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EVALUATION OF THE EDISON ULTRAVIOLET SURVEILLANCE FIRE WARNING SYSTEM AS A BURNER-CAN BURN-THROUGH DETECTOR

PROJECT 520-001-14X

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Purpose

To evaluate the capability of the Edison Ultraviolet Surveillance Fire Warning System in detecting fire from burner-can failures.

Background

Fire detectors in service have detected burner-can failures, but also some have gone undetected and often undiscovered until routine ground inspection. A burn-through impinging on a vital aircraft structure could endanger the entire aircraft if an early detection is not obtained.

System Description

The Edison Ultraviolet Surveillance Fire Warning System was developed for the United States Air Force as an engine nacelle fire detection system. It is designed to operate in ambient temperatures up to approximately 450°F.

The detection system operates on the principle of ultraviolet light striking tungsten electrodes encased in a quartz envelope filled with hydrogen (refer to Figure 1a). This causes photoelectron emission which ionizes the gas in the tube completing the electrical circuit and allowing the discharge of capacitor voltage to ground. This voltage reduction in the circuit quenches the discharge allowing the capacitor voltage to build up. The cycle repeats as long as the ultraviolet light is present. Each cycle is considered a pulse and the pulses are monitored and counted by other circuitry in the control unit. The system is designed so that fifty pulses per second will trigger the five warning lights. Each sensor is equipped with a test lamp, as shown in Figure 1b, which is part of a push-to-test circuit used to check the system integrity. The system is designed to detect only ultraviolet radiation emitted from flames (between the wave lengths of 1800 and 2800 Å approximately).

A typical engine detection system installation would include three sensors, one junction connector, one control unit, and miscellaneous wires and tubing. The entire system would weigh approximately 7.5 pounds.

Procedure

The Edison ultraviolet detection system was mounted on the burner-can section of a J47 engine (see Figure 2 through Figure 5) to simulate possible in-flight detector configurations. The push-to-test circuit, fire detection light and a Hewlett-Packard Electronic Frequency Meter, Model 500B (used to count the pulses) were located in a control house adjacent to the test engine.

Tests were run to determine the range of the sensors in detecting a burn-through flame. The following procedure was used for all burn-through tests:

1. The sensors were mounted in the desired locations.

2. The power was turned on to the detector.

3. The sensors were tested with the push-to-test circuit.

4. The ultraviolet count was checked with the meter.

5. The engine was started and brought up to 85 percent power, with fuel shut off to the burner-can containing the burn-through hole so that no flame was emitted from the hole.

6. The ultraviolet count was checked with the meter.

7. The fuel was switched on to the burner-can containing the burn-through hole so that the burn-through flame was emitted.

8. The ultraviolet counts were recorded at 85, 70, 50 and 20 percent engine power (in seven tests the ultraviolet count was recorded only at 85 percent engine power).

9. The engine was shut down and the final ultraviolet count was checked with the meter.

The initial series of tests was performed with two sensors mounted on a bracket at the forward end of the burner-can section as shown in Figure 5. Referring to Figure 6 they were located 9.5 inches forward of the burn-through hole, 120° apart, at 60° and 300° from the burn-through hole on the engine circumference, and 4 inches above the burner-cans with the lenses looking tangent to the burner-cans. These tests involved first using both sensors together and subsequently each one separately. The latter was accomplished by hooding the unused sensor, as shown in Figure 3. The sensors were then relocated around the engine circumference in several different locations, as noted in Table 1. The test procedure was repeated after each relocation.

For the next series of tests the sensors were located at the center and subsequently, at the aft end of the burner-can area. These tests were performed using the procedure described in the first series above. All the aforementioned tests were repeated with the sensors mounted as shown in Figure 4.

The angular viewing range of the sensors was determined by performing tests using a small propane torch. A sensor was mounted on a bracket and the ultraviolet pulse count was monitored as the propane torch was positioned at various angles to the sensor lens.

Discussion and Results

After installation of the detection system, it was discovered that when power was switched on to the system it would immediately false alarm. All wiring was checked and found to be in compliance with the manufacturer's Flight Test Instruction manual. This condition persisted until the push-to-test circuit failed. All tests were performed with the push-to-test circuit inoperative.

The range of the detector system varied approximately 10 to 15 degrees around the engine circumference as the engine power setting varied between 50 and 85 percent (see Figures 7 and 8). When the power setting was brought down to 20 percent there was a very noticeable decrease in pulses per second. The angular range of the system detecting a propane torch flame differed greatly from the range in detecting a burn-through flame. Figure 9 shows the angular view needed to:

1. Produce a fire warning from a flame of a small propane torch.

2. Produce 840 pulses per second from a burner-can burn-through flame.

3. Produce a fire warning from a burner-can burn-through flame.

Since previous ultraviolet detectors have proven troublesome when lenses have become coated with oil, it was decided to perform an additional test on the Edison system. The detection system was tested after a thin coating of oil was applied to the lenses of both sensors, as noted in Table 1. The ultraviolet count before the oil was applied was 800 pulses per second (Table 1, Run 1). After the oil was applied there was no fire detection and the pulse rate was zero (Table 1, Run 1A).

On two occasions during the evaluation a false alarm was observed when the sensor lens was struck directly by sunlight. The first occurrence was at approximately 3:30 p.m., in mid December. An intermittent fire warning was noted with the pulse rate varying between 10 and 40 pulses per second. The second occurrence was at approximately 11:00 a.m., in late December.

A continuous false alarm was noted with a pulse rate varying between 40 and 60 pulses per second. The times of occurrences are noted because the intensity of solar ultraviolet radiation depends on the zenith angle of the sun, with the least intense time being midwinter. The time of day that the ultraviolet intensity is the greatest is 12 o'clock noon; see Reference 1.

On the final test one of the sensors became inoperative and failed to detect any ultraviolet light. It was conclusively determined that the sensor had failed, rather than another component. It was replaced by a spare sensor, and the tests were completed.

