SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
485 LEXINGTON AVENUE
NEW YORK 17, N.Y.

AERONAUTICAL STANDARD AS 401B

POWERPLANT FIRE DETECTION INSTRUMENTS - THERMAL & FLAME CONTACT TYPES (RECIPROCATING ENGINE POWERED AIRCRAFT)

Issued 12-1-47
Revised 1-15-61

1. PURPOSE: To specify minimum requirements for powerplant fire detection instruments primarily for use in reciprocating engine powered civil transport aircraft, the operation of which may subject the instrument to environmental conditions specified in Paragraph 3.3.

2. SCOPE: This Aeronautical Standard covers the following basic types of fire detection instruments, or combinations thereof, intended for use in protecting aircraft powerplant installation, auxiliary powerplants, combustion heaters and other installations where fuel, oil or similar fires may occur.

2.1 Basic Types: Definition of

Type I Thermal - Fixed Temperature, an instrument which will actuate an alarm signal when exposed to any temperature above a definite pre-established level.

Type II Thermal - Rate of Rise, an instrument which will actuate an alarm signal when exposed to any rate of temperature change above a definite pre-established level.

Type III Flame - Contact, an instrument which will actuate an alarm signal when exposed to physical contact with flame.

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

3.1.1 Materials: Materials shall be of a quality which experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 Workmanship: Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 Identification: The following information shall be legibly and permanently marked on the instrument or attached thereto:

(a) Name of Instrument (Powerplant Fire Detector)
(b) SAE Aeronautical Standard AS 401B
(c) Manufacturer's Part Number
(d) Manufacturer's Serial Number or Date of Manufacture
(e) Manufacturer's Name and/or Trademark
(f) Type Number
(g) Alarm Temperature (Sensing element, where applicable)
(h) Rating (Electrical, Vacuum, etc.)

3.3 Environmental Conditions: The following conditions have been established as minimum design requirements. Tests shall be conducted as specified in Sections 5, 6 and 7.

3.3.1 Temperature: When installed in accordance with the manufacturer's recommendations, the instrument shall function over the range of ambient temperatures shown in Column A below and shall not be adversely affected by exposure to the temperatures shown in Column B below:

Instrument Location	A	B
Powerplant Compartments	-30 to 100C	-65 to 100C
Pressurized Areas	-30 to 50C	-65 to 70C
Nonpressurized or external Areas	-55 to 70C	-65 to 70C

If instrument is intended for use in compartments where maximum ambient is higher than 100°C, appropriate special limits shall be selected for Column A and B, and specified by the manufacturer.

3.3.2 Humidity: The instrument shall function and shall not be adversely affected when exposed to any relative humidity in the range from 0 to 95 percent at a temperature of approximately 70°C.

3.3.3 Altitude: When installed in accordance with the instrument manufacturer's instructions, the instruments shall function from sea level up to the altitudes and temperatures listed below. Altitude pressures are per NACA Report 1235.

Instrument Location		
Powerplant Compartments	50,000'	(80 C)
Pressurized Areas	15,000'	(50 C)
Nonpressurized Areas	50,000'	(20 C)

The instrument shall not be adversely affected following exposure to extremes in ambient pressure of 50 inches, and 3 inches, of mercury absolute, respectively.

3.3.4 Vibration: When installed in accordance with the instrument manufacturer's instructions, the instrument shall function and shall not be adversely affected when subjected to vibrations of the following characteristics:

	Frequency Cycles Per Sec.	Max. Double Amplitude - Inches	Maximum Acceleration
Airframe Structure Mounted	5-500	.050	10g
Shock-Mounted Panel	5-50	.020	1.5g
Powerplant Mounted	5-500	.100	20g

3.4 Radio Interference: The instrument shall not be the source of objectionable interference, under operating conditions at any frequencies used on aircraft, either by radiation or feedback, in electronic equipment installed in the same aircraft as the instrument.

3.5 Magnetic Effect: The magnetic effect of the instrument shall not adversely affect the operation of other instruments in the same aircraft.

