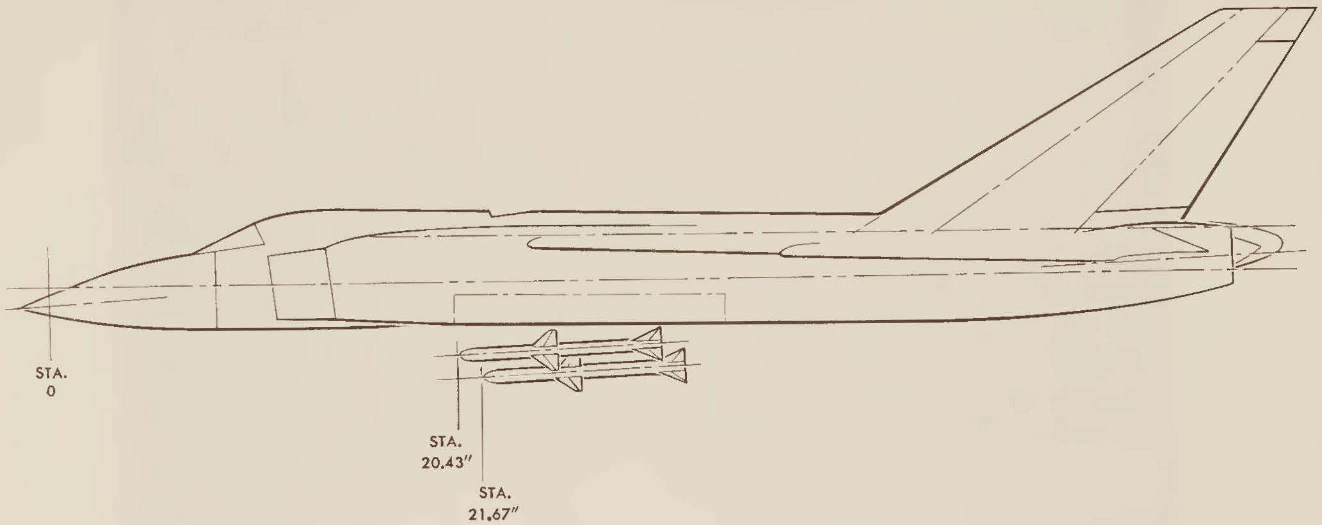


FIG. 6 C105 .07 SCALE SPARROW 2 MISSILE PACK INSTALLATION

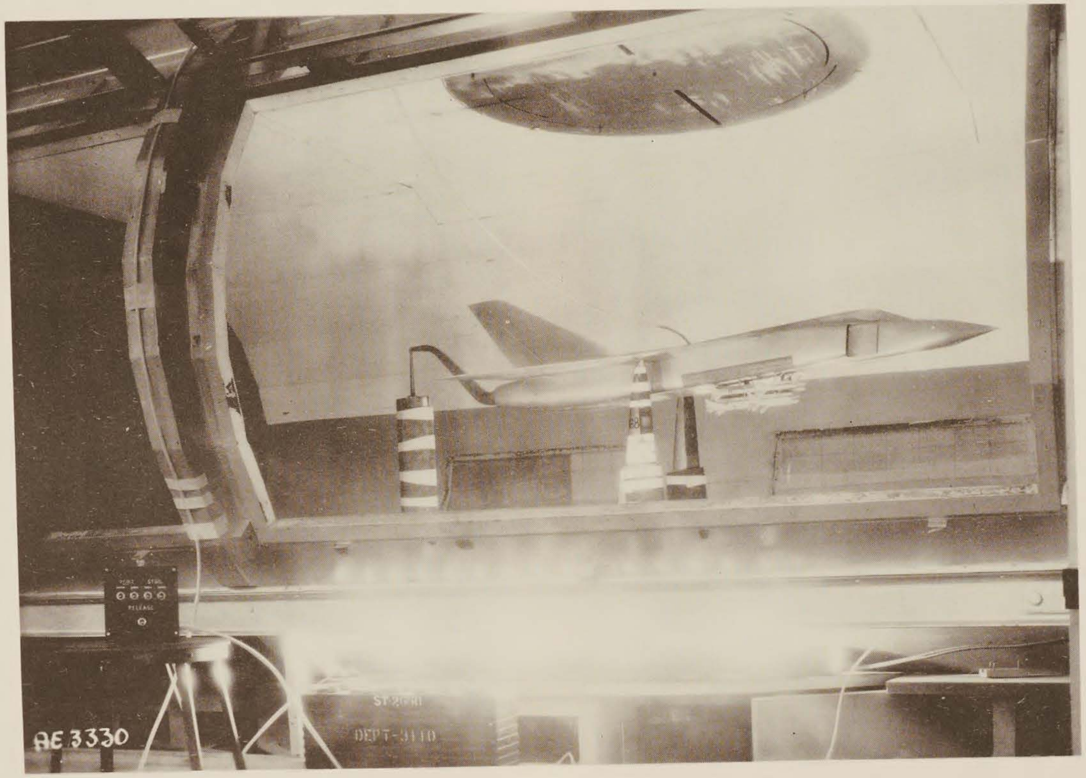


FIG. 7 JETTISON TEST ARRANGEMENT IN THE