Summary of Results

1. In all tests the detector responded immediately to any flame within its range, as defined in Figure 9, except when the lens was covered with an oil film.

2. Direct sunlight impinging on the sensor lens caused false fire warnings.

3. Problems encountered with the detection system involved continuous false alarms until the push-to-test circuit became inoperative, after which no further unexplainable false alarms were noted and toward the end of the testing one sensor failed to detect ultraviolet light.

REFERENCES

1. Ultra-Violet and Infra-Red Engineering
Dr. W. Summer, Interscience Publishers, Inc., New York, N. Y. 1962

TABLE I
RESULTS OF DETECTION TESTS

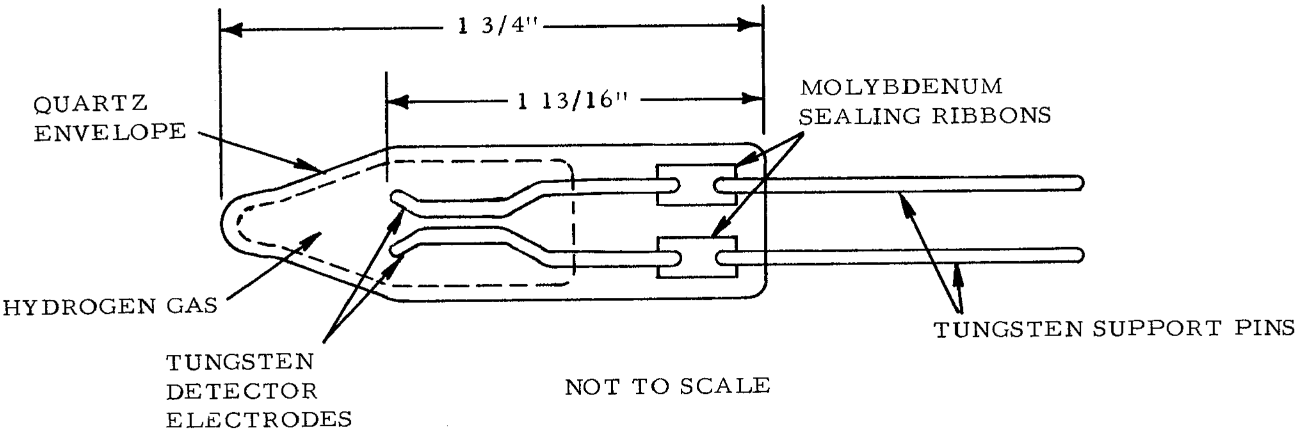
Run No.	Location of Detectors[1] Detector No. 1	Detector No. 2	Position of Detectors[2] Detector No. 1	Detector No. 2	Ultraviolet Light Intensity (Pulses Per Second)[3] 20% Power	50% Power	70% Power	85% Power	Detection	False Alarm	Remarks
1	65^{o} X 9½ in.	305^{o} X 9½ in.	Parallel to Engine Axis	Parallel to Engine Axis	---	---	---	800	Yes	No	
1A	65^{o} X 9½ in.	305^{o} X 9½ in.	Parallel to Engine Axis	Parallel to Engine Axis	---	---	---	0	No	No	Oil On Lens of Sensors
2	110^{o} X 9½ in.	350^{o} X 9½ in.	Parallel to Engine Axis	Parallel to Engine Axis	---	---	---	340-390	Yes	No	
3	90^{o} X 9½ in.	330^{o} X 9½ in.	Parallel to Engine Axis	Parallel to Engine Axis	790-820	840	840	840	Yes	No	
4	60^{o} X 9½ in.	300^{o} X 9½ in.	Perpendicular to Engine Axis	Perpendicular to Engine Axis	720	820	810-820	800	Yes	No	
5	110^{o} X 9½ in.	350^{o} X 9½ in.	Perpendicular to Engine Axis	Perpendicular to Engine Axis	840	840	840	840	Yes	No	
6	90^{o} X -2 in.	340^{o} X -2 in.	Parallel to Engine Axis	Perpendicular to Engine Axis	800-825	830	830	830	Yes	No	
7	60^{o} X -2 in.	310^{o} X -2 in.	Parallel to Engine Axis	Perpendicular to Engine Axis	400-700	830	830	800	Yes	No	
8	90^{o} X -15½ in.	340^{o} X -15½ in.	Parallel to Engine Axis	Perpendicular to Engine Axis	200	600	580	420	Yes	No	
9	65^{o} X 9½ in.	-	Parallel to Engine Axis	--	-	-	-	400	Yes	No	
9A	65^{o} X 9½ in.	-	Parallel to Engine Axis	--	-	-	-	0	No	No	Oil On Lens of Sensor
10	305^{o} X 9½ in.	-	Parallel to Engine Axis	--	-	-	-	780	Yes	No	
10A	305^{o} X 9½ in.	-	Parallel to Engine Axis	--	-	-	-	0	No	No	Oil On Lens of Sensor
11	350^{o} X 9½ in.	-	Parallel to Engine Axis	--	290-340	690-710	600	500	Yes	No	
12	110^{o} X 9½ in.	-	Parallel to Engine Axis	--	0	0	0	10-30	No	No	
13	90^{o} X 9½ in.	-	Parallel to Engine Axis	--	20-25	40-55	90-120	140-160	Yes No @ 20%	No	
14	330^{o} X 9½ in.	-	Parallel to Engine Axis	--	840	840	840	840	Yes	No	

1. As shown in Figure 6
2. If perpendicular, see Figure 4; if parallel, see Figure 5
3. Two readings indicate range of fluxuations