3.6 Fire Hazard: The instrument shall be so designed to safeguard against hazards to the aircraft in the event of malfunction of failure, and the maximum operating temperature of surfaces of any instrument component contacted by combustible fuel or vapor shall not exceed 200C due to self-heating.

4. DETAIL REQUIREMENTS:

4.1 Indication Means: The instrument shall be capable of actuating visual and/or aural alarm indicators.

4.2 Reliability: The instrument shall be of such design to withstand the mechanical and thermal shocks and stresses incident to its use in aircraft. False alarm signals shall not be produced by the instrument as the result of variations in voltage to be encountered during operation of the aircraft, abnormal attitudes, contaminating atmospheres, ambient light conditions, accelerations which could be encountered during flight, landing and take-off.

4.3 Integrity Test Means: The instrument shall be of such design to provide a means for testing the integrity of the instrument in flight.

4.4 Calibration Means: The instrument design shall be such that all calibration means be provided with tamper-proof seals.

4.4.1 Adjustible Detector Systems: Instruments which incorporate means for adjustment shall be tested to prove compliance with this standard, particularly paragraphs 7.2.1, 7.2.2, 7.2.3 and 7.12, throughout the range of adjustability.

5. TEST CONDITIONS:

5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this Aeronautical Standard shall be conducted at an atmospheric pressure of approximately 29.92 inches of mercury and at an ambient temperature of approximately 25 C and at a relative humidity of not greater than 85 percent. When tests are conducted with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variation from the specified conditions.

5.2 Vibration (To minimize friction): Unless otherwise specified, all tests for performance may be conducted with the instrument subjected to a vibration of 0.002 to 0.005 inch double amplitude at a frequency of 1500 to 2000 cycles per minute. The term double amplitude as used herein indicates the total displacement from positive maximum to negative maximum.

5.3 Vibration Equipment: Vibration equipment shall be used which will provide frequencies and amplitudes consistent with the requirements of Section 3.3.4 with the following characteristics:

5.3.1 Linear Motion Vibration: Vibration equipment for airframe structure-mounted or powerplant-mounted instrument components shall be such as to allow vibration to be applied along each of three mutually perpendicular axes of the test specimen.

5.3.2 Circular Motion Vibration: Vibration equipment for shock mounted panel instrument component shall be such that a point on the instrument case will describe, in a plane 45° to the horizontal plane, a circle the diameter of which is equal to the double amplitude specified.

5.4 Power Conditions: Unless otherwise specified, all tests shall be conducted at a power rating recommended by the manufacturer.

5.5 Test Position: Unless otherwise specified, the instrument shall be mounted and tested in its normal operating position.

5.6 Flame Temperature Measurement and Flame Size: All flame temperatures shall be measured by using chromel-alumel thermocouples of 18 gauge wire. The thermocouple bead shall be at the center of the flame and the two wires leading to the bead shall be parallel and extend for a distance of 3 inches horizontally into the flame. The nature and size of the flame and the method of test shall be as specified in Figures 2-1, 2-2, 2-3 and 2-4. The thermocouple and the test article shall be the same distance from the burner face, to assure that the test article is exposed to the temperature measured.

6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments or components of such shall be subjected to whatever tests the manufacturer deems necessary to demonstrate that production articles comply with this Aeronautical Standard including the following requirements where applicable.

6.1 Sensitivity and Calibration: The sensor shall be tested as specified in Paragraph 7.1, or in an equivalent manner which will test the response sensitivity and calibration

6.2 Dielectric: Each instrument shall be tested by the methods of inspection listed in Paragraphs 6.2.1 and 6.2.2.

6.2.1 Insulation Resistance: The insulation resistance measured at 200 volts D.C. for five seconds between all electrical circuits connected together and the metallic case shall not be less than 5 megohms. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc. since this measurement is intended only to determine adequacy of insulation.

