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EVALUATION OF KIDDE CONTINUOUS FIRE DETECTOR IN AN XB-45 NACELLE

<u>FOR LIMITED DISTRIBUTION</u>

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SUMMARY

At the request of the Department of the Air Force, tests were conducted at the Technical Development and Evaluation Center of the Civil Aeronautics Administration on a continuous fire-detection system so located that it would facilitate installation and maintenance. The continuous sensing elements were attached longitudinally to the air frame in the aft compartment of an XB-45 airplane nacelle and were subjected to test fires. Results indicated that longitudinal attachment of the continuous sensing element is inferior to the previously tested circumferential installations insofar as coverage and speed of detection are concerned.

INTRODUCTION

Continuous detectors, manufactured by Walter Kidde & Company, Inc. and installed in the XB-45 airplane-nacelle aft compartment so that they would encircle the jet-engine tail cones and tail pipes, were evaluated; and the results were published in a previous report.[1] That type of detector installation necessitated attachment of the detector sensing elements, by stand-off grommets, either to the removable nacelle access doors or to the outside surface of the tail cones and tail pipes. The Department of the Air Force requested that an evaluation be conducted with the Kidde continuous detector sensing elements installed longitudinally in the XB-45 airplane-nacelle aft compartment and located in such a way that it would preclude the necessity of removing or disconnecting any part of the detector system during engine change. Longitudinal installation of sensing elements placed them generally parallel to the movement of air through the aft compartment of the nacelle. This report presents the results of these tests.

TEST EQUIPMENT

Continuous detectors occupy a line in the nacelle space and are similar in shape to a wire. The continuous detectors used in the evaluation were manufactured by the Walter Kidde & Company, Inc., Belleville, New Jersey. The sensing element of these detectors is composed of 20-foot lengths of 0.062-inch o.d. inconel tubing containing two wires fused into and insulated by prebroken ceramic spaghetti. Detection is based on the principle that the resistance of the ceramic decreases sharply at a predetermined elevated temperature and in so doing completes a circuit to an amplifier which signals an alarm. When the source of the elevated temperature is removed, the resistance increases and the signal clears. The sensing element used in the

[1] C. M. Middlesworth, "Determination of Means to Safeguard Aircraft from Power Plant Fires in Flight, Part VI, The North American Tornado" CAA Technical Development Report No. 221

tests alarmed at 500° F when heated slowly in a furnace. A photograph of a coil of sensing element and of the control box are shown in Fig. 1.

Two 20-foot lengths of sensing element were attached by two-inch stand-off grommets at the locations shown in Fig. 2. One length was attached to the nacelle just above the access-door joints. The second length was attached to the lower portion of the nacelle structural keel and to the fire wall in the forward portion of the aft compartment. The aft compartment of the XB-45 nacelle contained a net volume of approximately 237 cubic feet and was 17.5 feet in length. An Esterline Angus operation time recorder was used to record a complete sequence of events during each test.

TEST PROCEDURE

Since the nacelle structure was essentially symmetrical about a vertical longitudinal plane, tests were conducted on one side only. During these tests, the No. 3 engine side of the nacelle was used. The fire locations used in testing are indicated in Table I and are shown in Fig. 3. These locations were selected as being representative of potential fire hazards such as flammable-fluid leaks and engine failures.

Test fires burned aviation gasoline at a rate of 0.6 gallon per minute. The aviation gasoline was spark-ignited and was allowed to flow for ten seconds during each test. Test fires were influenced by the air flow through the nacelle. In the XB-45 nacelle, the outlet ends of the jet-engine tail pipes are sufficiently recessed to cause an air-ejector action and thus induce cooling air to pass through the compartment from the inlet louvers at the forward end of the compartment.

The test sequence used was:

1. Turn on test-fire ignitor switch.

2. Turn on fuel supply for test fire.

3. Record time required for the detector system to alarm from time fuel was supplied as shown on the operation recorder.

The fire tests were conducted under simulated operation conditions, viz.;

1. Aircraft operating at cruising (both jet engines operating at 90 per cent of maximum rated rpm, ram air supplied to engine inlets.)

2. Ground taxi (both jet engines operating at 60 per cent of maximum rated rpm, and air drawn by the engine from the atmosphere.)