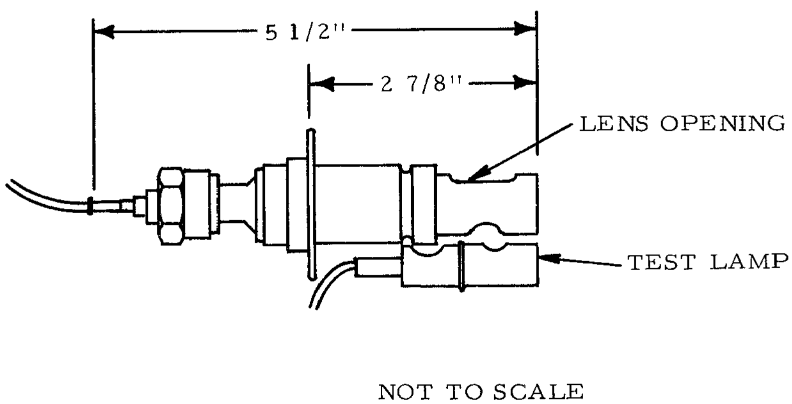
TABLE I
RESULTS OF DETECTION TESTS

Run No.	Location of Detectors[1] Detector No. 1	Location of Detectors[1] Detector No. 2	Position of Detectors[2] Detector No. 1	Position of Detectors[2] Detector No. 2	Ultraviolet Light Intensity (Pulses Per Second)[3] 20% Power	50% Power	70% Power	85% Power	Detection	False Alarm	Remarks
15	90° X -2 in.	-	Parallel to Engine Axis	--	0	5-20	30-45	80	No @ 20%& 50% Yes @ 70 & 85%	No	
16	60° X -2 in.	-	Parallel to Engine Axis	--	400	790-800	700-740	700	Yes	No	
17	90° X -15½ In.	-	Parallel to Engine Axis	--	0-80	600	560	400	Yes Intermittent @ 20%	No	
18	300° X 9½ in.	-	Perpendicular to Engine Axis	--	500-600	820	810	720-770	Yes	No	
19	60° X 9½ in.	-	Perpendicular to Engine Axis	--	400-500	740-790	750-780	700	Yes	No	
20	350° X 9½ in.	-	Perpendicular to Engine Axis	--	830	840	840	840	Yes	No	
21	110° X 9½ in.	-	Perpendicular to Engine Axis	--	0-5	0-15	0-13	0-10	No	No	
22	340° X -2 in.	-	Perpendicular to Engine Axis	--	820-830	830	830	830	Yes	No	
23	310° X -2 in.	-	Perpendicular to Engine Axis	--	300-400	820	780-810	700	Yes	No	
24	80° X 9½ in.	-	Perpendicular to Engine Axis	--	80-100	500	640-700	640-660	Yes	No	
25	330° X 9½ in.	-	Perpendicular to Engine Axis	--	820	840	840	840	Yes	No	
26	90° X 9½ in.	-	Perpendicular to Engine Axis	--	0	0	0	0	No	No	Faulty Sensor - Sensor Replaced
27	90° X 9½ in.	-	Perpendicular to Engine Axis	--	40-60	40-60	40-60	130	Yes	Yes	Fire Warning From Sun. 40-60 Pulses Per Second

1. As shown in Figure 6
2. If perpendicular, see Figure 4; if parallel, see Figure 5
3. Two readings indicate range of fluxuations