6.2.2 Overpotential Tests: Equipment shall not be damaged by the application of a test potential between electrical circuits, and between electrical circuits and the metallic case. The test potential shall be a sinusoidal voltage of a commercial frequency with an R.M.S. value of five times the maximum circuit voltage or per Paragraphs 6.2.2.1 or 6.2.2.2, whichever applies. The potential shall start from zero and be increased at a uniform rate to its test value. It shall be maintained at this value for five seconds, and then reduced at a uniform rate to zero.

Since these tests are intended to assure proper electrical isolation of the circuit components in question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

6.2.2.1 Hermetically sealed instruments shall be tested at 200 volts R.M.S.

6.2.2.2 Circuits that operate at potentials below 15 volts are not to be subjected to overpotential tests.

7. QUALIFICATION PERFORMANCE REQUIREMENTS: As many instruments as deemed necessary to demonstrate that the instruments comply with the requirements of this section shall be tested in accordance with the manufacturer's recommendations. The tests on each instrument shall be conducted consecutively in the order listed, and after the tests have been initiated, further adjustments to the instrument shall not be permitted. A false alarm signal occurring during any of the tests shall disqualify the instrument from further testing. A response time test per Section 7.1 shall be conducted after each test, except Sections 7.1.3, 7.2, 7.2.1, 7.2.3 and 7.12. In conducting the test of Section 7.12, the instrument(s) tested need not be the same instrument(s) being subjected to the entire series of qualification tests.

7.1 Response Time and Calibration: Each instrument shall be subjected to the response time and calibration tests listed below applicable to the particular type or combination thereof. Instruments shall be tested by the application of the test flame to a single unit type sensor or to a 6" length of a continuous type sensor. For instruments in which the sensitivity is affected by the number of sensing elements by the length of the sensing element (for continuous types) or by other factors which may be varied from one installation to another, all response time tests shall be conducted with the least sensitive configuration to be used. The unit sensor or segment of continuous sensor exposed to the test flame shall be that most critical for response time.

7.1.1 Response Time Test - Types I, II, and III: The sensor of the instrument shall be exposed to a maximum temperature test flame of 1100°C. as specified in Figure 2. The ambient temperature from which the test is started shall be room temperature, except a higher starting ambient temperature may be used if the sensor is specified for use only in locations where the ambient temperature will not, under continuous operating conditions, decrease below this value. The response time of all types shall not exceed five (5) seconds.

7.1.2 Calibration Test - Type I Only: The pre-adjusted operating temperature of the instrument specified by the manufacturer shall be that determined as the temperature at which an alarm signal occurs when the instrument is exposed in an essentially gradient free medium starting from room temperature with a low rate of temperature rise which will not affect the calibration.

7.2 False Alarm Due to Rate of Temperature Change: The tests of Paragraphs 7.2.1 and 7.2.2 shall be conducted in a temperature controlled air stream moving at a velocity of 250 feet per minute plus or minus 25 fpm. No alarm signal shall occur.

7.2.1 False Alarm Due to Local Temperature Rise: The sensor shall be subjected to various combinations of rates of temperature rise and durations of these rates of rise shown in the shaded area in Figure 3 (a). This test shall be conducted simulating conditions due to local overheating. No alarm signal shall occur.

7.2.2 False Alarm Due to General Temperature Rise: The test of 7.2.1 shall be repeated using Figure 3 (b). The test shall be conducted simulating conditions due to a general temperature rise throughout compartment where the sensor may be located. No alarm signal shall occur.

7.2.3 False Clearing of Alarm Due to Partial Extinguishing of Fire: With the instrument arranged to test the response time, in accordance with Section 7.1, the test flame shall be applied for 30 seconds. The test flame shall then be masked so as to reduce its effective area by approximately 50 percent. For detector types I, II and III, the sensor should be centrally located such that when 50 percent of the flame is masked, 50 percent of the sensor is also masked. The alarm signal shall not clear. After an additional 30 seconds, the flame shall be removed entirely and the alarm signal shall clear within 30 seconds.

7.3 Vibration:

Resonance: The instrument, while operating, shall be subjected to a resonant frequency survey of the appropriate range specified in Paragraph 3.3.4 in order to determine if there exists any resonant frequencies of the parts. The amplitude used may be any convenient value that does not exceed the maximum double amplitude and the maximum acceleration specified in Paragraph 3.3.4.