3. Engine starting (jet engines inoperative, therefore no air flow through the aft compartment.)

RESULTS AND DISCUSSION

The test results are shown in Table I. The time for detection is the time required for the detectors to give an alarm from the time the fuel is supplied for the test fire. No attempt was made to determine the clearing time for the detector system because of the difficulty of determining the precise duration of the test fires. The fire-detector system detected the test fires under the conditions of simulated operation except during three tests. It was apparent that during those tests the flame was stratified by the air flow in the region of the nacelle aft of the fire nozzle to the extent that neither flame nor heated air contacted the detector sensing element. The detector system did not false-alarm or malfunction during the tests and was not damaged by the test fires or vibration; however, the XB-45 nacelle as mounted for test-cell operation was relatively free of vibration.

Results of tests conducted and reported previously with the sensing element installed to encircle the engine tail cones and tail pipes are shown in Table II for comparison. The two sensing elements used were mounted transversely at nacelle Stations ≠ 23 and ≠ 100. Each sensing element was connected to a separate control box, and a separate record was made for each element. All test fires were detected by the two elements in combination.

Results of bench tests of a Kidde continuous detector, conducted in accordance with SAE Specification AS-401A, are shown in Table III.[2]

CONCLUSIONS

1. The detector sensing element as installed during these tests was not as vulnerable to damage during engine change and maintenance as a detector sensing element encircling the engines and attached either to the engines or to the nacelle and access doors.

2. Better fire detection, from the standpoints of speed and coverage, was provided by the previously tested transverse system than by the longitudinal system described in this report.

[2] J. J. Gassmann, "A Burner and Test Bench for Evaluating Aircraft Fire and Heat Detectors," CAA Technical Development Report No. 217, October 1953

TABLE I

TIME REQUIRED FOR FIRE DETECTION
(Detector elements installed longitudinally;
aft compartment, XB-45 nacelle)

Test No.	Test Conditions	Fire Location (See Fig. 3)	Alarm* Time (Seconds)
1	Engine Starting	G	9
2	Ground Taxi	G	3
3	Normal Cruising	G	3
4	Normal Cruising	G	2
5	Engine Starting	S	11
6	Engine Starting	S	11-1/2
7	Ground Taxi	S	4-1/2
8	Normal Cruising	S	4
9	Normal Cruising	S	3
10	Engine Starting	J	4-1/2
11	Ground Taxi	J	No Detection**
12	Normal Cruising	J	No Detection**
13	Engine Starting	X	8-1/4
14	Ground Taxi	X	4-1/4
15	Normal Cruising	X	No Detection
16	Normal Cruising	X	10
17	Ground Taxi	Q	6
18	Normal Cruising	Q	6-1/2
19	Normal Cruising	Q	5-3/4
20	Engine Starting	V	5-1/2
21	Engine Starting	V	6
22	Normal Cruising	V	4
23	Ground Taxi	W	5
24	Normal Cruising	W	3
25	Normal Cruising	W	4
26	Engine Starting	W	5
27	Engine Starting	U	9
28	Ground Taxi	U	9
29	Normal Cruising	U	4
30	Normal Cruising	U	4
31	Engine Starting	T	10
32	Ground Taxi	T	6
33	Normal Cruising	T	5-3/4

Average time for alarm was 5.9 seconds.

* Alarm time is based on the time between release of fuel and indication from the detection system. Spark ignitor in operation before and during release of fuel.

** Test fires at this location were influenced by high-velocity air flow.

TABLE II

TIME REQUIRED FOR FIRE DETECTION

(Detector elements installed around tail cone and tail pipe at Stations + 23 and + 100; aft compartment, XB-45 nacelle)

Test No.	Test Conditions	Fire Location (See Fig. 3)	Alarm Time* Element at Station + 23 (Seconds)	Alarm Time* Element at Station + 100 (Seconds)
1	Normal Cruising	T	2	
2	Normal Cruising	T	2	
3	Normal Cruising	W	6	8
4	Normal Cruising	W	4	5
5	Normal Cruising	V	5	
6	Normal Cruising	V	4	
7	Normal Cruising	U	4	
8	Normal Cruising	U	4	
9	Normal Cruising	U	6	
10	Ground Taxi	U	5-1/2	
11	Normal Cruising	U	3-1/2	
12	Normal Cruising	U	6	
13	Normal Cruising	U	3	
14	Normal Cruising	U	5	6
15	Normal Cruising	X	3	4
16	Normal Cruising	X	2	2
17	Normal Cruising	Q	7	7
18	Normal Cruising	Q	2	8
19	Normal Cruising	Q	7	6
20	Normal Cruising	Q	5	
21	Normal Cruising	Q	3	
22	Normal Cruising	G		2
23	Normal Cruising	G		3
24	Normal Cruising	S	2	2
25	Normal Cruising	S	2	2
26	Normal Cruising	S		2
27	Normal Cruising	S		2
28	Normal Cruising	J		3
29	Normal Cruising	J		2
30	Ground Taxi	J		4
31	Normal Cruising	J		3
32	Normal Cruising	J		2-1/2
33	Normal Cruising	J		2
34	Normal Cruising	J		3
35	Normal Cruising	J		2

Average time for alarm was 3.5 seconds.