(a) ULTRAVIOLET DETECTION LAMP



(b) ULTRAVIOLET SENSOR WITH TEST LAMP

FIG. 1 EDISON ULTRAVIOLET SURVEILLANCE FIRE WARNING SYSTEM SENSOR

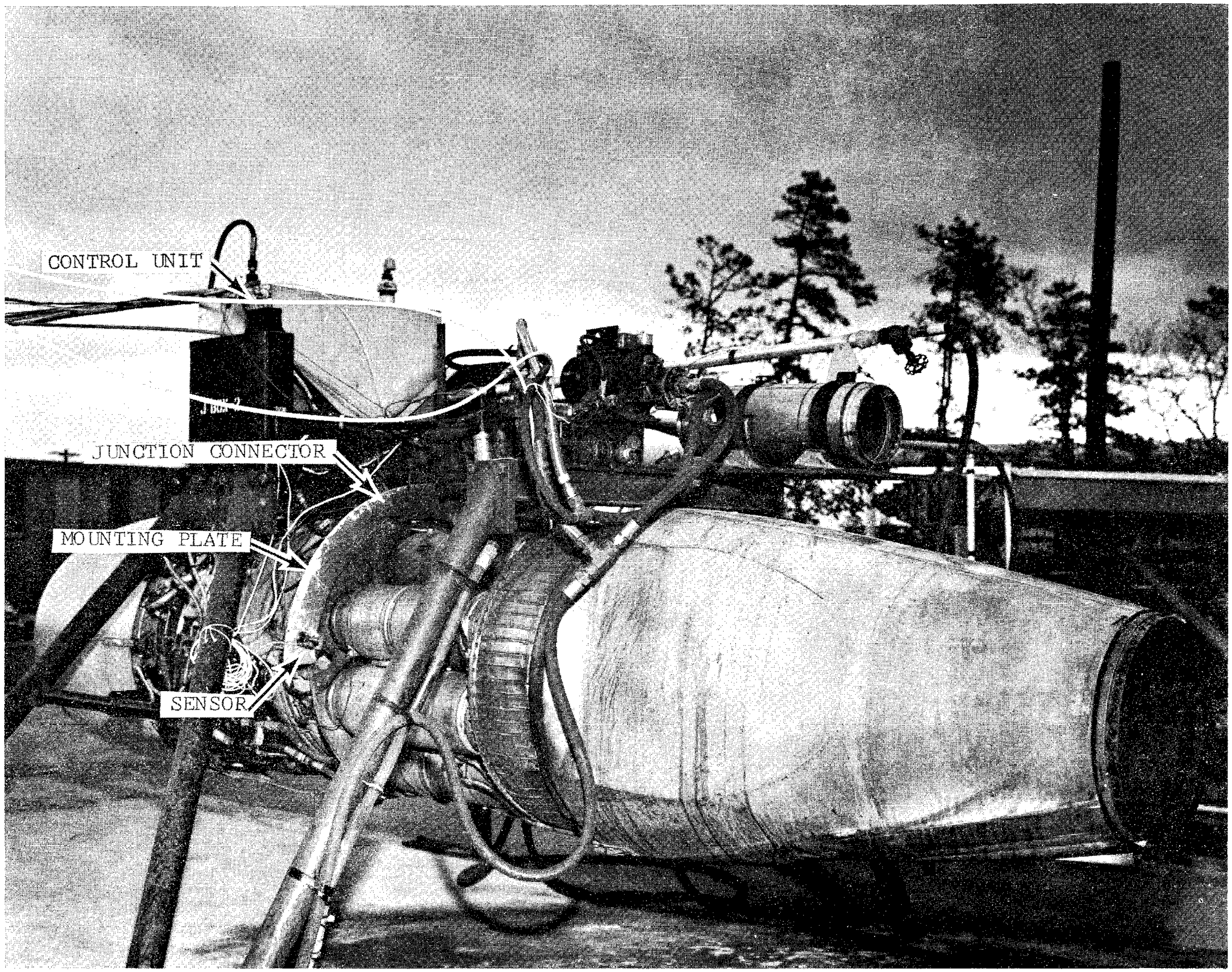


FIG. 2 J47 ENGINE WITH EDISON ULTRAVIOLET SURVEILLANCE FIRE WARNING SYSTEM MOUNTED IN TEST POSITION