The instrument shall then be subjected to vibration at the appropriate maximum double amplitude or maximum acceleration specified in Paragraph 3.3.4 at the resonant frequency for a period of one hour in each axis.

When more than one resonant frequency is encountered with vibration applied along any axis, a test period may be accomplished at the most severe resonance or the period may be divided among the resonant frequencies, whichever shall be considered most likely to produce failure. The test period shall not be less than one-half hour at any major resonant mode.

When resonant frequencies are not apparent within the specified frequency range, the instrument shall be vibrated for two hours in accordance with the vibration requirements schedule (Section 3) at the maximum double amplitude and the frequency to provide the maximum acceleration.

Cycling: The instrument, while operating, shall be tested with the frequency cycled between limits specified in Section 3.3.4 in 15 minute cycles for a period of one hour in each axis at an applied double amplitude specified in Section 3.3.4 or an acceleration specified in 3.3.4 whichever is the limiting value.

7.4 Water Spray: The instrument components which are to be located outside the pressurized area of the aircraft shall be subjected to the following tests:

7.4.1 Simulated Rain: The component shall be subjected to a spray of water to simulate rain for a period of three hours. The component shall not be dried prior to testing per Section 7.1.

7.4.2 Salt Spray: The instrument components which are to be installed in exposed portions of the aircraft shall be subjected to a finely atomized spray of 20 percent sodium chloride solution for 50 hours. At the end of this period, the component shall be allowed to dry and may then be cleaned prior to conducting the test per Section 7.1.

7.5 Humidity: The instrument shall be mounted in a chamber maintained at a temperature of 70 ±2C and a relative humidity of 95 ±5% for a period of six hours. After this period, the heat shall be shut off and the instrument shall be allowed to cool for a period of 18 hours in this atmosphere in which the humidity rises to 100% as the temperature decreases to not more than 38C. This complete cycle shall be conducted:

a. Five times for components located in uncontrolled temperature areas.

b. Once for components located in controlled temperature areas.

Immediately after this cycling, there shall be no evidence of damage or corrosion which affects performance.

7.6 Fuel and Oil Immersion: The instrument components which are to be installed in engine compartments or other locations in the aircraft where it may be contaminated by fuel or oil shall be subjected to the following tests:

7.6.1 Fuel Immersion: The component shall be thoroughly immersed in normally leaded 100 octane fuel at approximately room temperature and then allowed to drain for one (1) minute before being tested per Section 7.1. No cleaning other than the drainage as specified shall be accomplished prior to conducting subsequent tests.

7.6.2 Oil Immersion: The test procedure outlined in Section 7.6.1 shall be conducted with used SAE #50 oil.

7.7 Sand: The instrument components which are to be located in externally exposed portions of the aircraft (such as in nacelles, wheel wells, etc.) of $2\frac{1}{2}$ pounds per hour for four (4) hours. The airstream shall be formed of sand that has been sifted through a 150 mesh screen and the particles shall come in contact with all parts of the component being tested. The test chamber shall be equivalent to that shown in Figure 1.

7.8 High Temperature Operation: The instrument shall be subjected to the applicable high ambient temperature listed in Column A of Paragraph 3.3.1 for a period of 48 hours without operating (electrical equipment shall be energized). Where the highest recommended operating temperatures exceeds those of Column A, this higher temperature shall be used. The instrument shall meet, while at that temperature(s), the performance test of Paragraph 7.1. It may be necessary to remove one or more components from the high temperature environment to perform the test of Paragraph 7.1; if this be the case, the transfer time shall be a maximum of 30 seconds.

7.9 Low Temperature Operation: The instrument shall be subjected to the applicable low ambient temperature listed in Column A of Paragraph 3.3.1 for a period of 48 hours without operating (electrical equipment shall not be energized). The instrument shall meet at that temperature, the performance tests of Section 7.1. However, the requirements shall be considered to have been met in this case if the time of response does not exceed twice the time permitted in Section 7.1. It may be necessary to remove one or more components from the low temperature environment to perform the test of Section 7.1; if this be the case, the transfer time shall be a maximum of 30 seconds.