6 X 10 LOW SPEED WIND TUNNEL

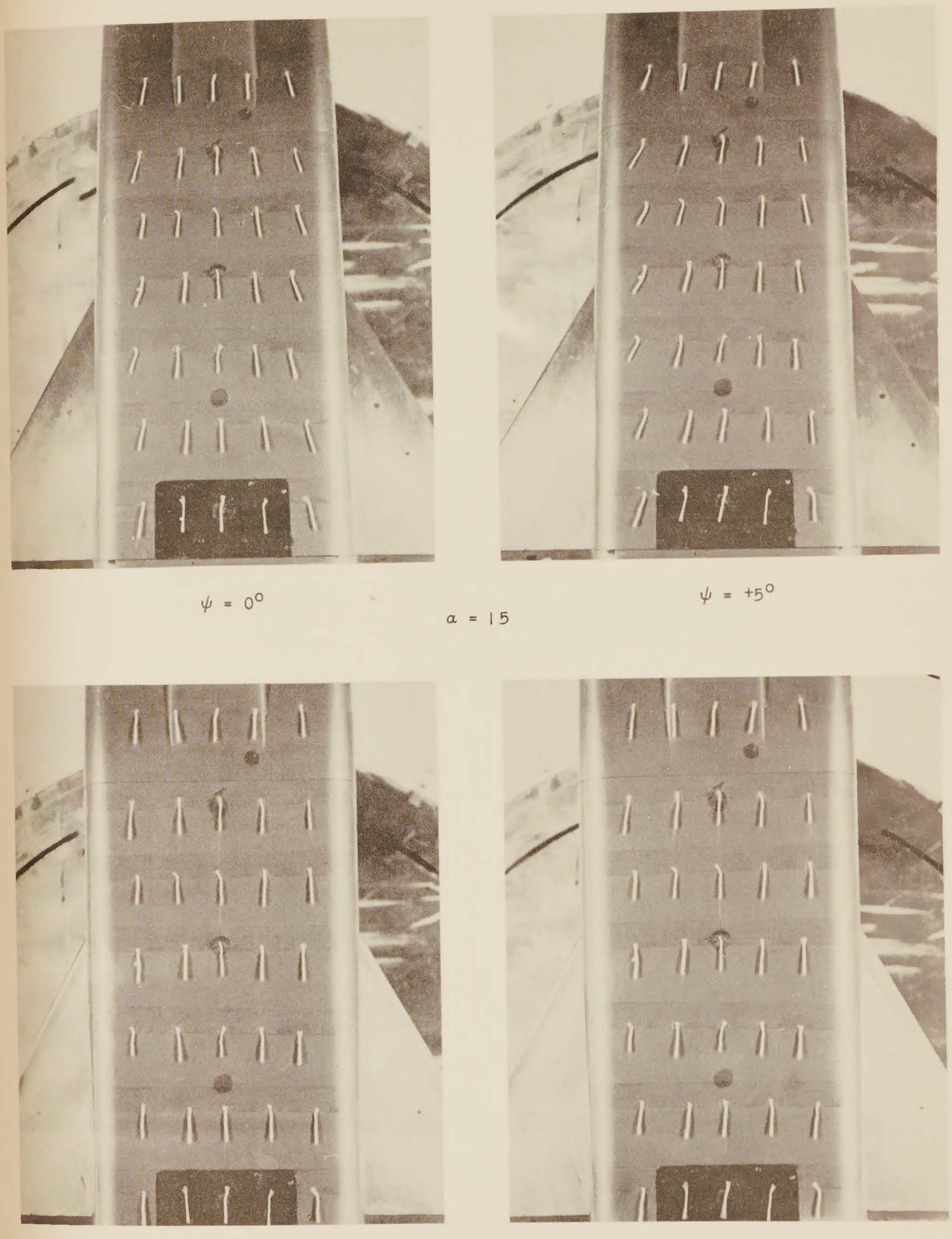


FIG. 11 WOOL TUFT FLOW VISUALIZATION UNDERNEATH MISSILE PACK.
R.N. $= 2.68 \times 10^6$ (REFERENCE - P/WIND TUNNEL/155)