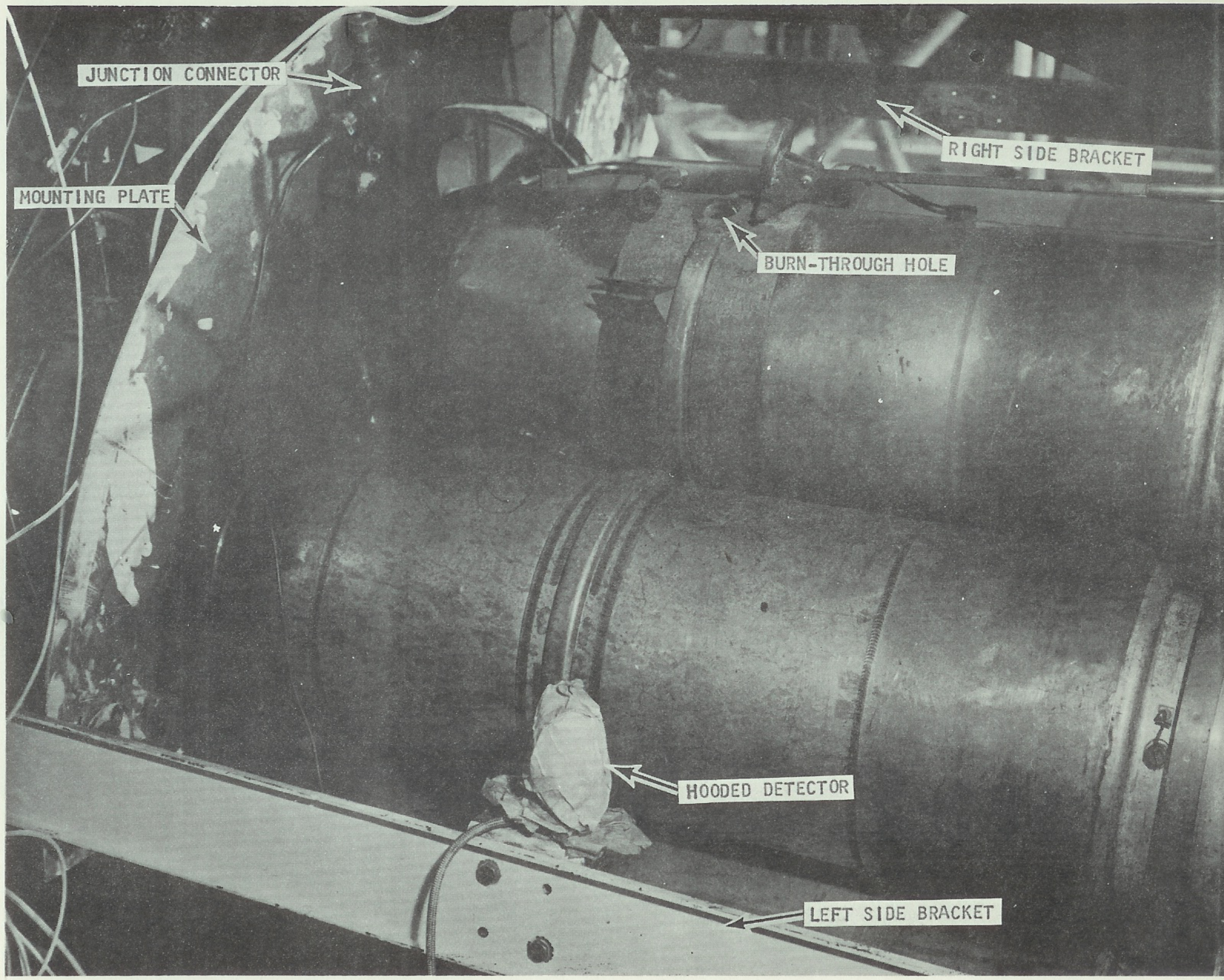


FIG. 3 SENSOR HOODED TO PREVENT ULTRAVIOLET PICKUP

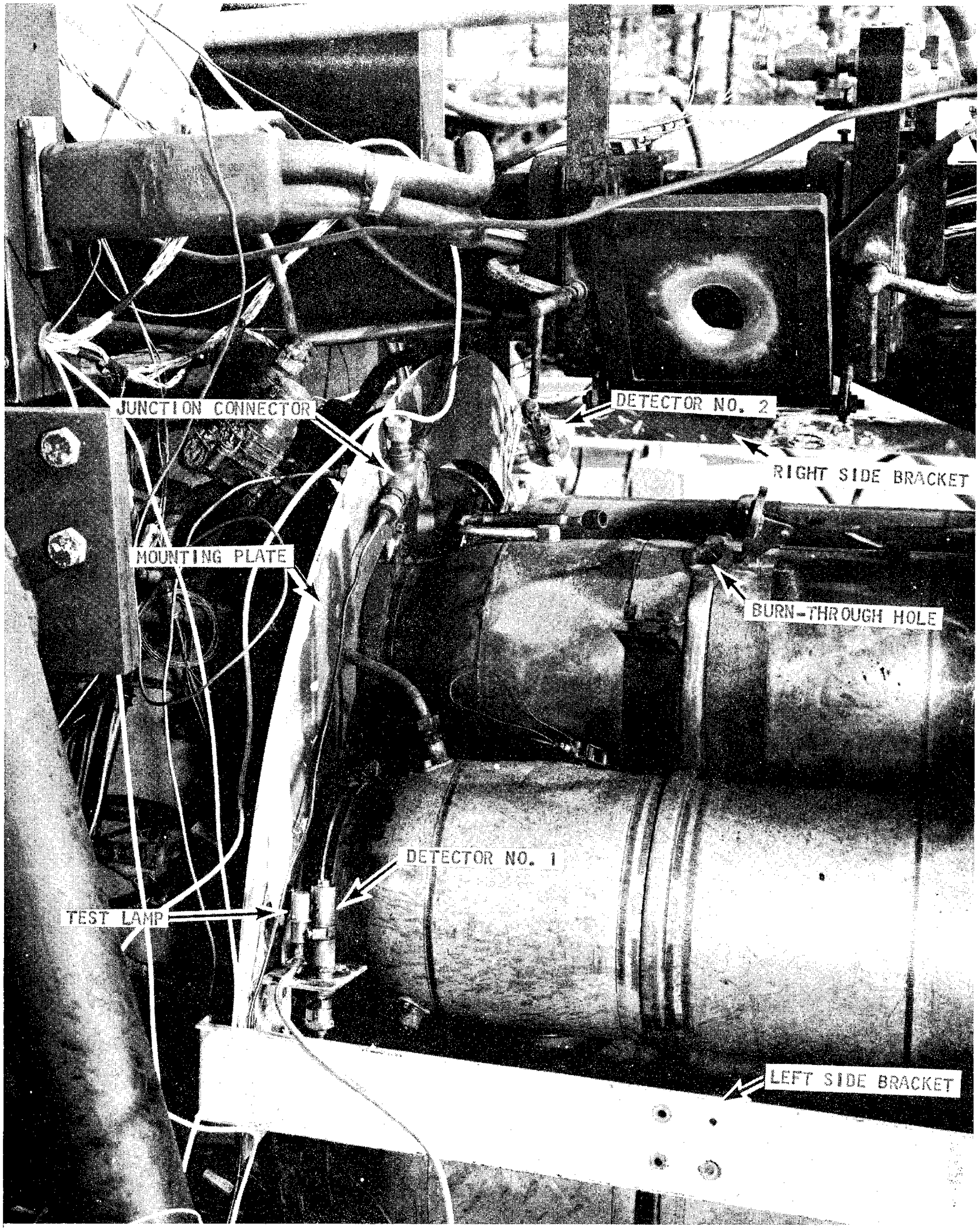


FIG. 4 SENSORS LOCATED PERPENDICULAR TO ENGINE AXIS, 9 1/2 INCHES FORWARD OF BURN-THROUGH HOLE, 4 INCHES ABOVE THE BURNER-CANS, WITH LENSES LOOKING AFT