7.10 Altitude Effects:

7.10.1 High Altitude and Rate of Climb: The instrument shall be subjected to a pressure that is varied from normal atmospheric pressure to an altitude pressure equivalent to 50,000 feet at a rate of not less than 3,000 feet per minute. The instrument shall be maintained at the altitude pressure equivalent to 50,000 feet for a period of 48 hours. The instrument shall then be returned to sea level conditions and then tested per Paragraph 7.1. Sealed components shall not leak as a result of exposure to this pressure and a leak test shall be demonstrated by immersion in water.

7.10.2 Low Altitude: The instrument shall be subjected to the same test as outlined in Paragraph 7.10.1, except that the pressure shall be maintained at an altitude pressure equivalent to -1000 feet and that the rate of pressure variation need not be as specified therein.

7.10.3 Pressurization Test: The components which are to be located in a pressurized area shall be subjected to an external pressure of 50 inches of mercury absolute for a period of 15 minutes. The response time test of the instrument per Paragraph 7.1 shall be conducted while the component involved is under this pressure.

7.11 Voltage Variation: The instrument shall be operated with the voltage cycled between 75 and 110 percent of the rated voltage. The instrument shall then be tested per Paragraph 7.1 under these conditions. Compliance with the provisions of Paragraph 4.2 shall also be demonstrated.

7.12 Clearance Time: The instrument components which are to be installed in a fire zone shall be subjected to a flame of a temperature of 1100°C minimum for two periods of one minute each. The flame shall be as specified in Figure 2. The component shall be cooled to approximately room temperature or to the ambient temperature permitted in Paragraph 7.1 after each exposure to the flame. The component shall then be exposed to the flame a third time. An alarm signal shall occur not to exceed five (5) seconds after each exposure to the flame. During cooling of the component after the first two exposures to flame, the alarm shall clear in not more than 45 seconds after the flame has been removed after each exposure. The established air velocity over the sensor shall be zero during the cooling portion of this test, except a specific higher velocity may be established providing the sensor is specified for use in areas where the air velocity under normal operating conditions will not decrease below this value. Artificial means of cooling the component shall not be used until after the alarm has cleared. A manual resetting means may be used to clear the alarm provided it is demonstrated that the resetting means will clear the alarm only if the flame has been removed. After the third exposure of the component to flame, the instrument need not be capable of further operation. During this test, the sensor shall be subjected to vibration with frequency and amplitude as specified in Paragraph 7.3.

