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IMCO Fire Test of Deck Coverings
A Method for Smoke Measurement
and
Simplified Gas Analysis

by

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U.S. DEPARTMENT OF COMMERCE

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ABSTRACT

A description is furnished of a method for measuring the rate of smoke production from deck or floor covering materials during a fire endurance test. A simplified method of gas analysis is also suggested.

1. Introduction

The proposed IMCO interlaboratory tests of deck covering materials have been planned without any specific recommendations for smoke and decomposition product measurements. This paper describes procedures which have been suggested for this purpose.

2. Apparatus

A. Smoke Canopy and Photometer

Figures 1 and 2 show the sheet metal canopy which serves to collect a sample of the smoke produced. Nine holes of 2-in. (50 mm) diameter in the top serve as a means for controlled discharge of smoke while the 2-in. (50 mm) extension of the angle legs below the bottom of the skirt serves to provide an aperture metering the inlet of fresh air. Two small holes located, one on each side of the top midway between ventilation holes serve together with pins on the photometer to locate it in position over the pair of photometer openings.

The photometer, Figs. 1 and 3, was assembled on a 1/4 x 2 x 2 aluminum angle. It consists of two elements each assembled in a small sheet steel box. One box houses a light source and projection lens, while the other contains an image-forming lens, aperture diaphragm, and photoelectric cell together with a battery power source. In assembly, the photo tube is moved until the illuminated disc on the cathode assumes a size of about 3/4 of the cathode width near the center of the cathode. The two boxes are fastened to but spaced from the supporting angle by bolts and 2-in. dia. tubing.

The lamp is powered from a well-regulated power source either d-c or a-c with a voltage close to that normally recommended for the lamp. The gas or vacuum phototube used should be connected in series with a battery of 15 to 45 volts and the input of a high impedance electronic voltameter or recorder. If this instrument is provided with a decade variation of range, a very wide range of optical density may be measured by simple changes of range. This procedure is only possible, however, when the input impedance remains constant. A suitable input resistance has been found to be in the range of 100,000 ohm and one megohm.

The pilot flame burner used to determine the time of ignition of the covering material is shown in Fig. 3. This is designed so that it may be slid beneath the skirt of the canopy and, when the tube touches the skirt, the tip will be located 4 mm away from the specimen surface. By using slightly bowed skid on the bottom of each leg, the pilot will move easily over moderate size cracks or carpet pile. A needle valve was used to permit adjustment of pilot flame size. This adjustment was made with the pilot burner in the position it would normally assume when in use.

The pilot flame orifice has been drilled with the use of a No. 60 drill (.040 in.) corresponding to about 1 mm dia. This is smaller than the 3 mm size orifice recommended, but has proved useful when using natural gas.

B. Smoke Analysis Equipment

The exact measurement of decomposition products produced during pyrolysis or burning of materials is a complex chemical analytical problem. It is possible, however, to secure approximate indications of specific gas concentrations with the use of colorimetric indicator tubes. We know of at least three sources for this type of gas detection equipment:

1. Mine Safety Appliance Co.
   201 N. Braddock Ave.,
   Pittsburgh, Pennsylvania 15208

2. Draeger Indicator
   Dragerwerk
   Heinr & Bernh Drager
   Lubeck, Germany

   In USA - Scott Aviation Corp.
   Lancaster, New York

3. Kitagawa Indicator
Kamyo Chemical Company
Tokyo, Japan

In USA - Union Industrial Equipment Corp.
Portchester, New York

On the basis of our experience with materials similar to those proposed for this study, we suggest that the following compounds may be produced in measurable quantities from the materials indicated:

(1)	Marine paint and Anti-corrosive paint	CO, HCN, HCℓ
(2)	Anti-corrosive paint + Carpet pad + nylon/wool carpeting	HCN, NO, CO
(3)	Anti-corrosive paint + Carpet pad + wool carpet	HCN, CO, NO, HCℓ
(4)	Adhesive + Vinyl tile	HCℓ, CO
(5)	Adhesive + Vinyl Asbestos tile	HCℓ, CO
(6)	Latex Paint	CO, HCN, SO_2
(8)	Magnesite underlay + Magnesite	CO, HCℓ
(11)	Vinyl tile	HCℓ, CO
(12)	Magnesite + Vinyl tile	HCℓ, CO
(13)	Anti-corrosive paint + wood	CO, CO_2
(14)	Urethane deck covering	HCN, NO

3. Test Method

The canopy through which smoke measurements are made operates through natural convection of the heated gases. As a result, tests of this type must be conducted under essentially draft-free conditions. The canopy and specimen must be sheltered from forced ventilation such as produced by fans, winds, etc. The photometer, itself, is insensitive to normal room illumination. It may, however, yield erroneous results if exposed to direct sunlight or strong artificial illumination and should, thus, be protected from this type of exposure.