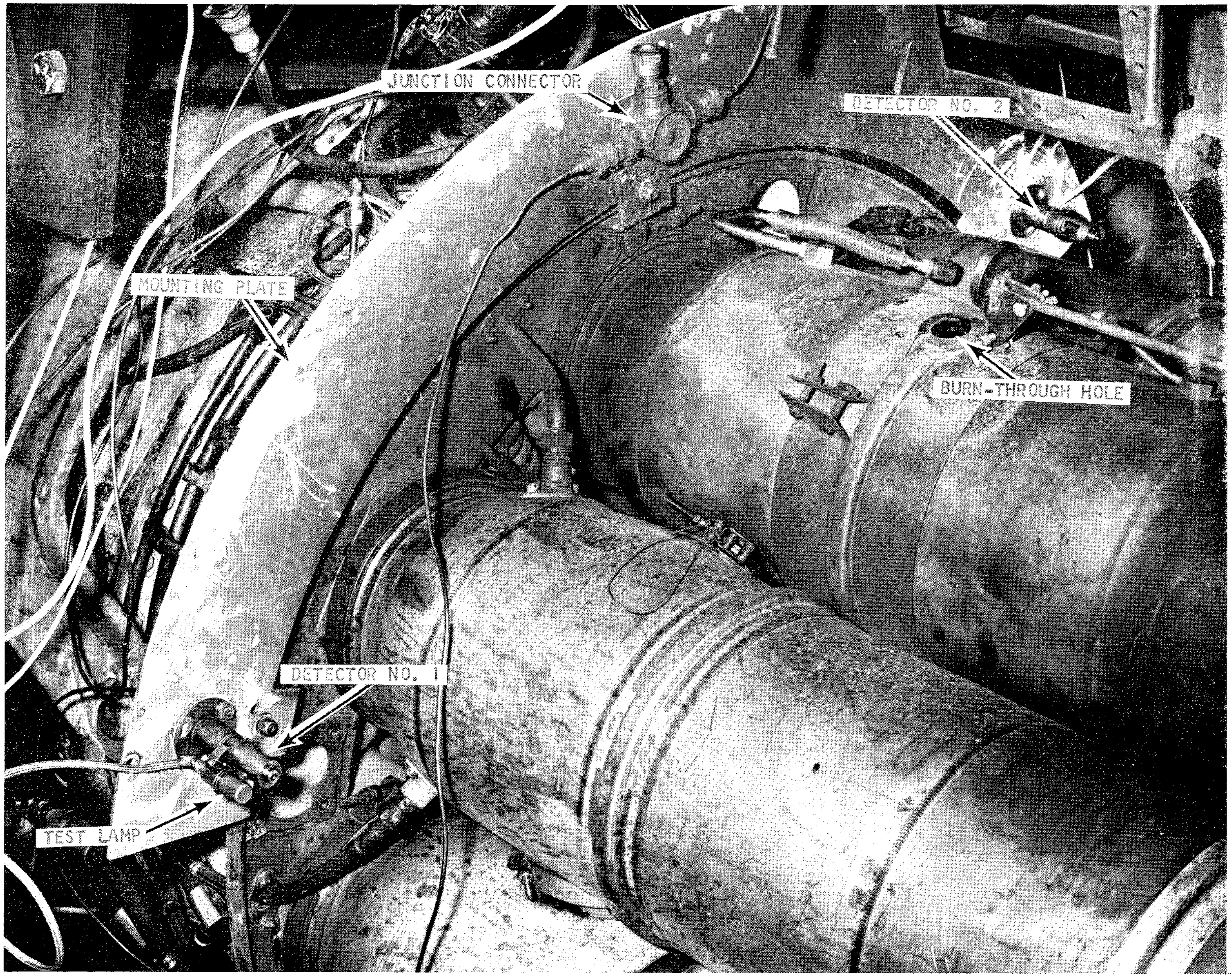


FIG. 5 SENSORS LOCATED PARALLEL TO ENGINE AXIS, 9 1/2 INCHES FORWARD OF BURN-THROUGH HOLE, 4 INCHES ABOVE THE BURNER-CANS, WITH LENSES LOOKING TANGENT TO BURNER-CANS