FIG. 12 (b) SIDE VIEW RUN NO. 47 - SEA LEVEL, M = .8, α = 1°
CONFIGURATION 1, ψ = 5°
FILM SPEED 980 frames per second

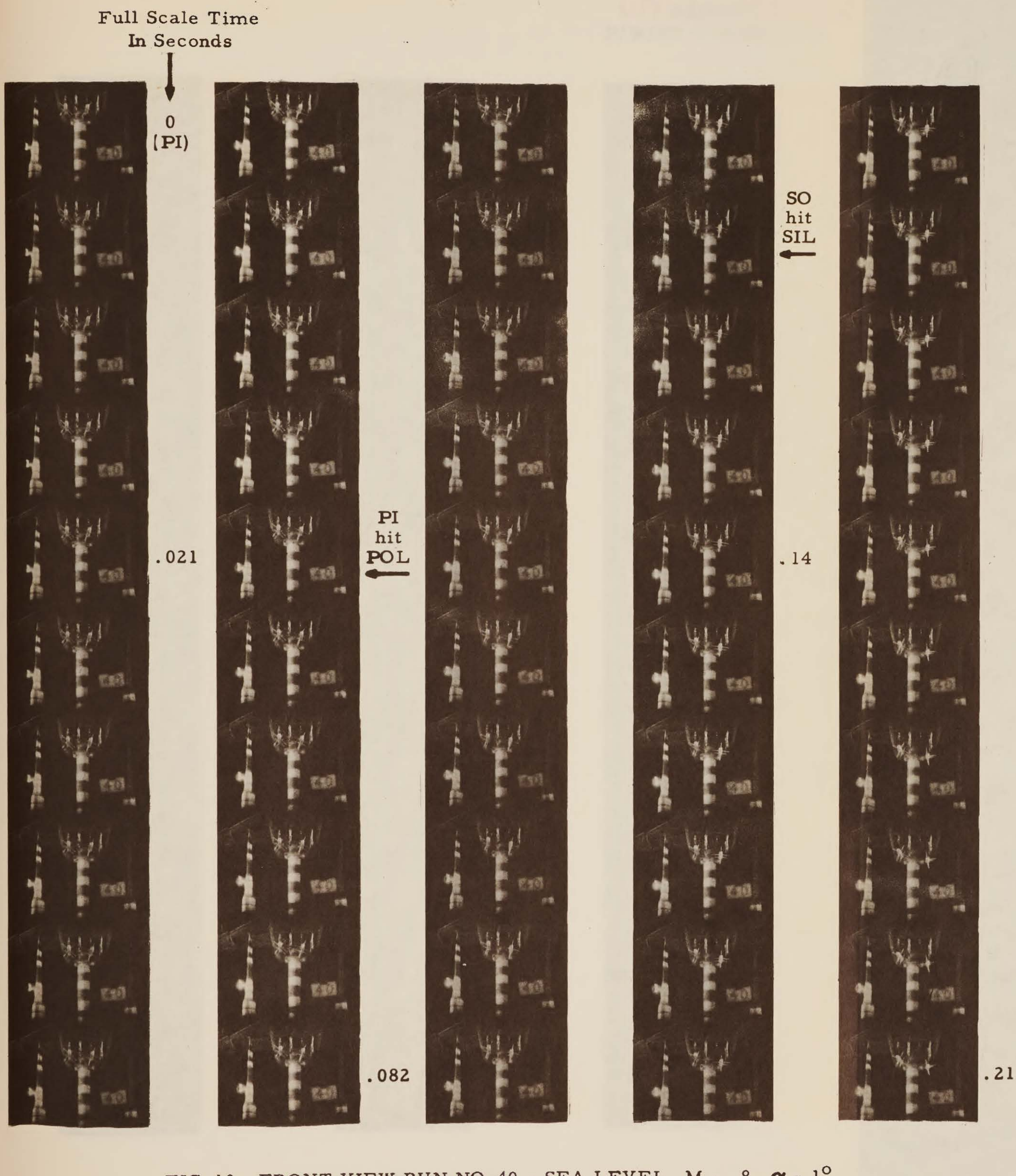