In performing a smoke test on a specimen, the canopy is placed roughly in the center of the unexposed surface of the specimen. The photometer with associated lamp, power line, and signal cables attached is placed in position on the canopy. The signal leads are attached to the high impedance of the voltameter or recorder, the lamp is lit and sensitivity of the assembly adjusted, either through change of the voltameter span and range controls or adjustment of the input impedance of the voltameter, to provide a full scale meter deflection. Obstruction of the lamp beam or disconnection of the lamp from the power circuit should result in a zero indication of the meter.

The test is then started and measurements are made of smoke either continuously with a recorder or periodically at a convenient but frequent rate through manual recording of the meter indication.

It is convenient to plot transmission directly on semilogarithmic paper as shown on Fig. 6. By use of this inverted logarithmic ordinate scale, absolute ordinate distances become directly proportional to optical density and the area under the curve serves as a measure of total smoke production.

Gas analysis measurements are made by inserting the open end of the indicator tube through the central top ventilation opening and, at least, one-half inch below the upper surface of the canopy. The suction device is then operated as directed by the manufacturer of the particular device involved. In some instances, full-scale indication of the detector may be achieved with use of only a fraction of the recommended gas sample. Under such cases, an estimate of the actual gas concentration may be achieved by dividing the indicated concentration by the fractional part of the recommended gas volume which has been sampled.

We still have insufficient information on which to make firm recommendations with respect to the most useful time at which to make gas analysis measurements. However, since gas evolution rate varies continuously through the test and, since the sampling procedure may require as long as five minutes for certain gases, it becomes important to have a way of normalizing the results of the measurements.

It seems reasonable to assume that, at least during the pre-flame pyrolysis process, the concentration of gas being measured is directly proportional to the optical density of the smoke during the period of gas collection. It is suggested, therefore, that all gas measurements be normalized to correspond with the highest smoke optical density measurement. Thus, the gas concentration measured will be divided by the average smoke optical density during the sample collection period and multiplied by the highest optical density observed.

In making these tests, it may be necessary to use an air-supplied breathing mask to avoid the harmful and irritating effects of the gases produced.

4. Discussion

The principal of the operation of the smoke canopy is essentially one of providing a means for collection and confinement of the smoke, while photometric measurement of it can be accomplished. The openings at the top of the canopy provide a gas flow metering device. Their combined area is much less than that provided between the skirt and the specimen. As a result, warpage of the specimen or some obstruction of air flow at the bottom of the skirt will not significantly change the smoke measurements. Since the canopy is continually ventilated, the photometric measurement at any given time serves as a measure of the rate of smoke production and the area under a plot of the measured optical density versus time curve serves to define the total quantity of smoke measured. The use of a convection-ventilated canopy rather than a collection and pumping of the smoke through a photometer has been proposed for the following reasons:

1. It provides a very simple measurement method requiring minimum maintenance of equipment and attention during test.

2. By collection and measurement immediately above the specimen, the smoke being measured is in a condition very similar to that rising from the specimen.

3. It avoids many of the condensation and other smoke-modifying processes acting when the smoke is collected in a duct and pumped through a photometer.

However, the dependence on natural convection does have the influence of modifying the flow rate and thus the apparent smoke production rate as the temperature of the plate and that of the rising gases change. In spite of this confusing influence, we consider this method of smoke measurement the most useful and practical one associated with a fire endurance test.

The measurement of decomposition products is a complex and difficult one at best. The colorimetric indicator tubes can only be considered as yielding an approximate indication of concentrations and gases present. However, it seems the only method that could be considered within the reach of all laboratories. Errors of concentration indications as large as 100 percent or more should not be considered impossible. In addition, it is possible that false indications may sometimes occur. As a result, indications obtained through this means should be considered with caution. Nevertheless, we suggest the use of these indicators as better than nothing and much safer than the simple use of a nose!