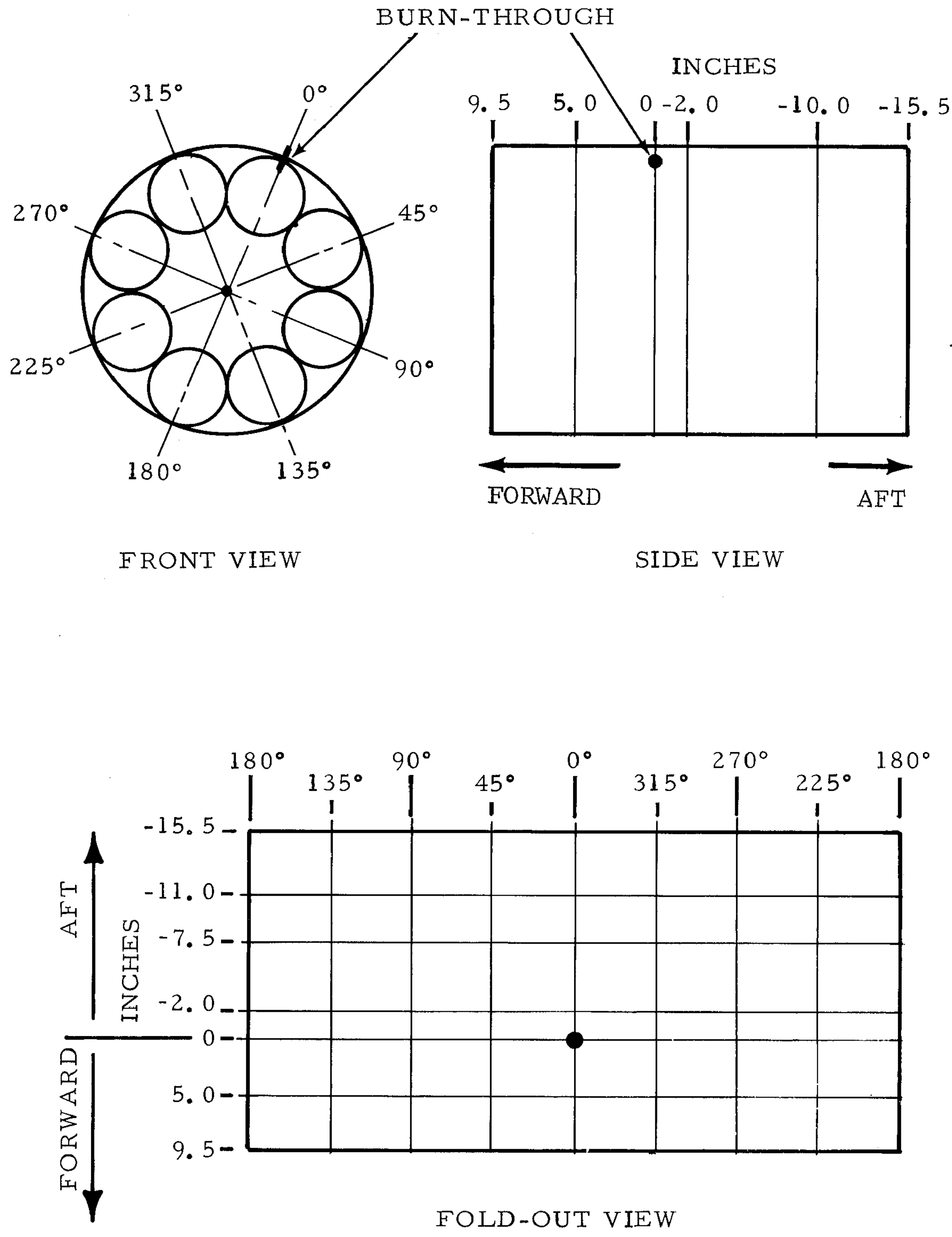


FIG. 6 COORDINATE SYSTEM USED TO DEFINE LOCATION OF SENSORS

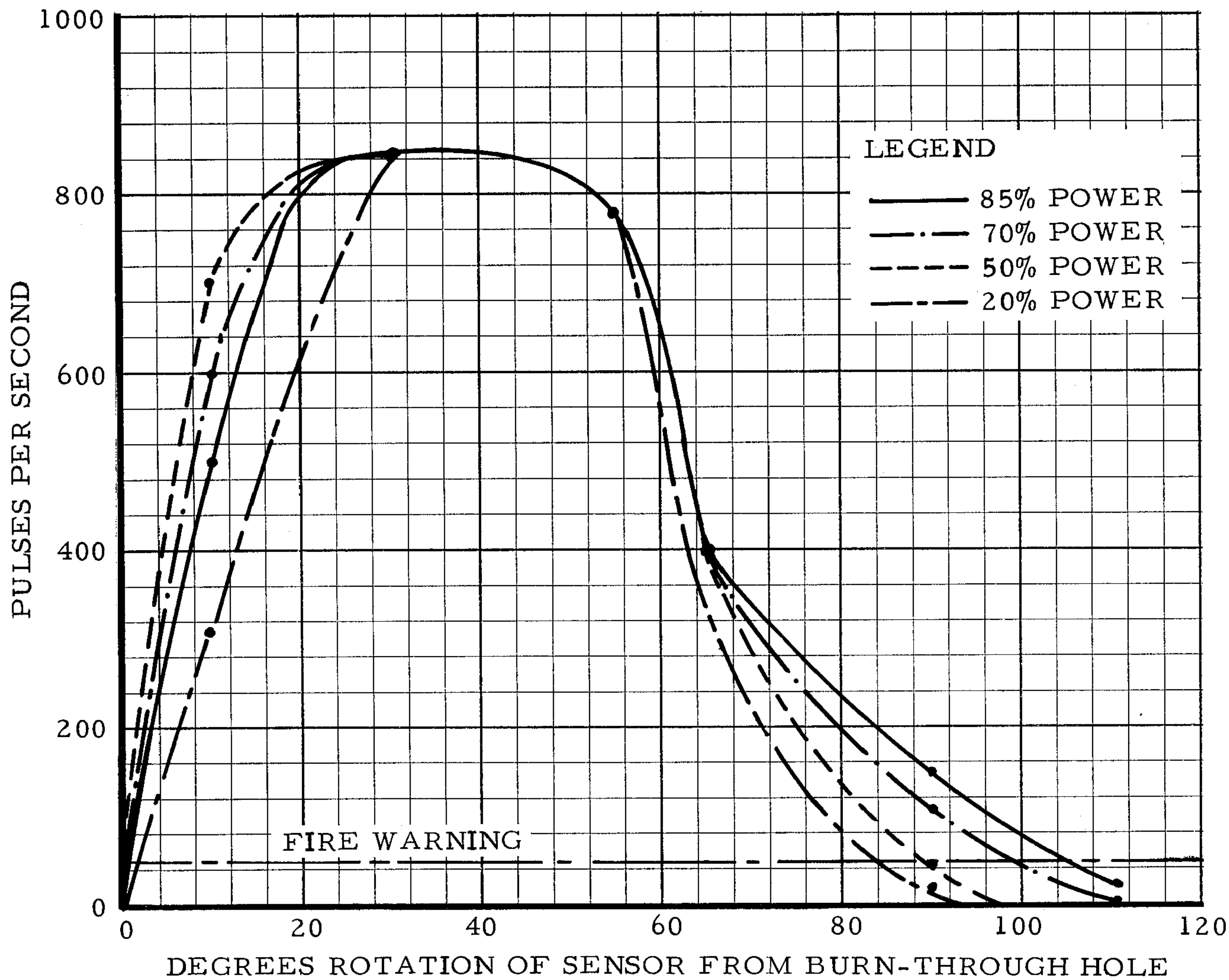


FIG. 7 PULSES PER SECOND RECEIVED FROM SENSOR, LOCATED IN POSITION AS DEFINED IN FIG. 5, AS IT IS ROTATED AROUND ENGINE CIRCUMFERENCE, AT FOUR DIFFERENT ENGINE POWER SETTINGS.