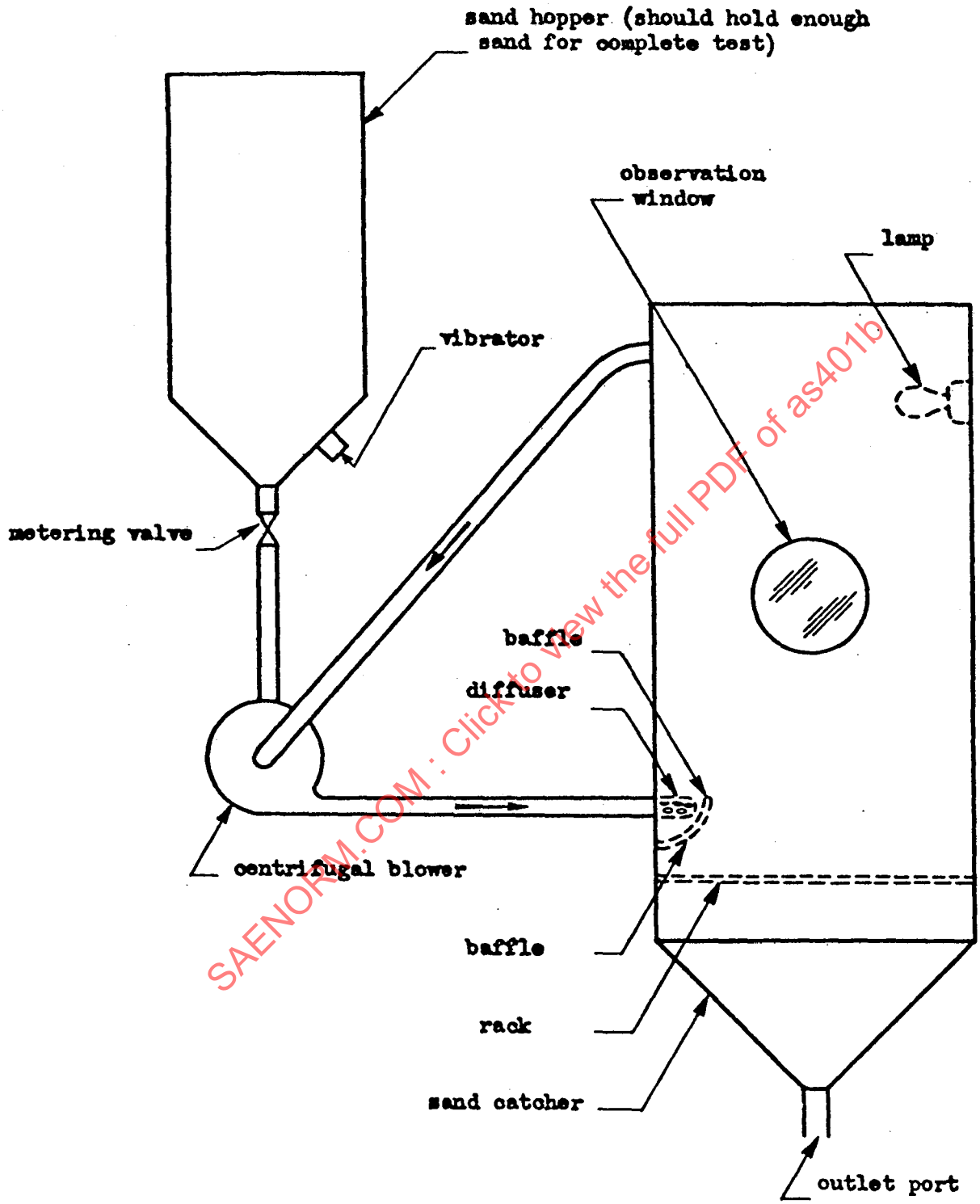

FIGURE 1
Schematic Sand Test Arrangement (Ref. Section 7.7)