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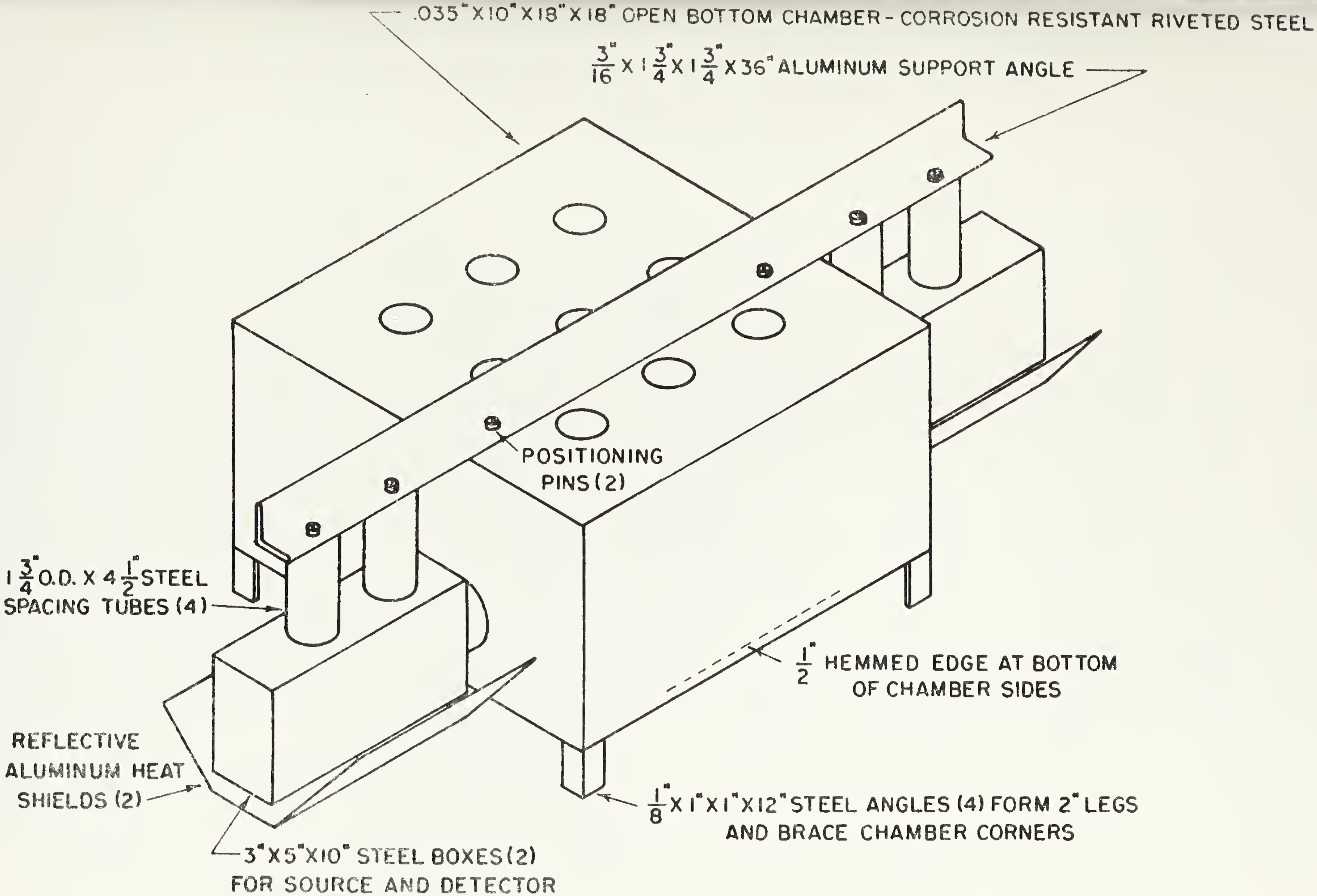