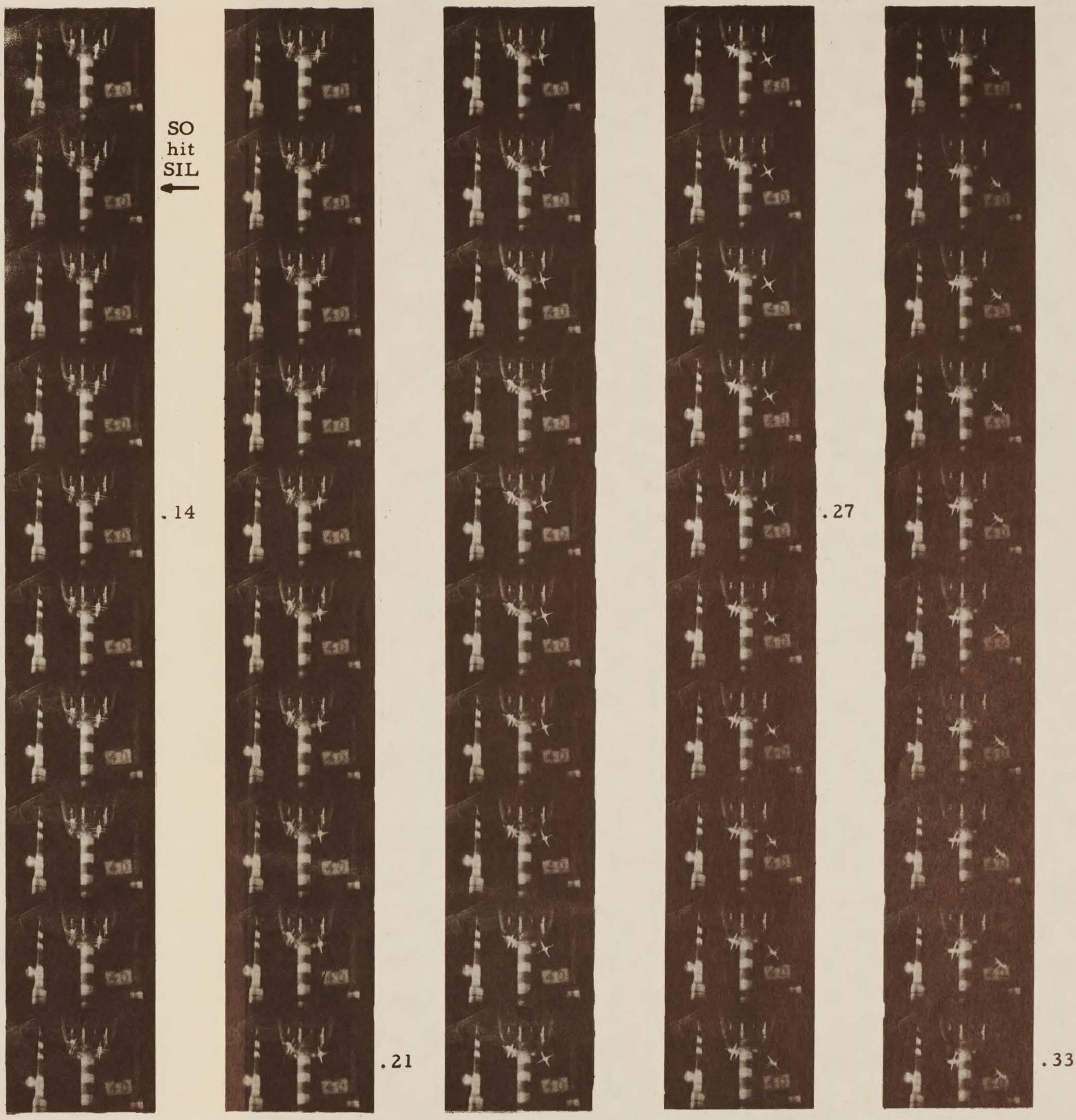


FIG. 13 FRONT VIEW RUN NO. 40 - SEA LEVEL, M = .8, $\alpha = 1^{o}$,
CONFIGURATION 2, $\psi = -5^{o}$
FILM SPEED 920 frames per second