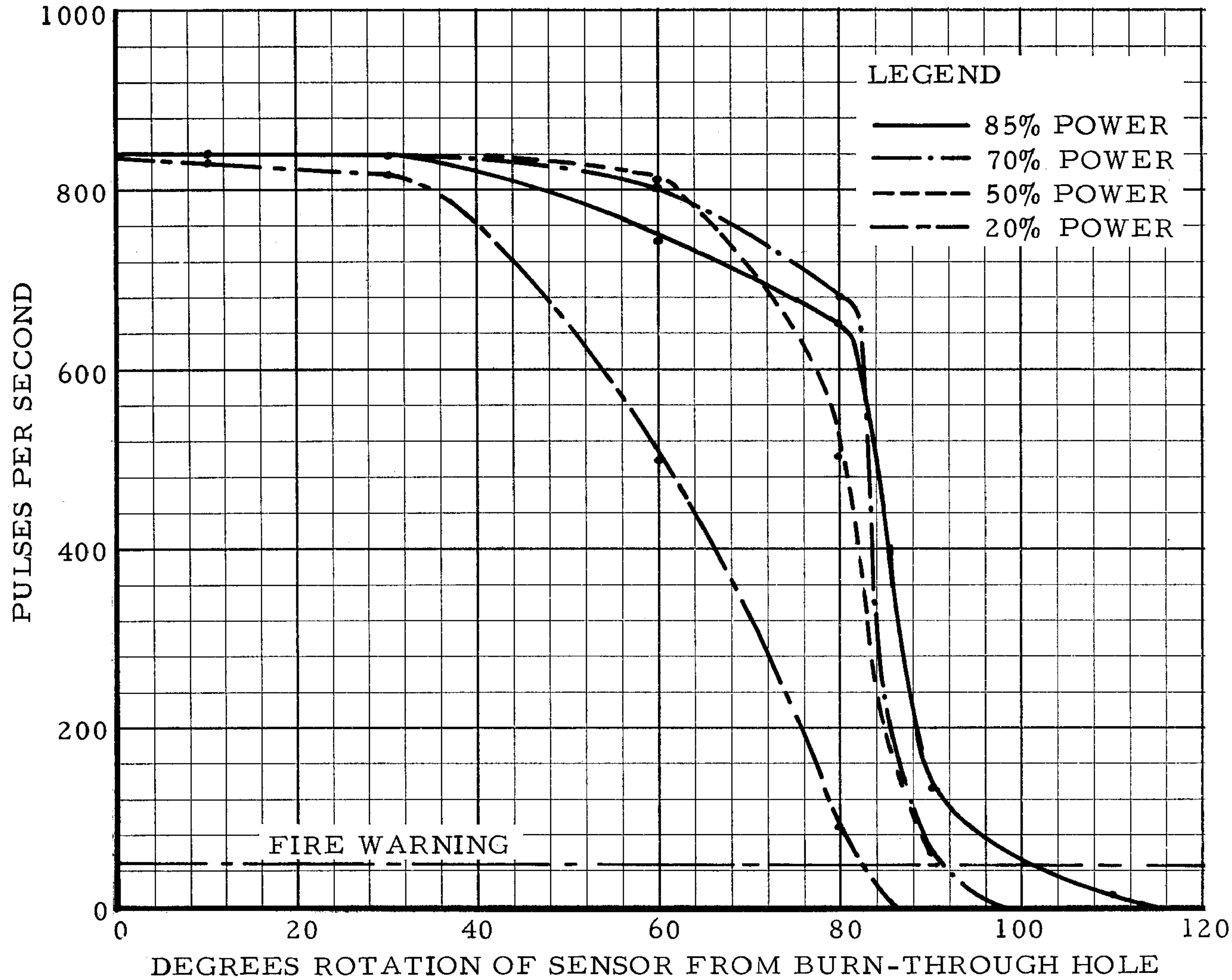
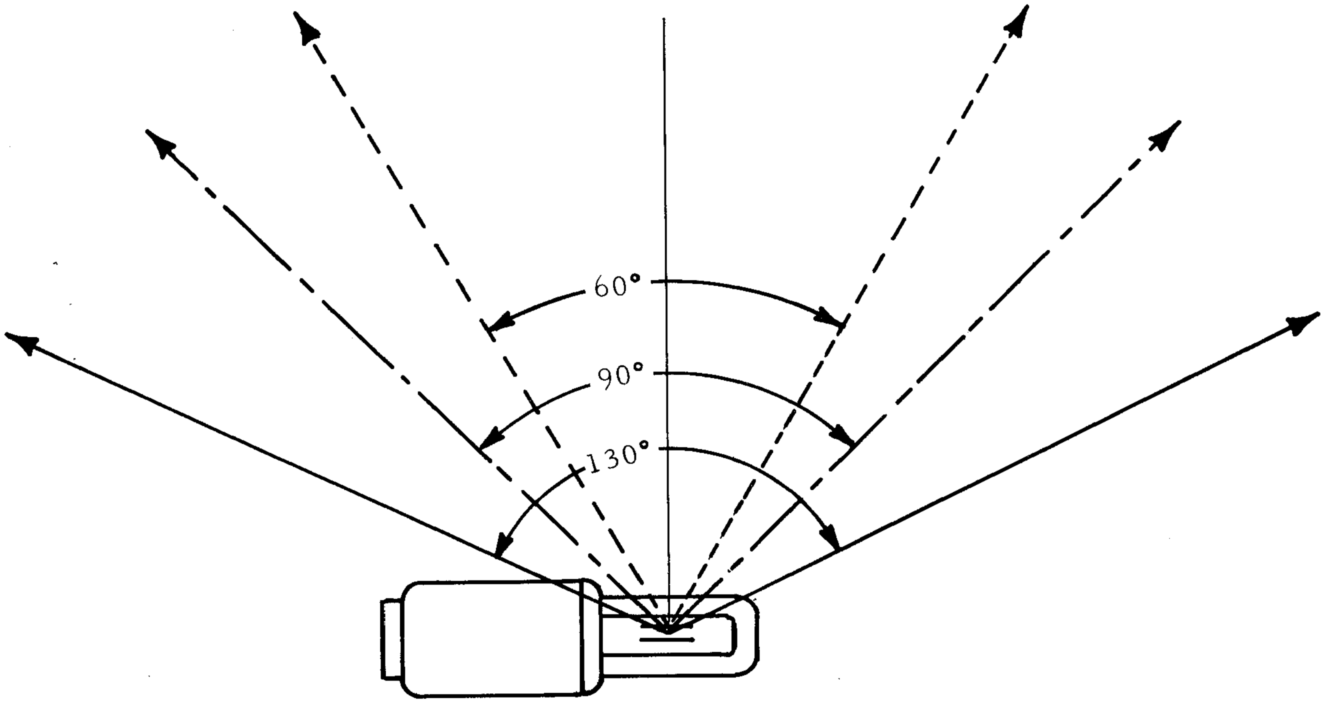
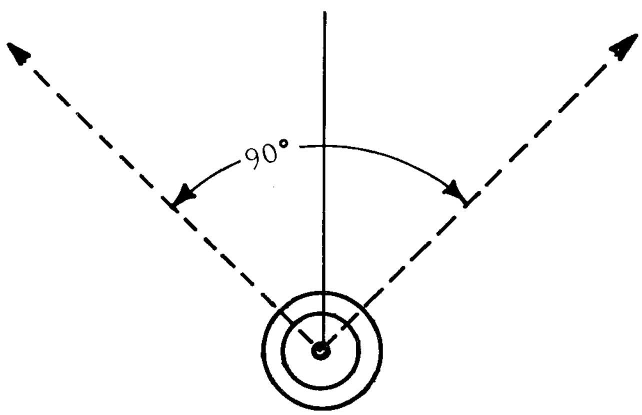


FIG. 8 PULSES PER SECOND RECEIVED FROM SENSOR, LOCATED IN POSITION AS DEFINED IN FIG. 4, AS IT IS ROTATED AROUND ENGINE CIRCUMFERENCE, AT FOUR DIFFERENT ENGINE POWER SETTINGS.



SIDE VIEW



END VIEW

LEGEND

——— BURN-THROUGH HOLE FLAME (FIRE WARNING)

— · — BURN-THROUGH HOLE FLAME (840 PULSES PER SECOND)

- - - - - USING PROPANE TORCH

FIG. 9 ANGULAR RANGE OF EDISON ULTRAVIOLET SENSOR.