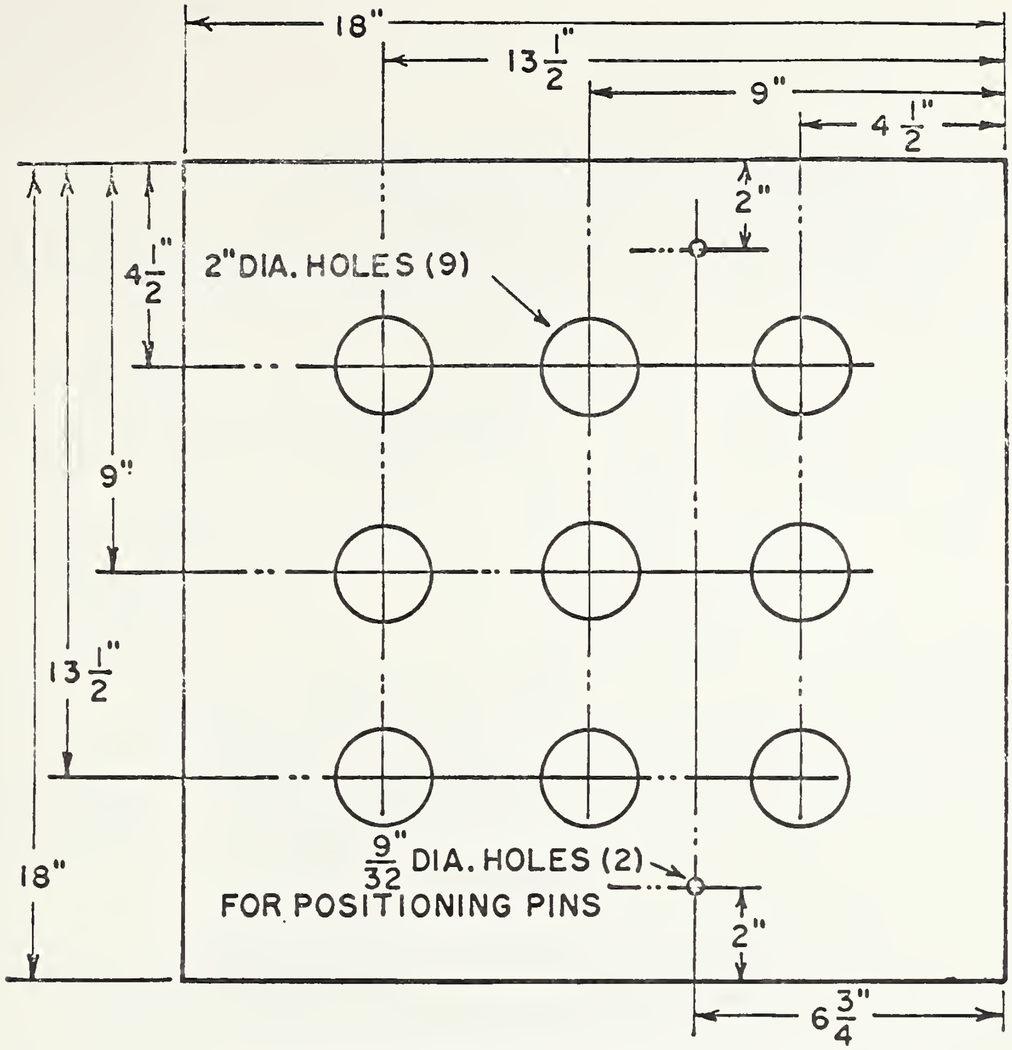
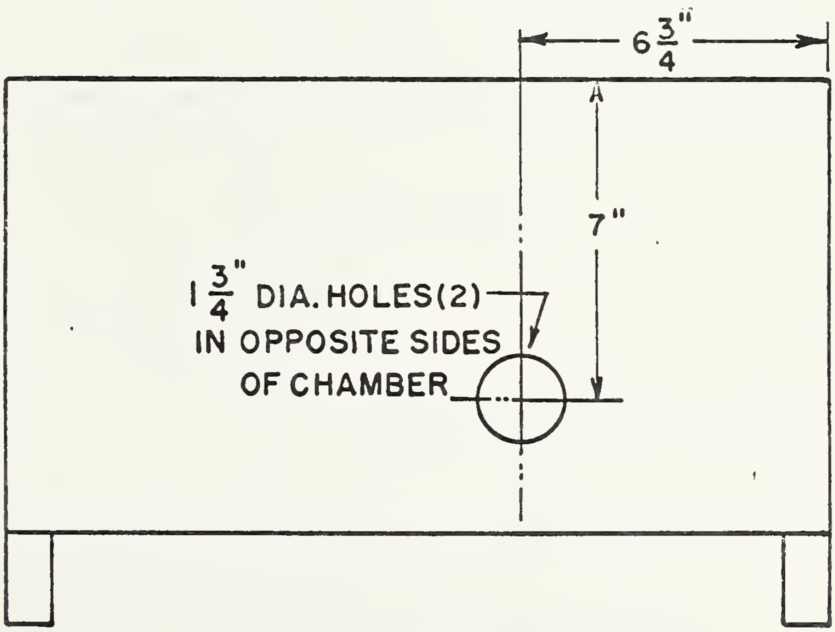