EA LEVEL, M = .8, $\alpha = 1^{o}$,
5°
second

SO = Starboard Outboard Missile
PI = Port Inboard Missile
POL = Port Outboard Launcher
SOL = Starboard Outboard Launcher

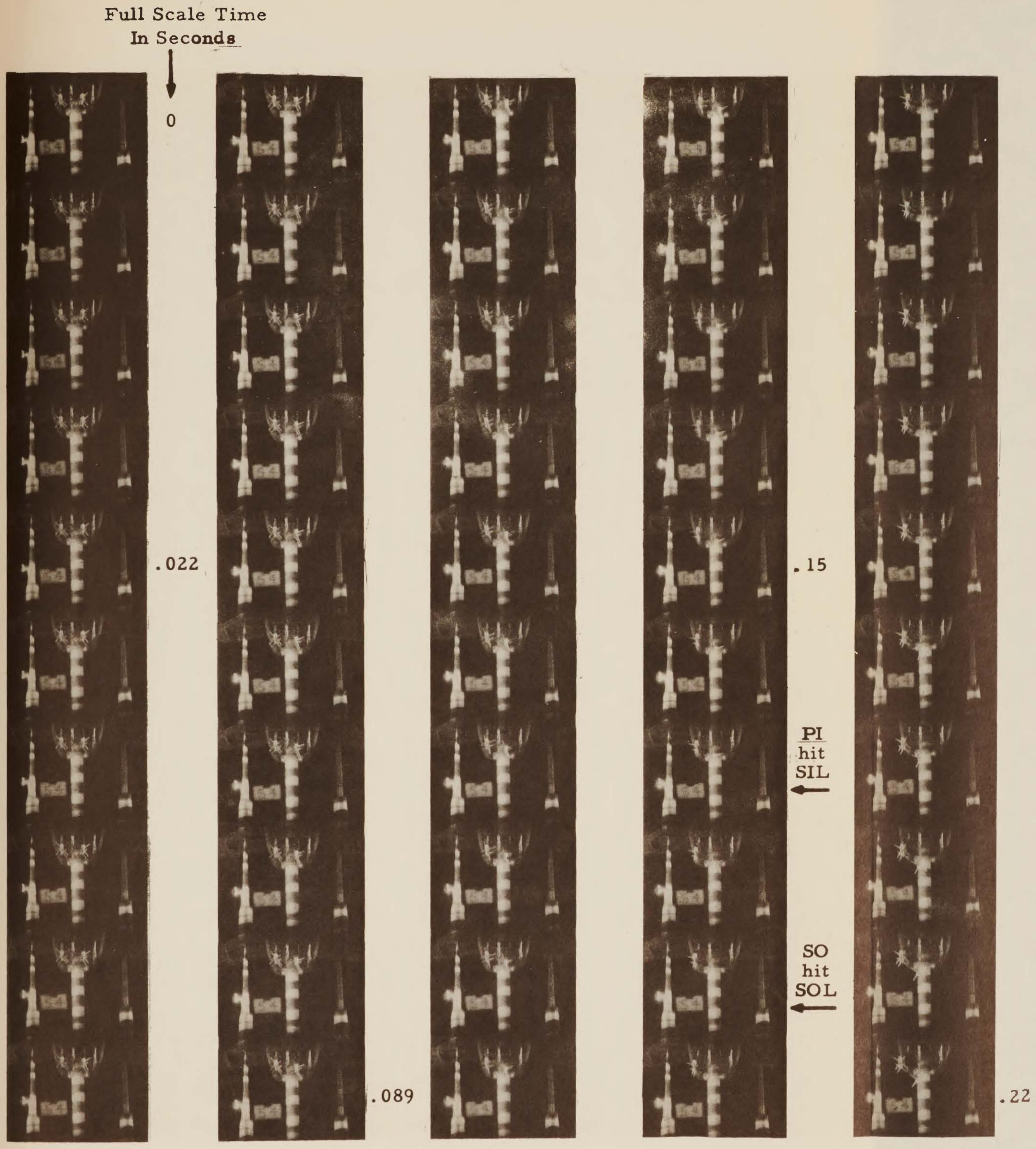


FIG. 14 (a) FRONT VIEW RUN NO. 54 - SEA LEVEL, M = .8, $\alpha = 1^{\circ}$
CONFIGURATION 2, $\psi = 5^{\circ}$
FILM SPEED 850 frames per second