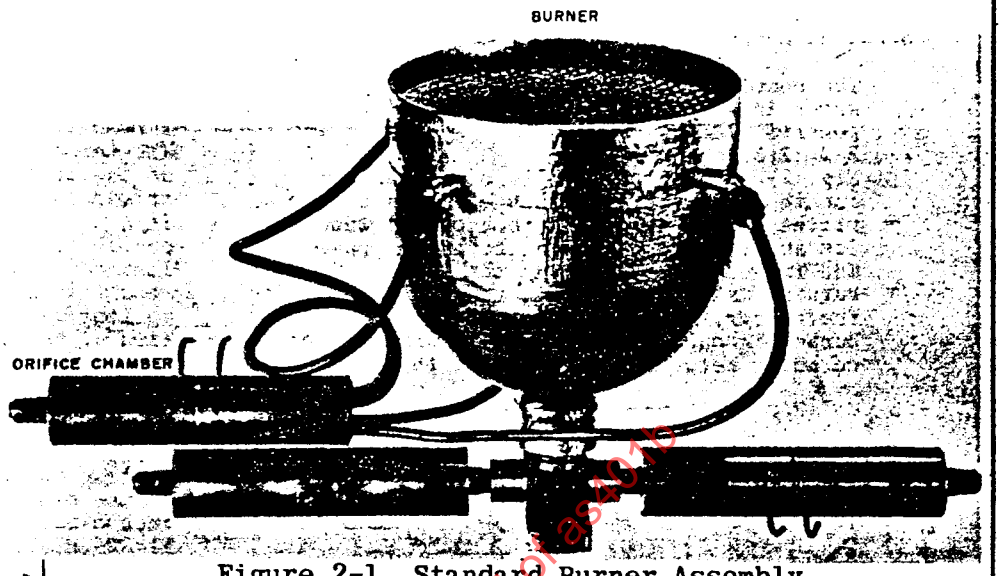

Figure 2-1. Standard Burner Assembly

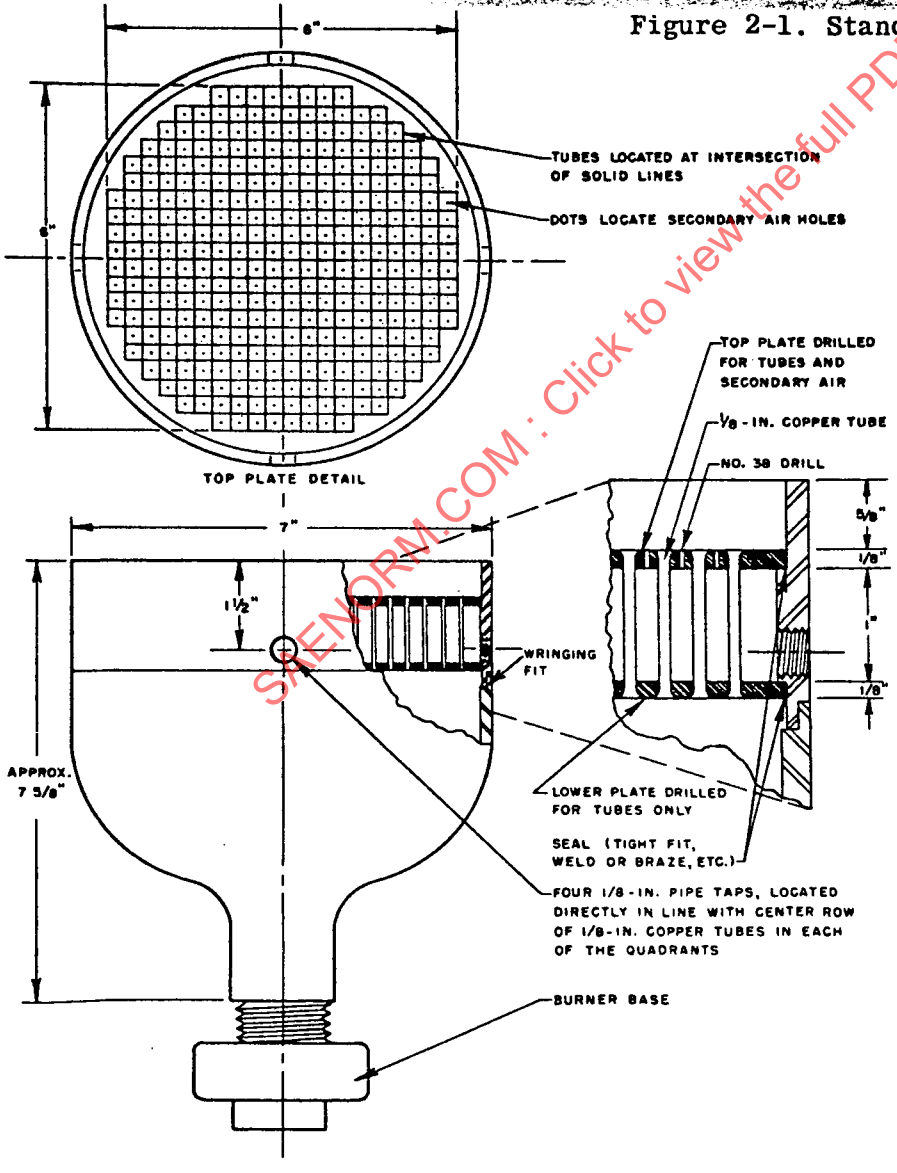

Figure 2-2. Standard Burner