ASSEMBLED SMOKE MEASUREMENT DEVICE

FIGURE 1

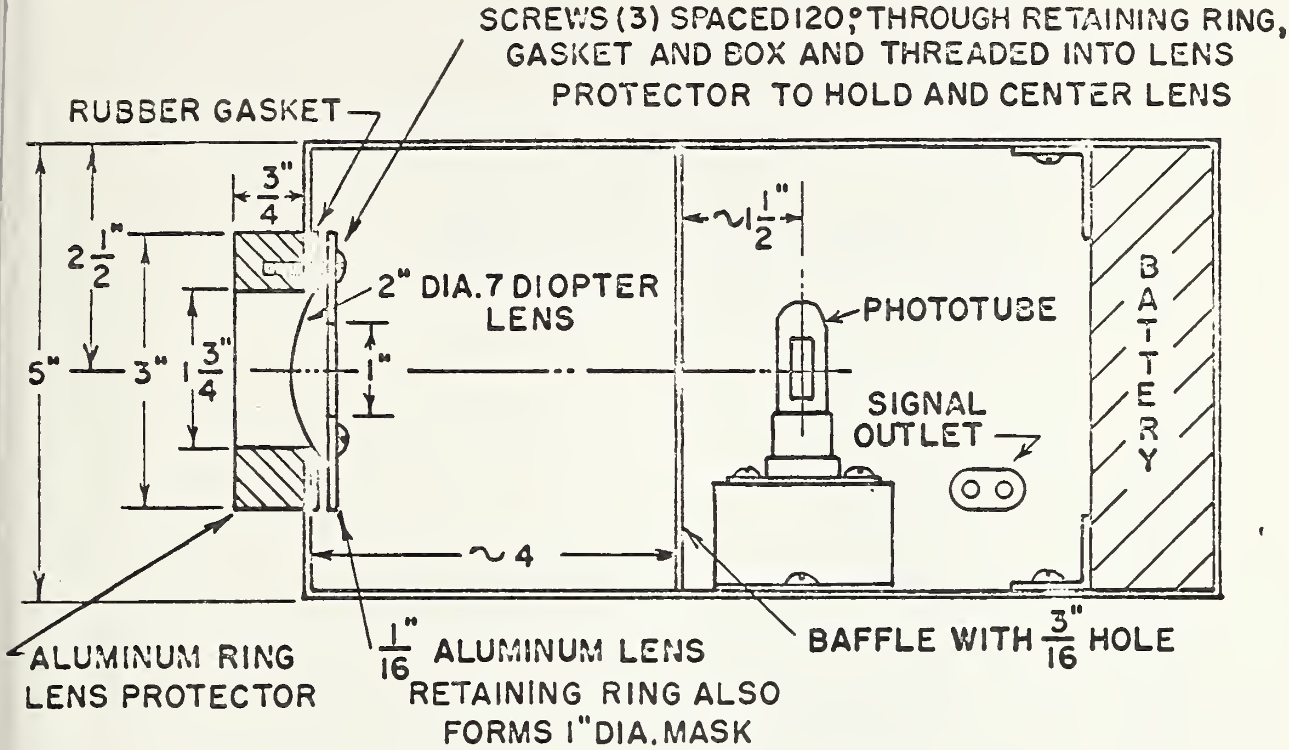


LAYOUT FOR HOLES IN CHAMBER TOP



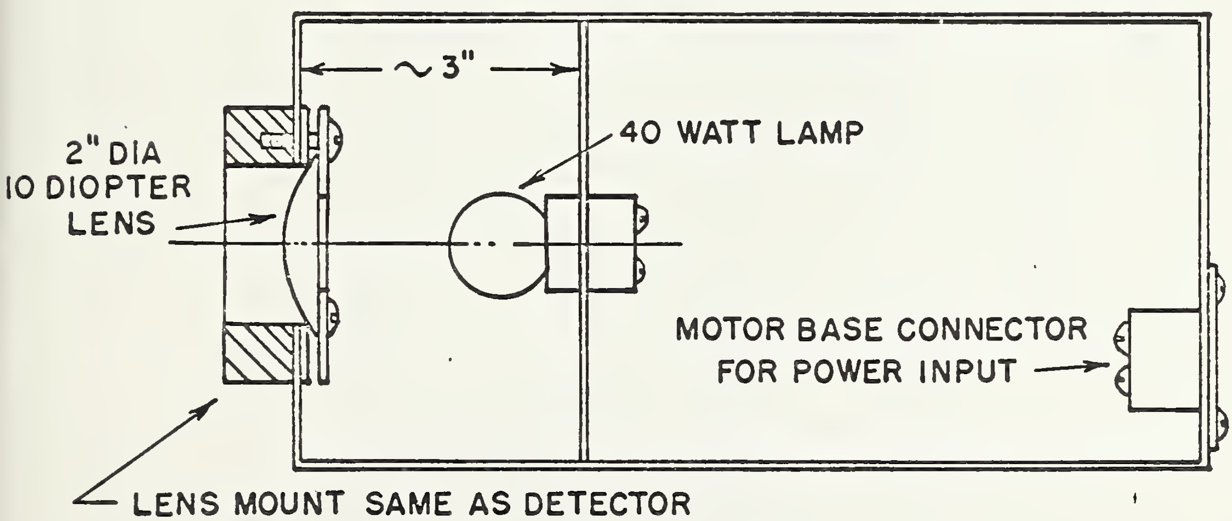
LAYOUT FOR HOLES IN CHAMBER SIDES