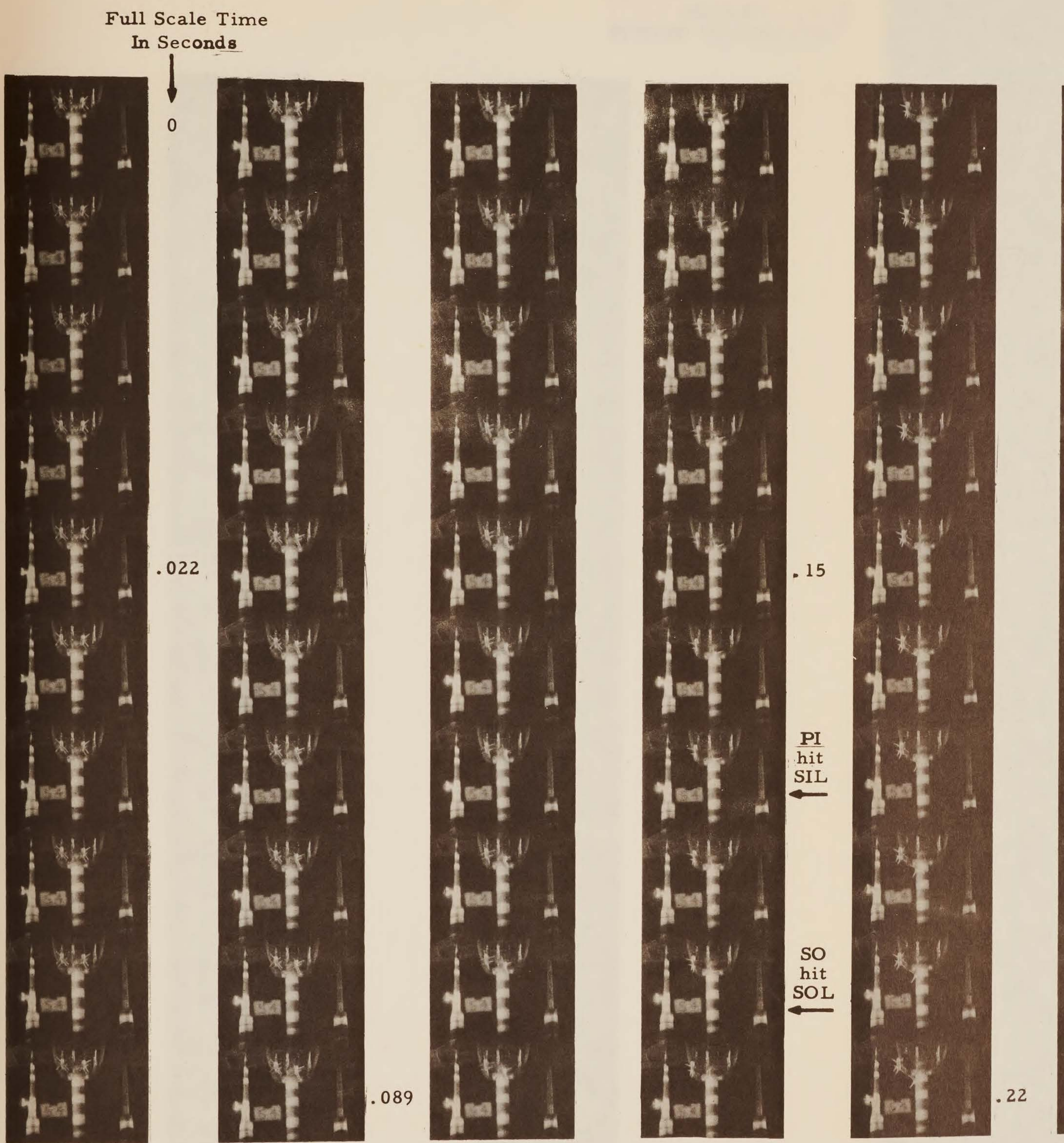