* Alarm time is based on the time between release of fuel and indication from the detection system. Spark ignitor in operation before and during release of fuel.

TABLE III

RESULTS OF BENCH TESTS ON KIDDE CONTINUOUS
AIRCRAFT FIRE DETECTOR
(Tests conducted in accordance with SAE Specification
AS-401A Paragraphs 7.1, 7.1.1, and 7.14)

1500° F Flame 30,000 BTU Per Hour		2000° F Flame, 65,000 BTU Per Hour				
		1st Exposure		2nd Exposure		3rd Exposure
Response Time (Sec.)	Repeat Response Time (Sec.)	Response Time (Sec.)	Clearing Time (Sec.)	Response Time (Sec.)	Clearing Time (Sec.)	Respons Time (Sec.)
4.0	1.5	2.4	20.5	2.2	20.5	2.3

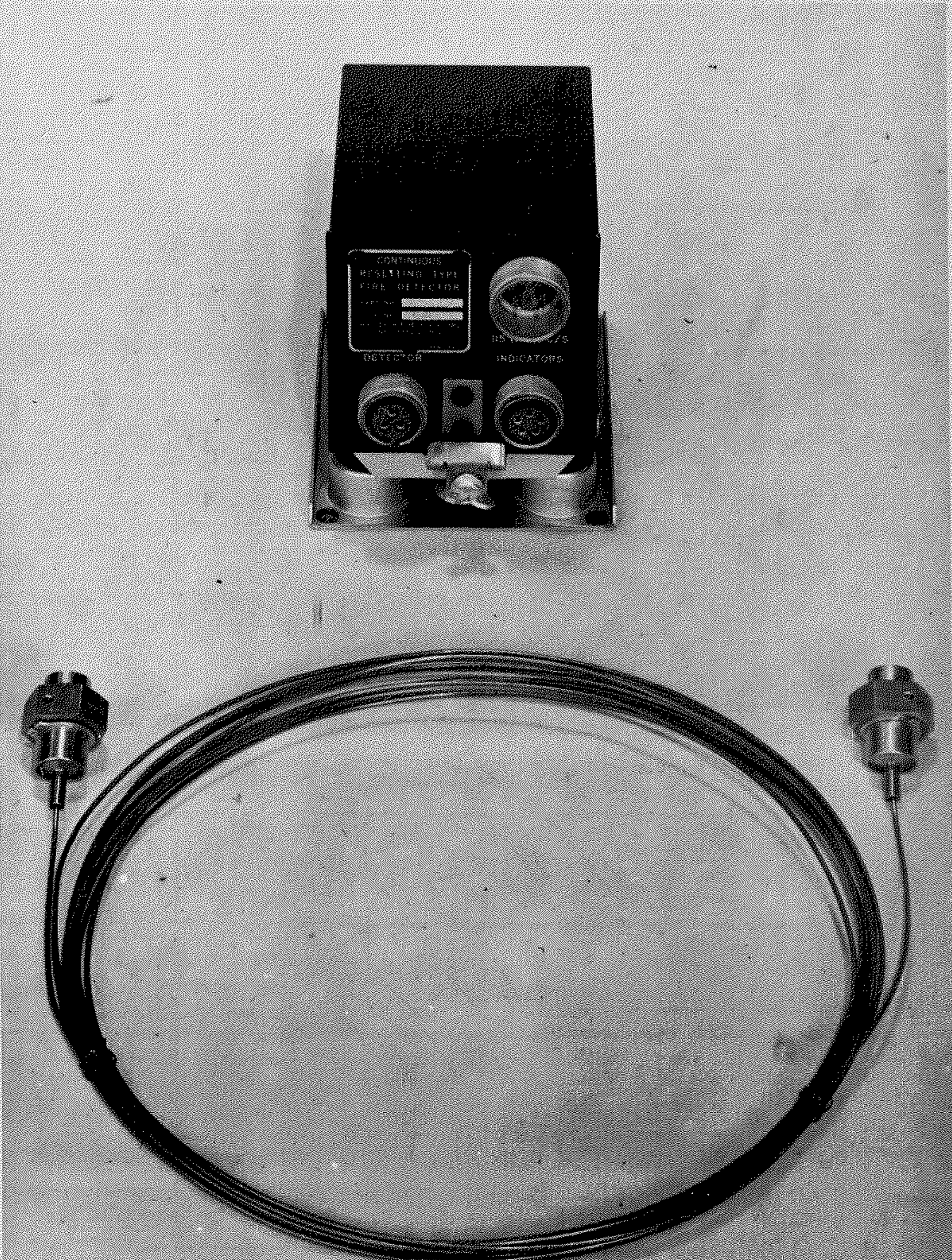

FIG. I THE KIDDE CONTINUOUS FIRE DETECTOR

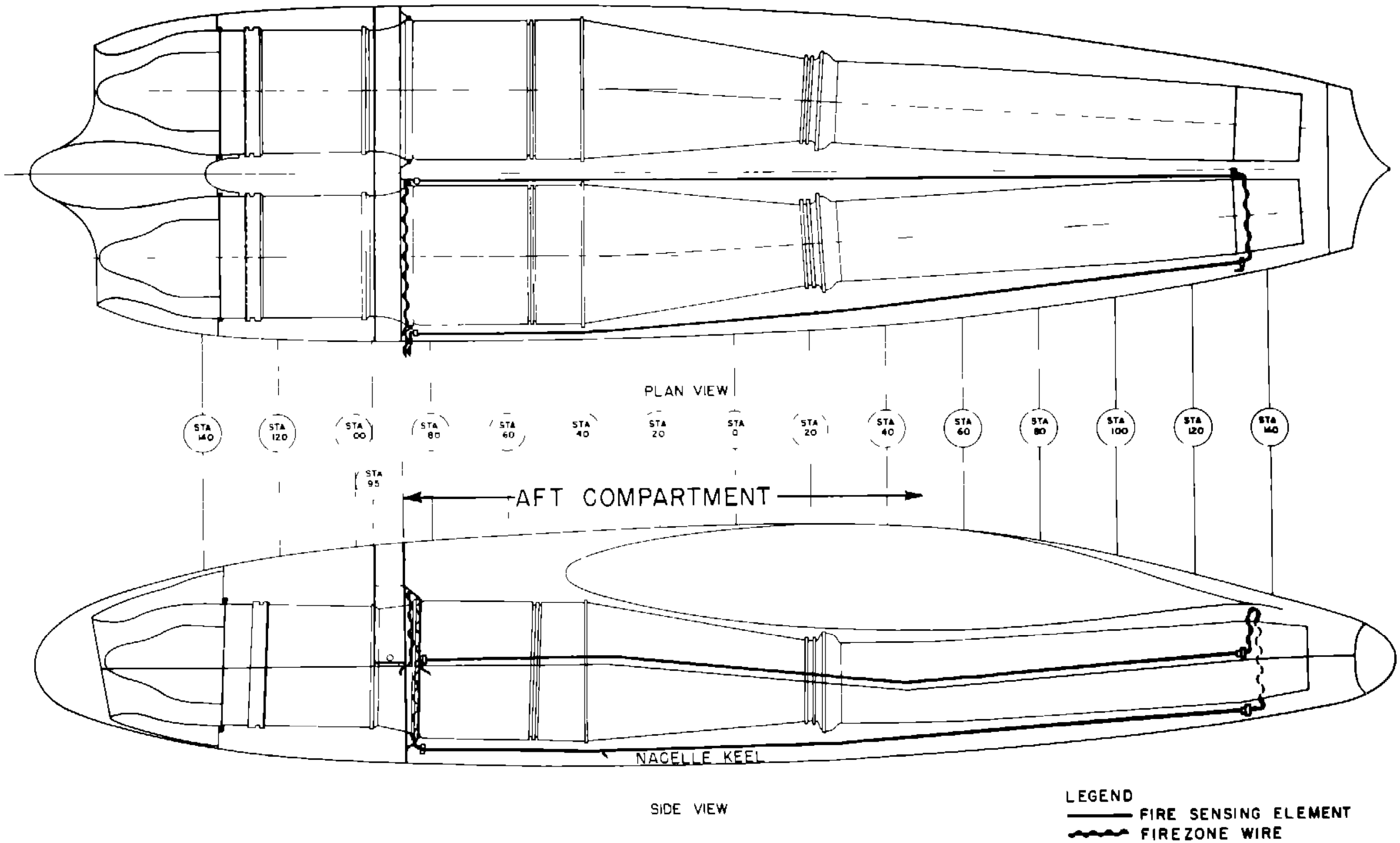

FIG 2 LOCATION OF CONTINUOUS-FIRE-DETECTOR SENSING ELEMENT IN XB-45 NACELLE, KIDDE SYSTEM

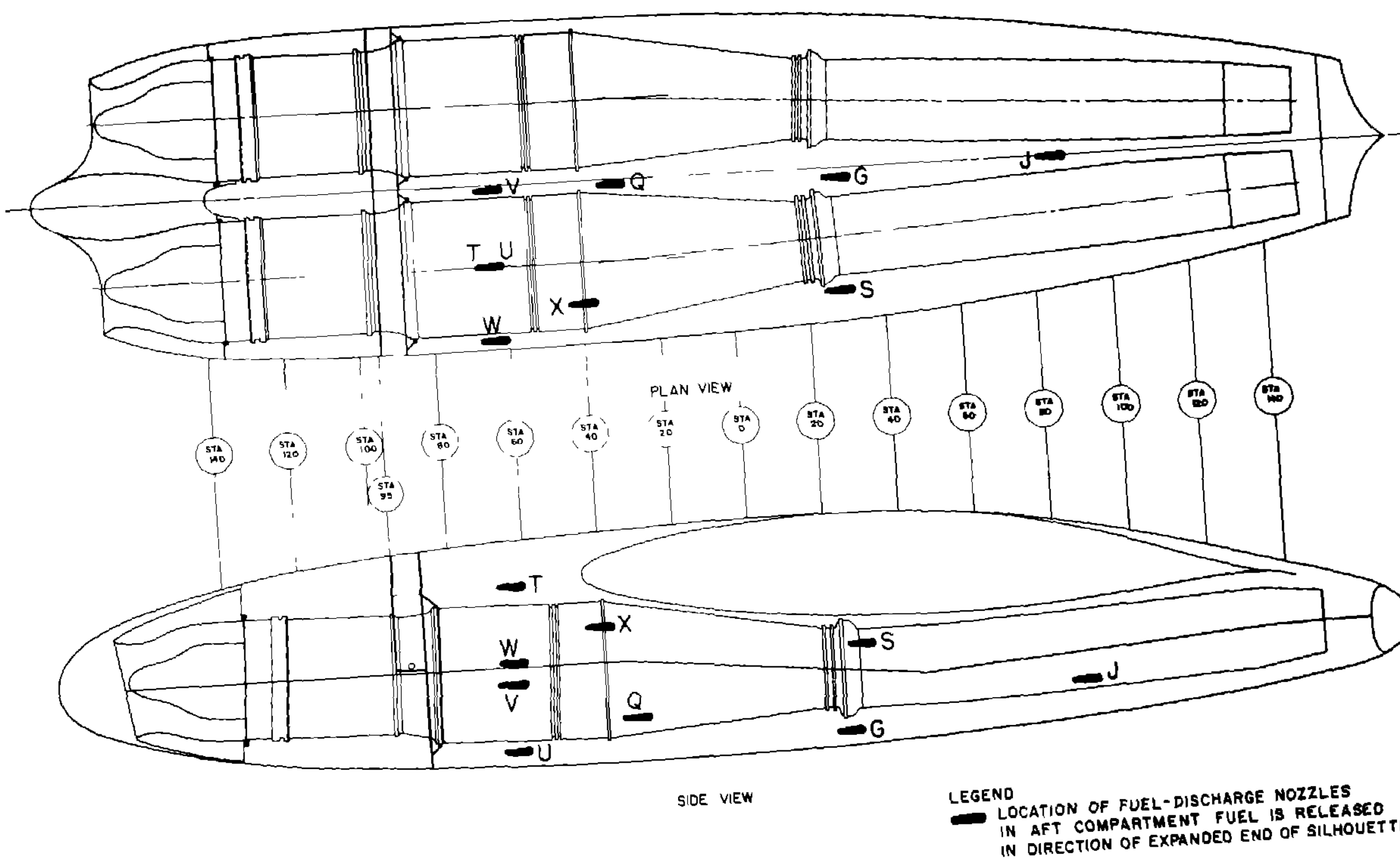

FIG 3 FIRE NOZZLE LOCATIONS FOR DETECTOR TESTS, XB-45 NACELLE