FIGURE 2



DETECTOR CONSTRUCTION

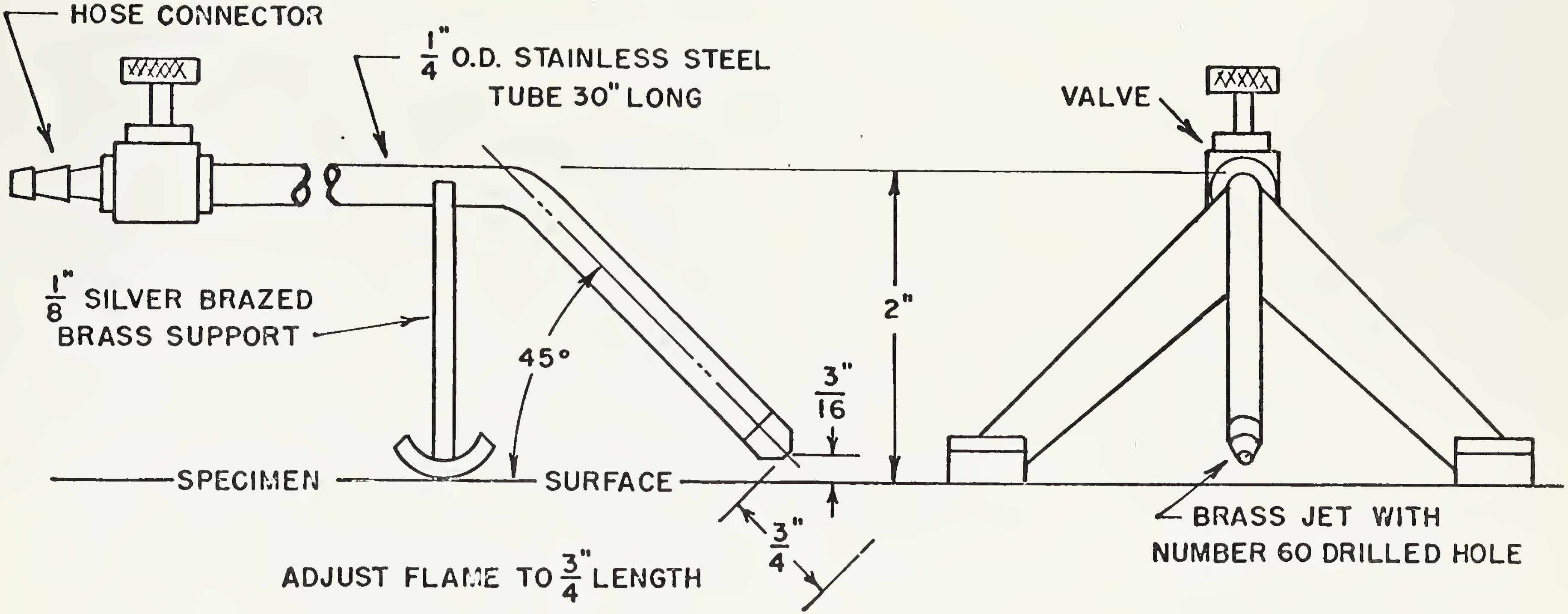
BOX TO BE DUST TIGHT AND PAINTED FLAT BLACK INSIDE



LIGHT SOURCE CONSTRUCTION

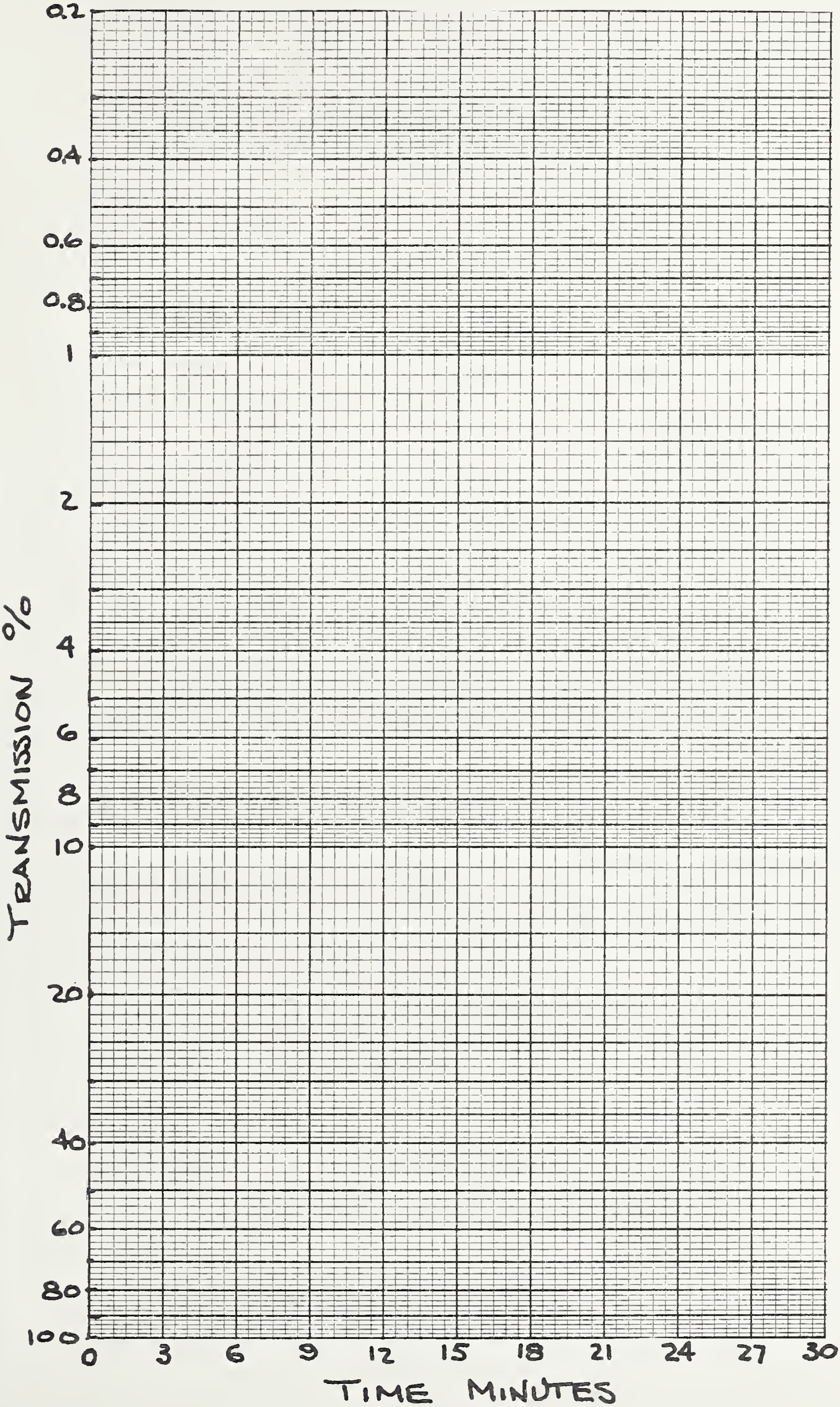
BOX TO BE DUST TIGHT

FIGURE 3



GAS PILOT CONSTRUCTION

FIGURE 4


0.2
0.4
0.6
0.8
1
2
4
6
8
10
20
40
60
80
100
TRANSMISSION %
0
3
6
9
12
15
18
21
24
27
30
TIME MINUTES
FIGURE 5