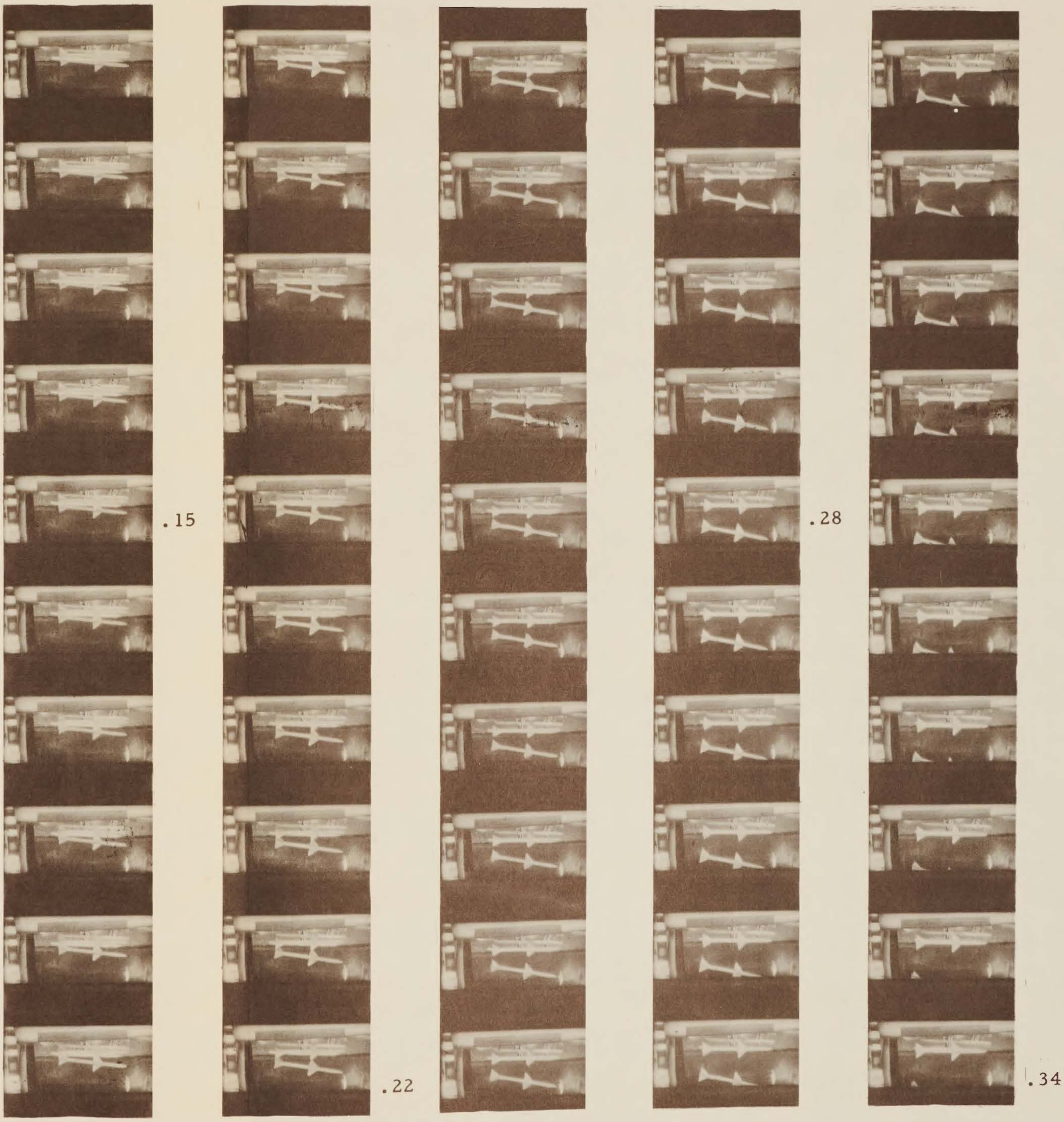


FIG. 14 (a) FRONT VIEW RUN NO. 54 - SEA LEVEL, M = .8, $\alpha = 1^{o}$
CONFIGURATION 2, $\psi = 5^{o}$
FILM SPEED 850 frames per second

FIG. 14 (b) SIDE VIEW RUN NO. 54 - SEA LEVEL, M = .8, $\alpha = 1^{\circ}$,
CONFIGURATION 2, $\psi = 5^{\circ}$
FILM SPEED 880 frames per second

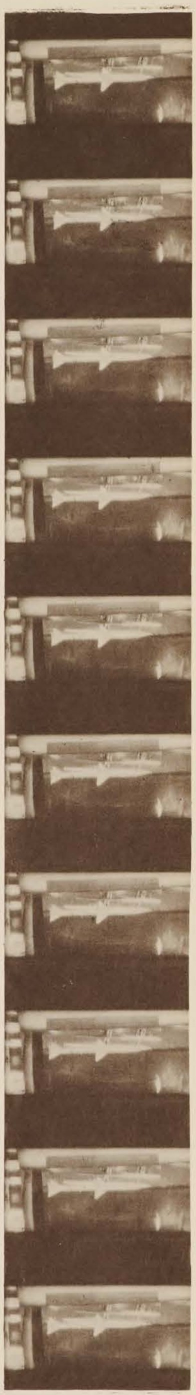


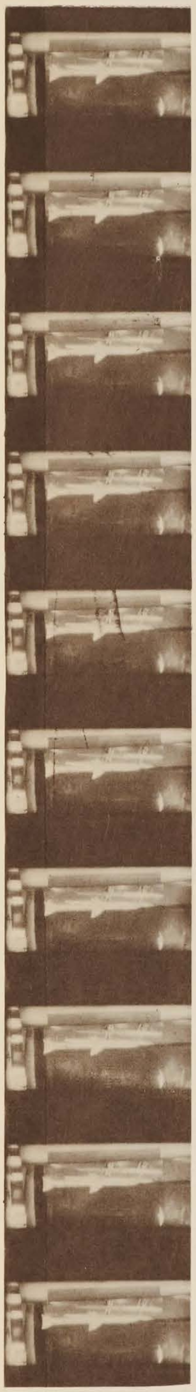
EL, M = .8, $\alpha = 1^{o}$,

nd

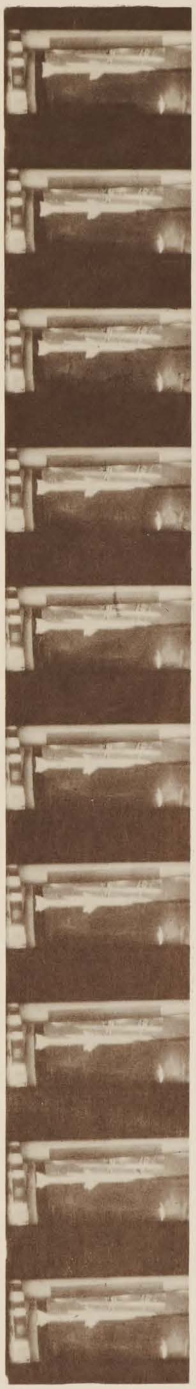
FIG. 14 (b) CONTINUED

47

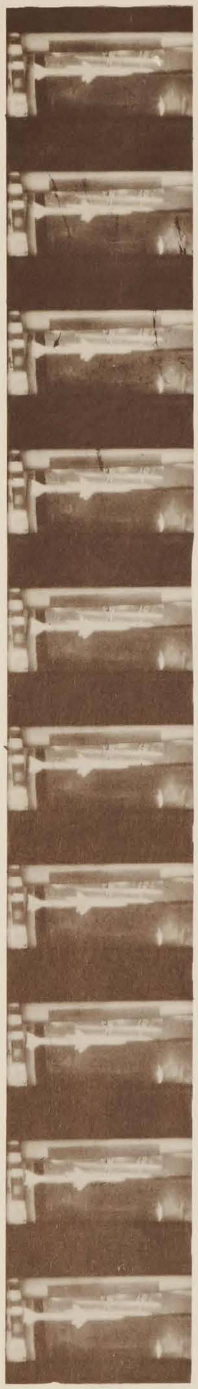


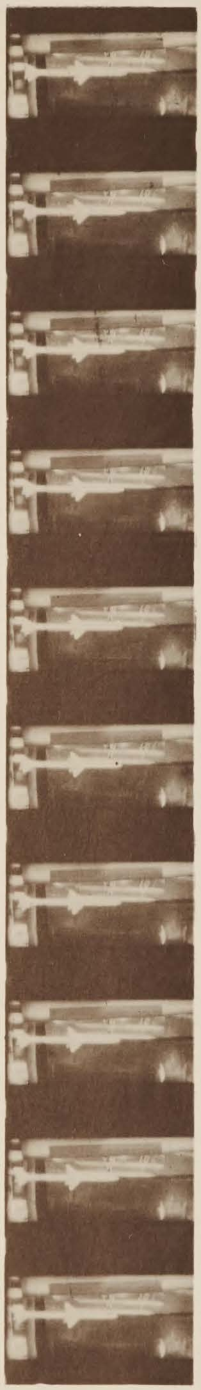


.54



.60





.67

FIG. 14 (b) CONCLUDED