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NATIONAL BUREAU OF STANDARDS REPORT

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AN IMPROVED DEVICE FOR LIGHT-EXPOSURE TESTS
OF PLASTICS FILMS

Nov. 1969

by

William F. Brucksch, Jr.

WEATHERABILITY OF PLASTICS

Sponsored by

Manufacturing Chemists Association, Inc.
Washington, D. C. 20009



U.S. DEPARTMENT OF COMMERCE
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William F. Brucksch, Jr.

I. INTRODUCTION

The subject of this report is an apparatus to test plastic films by exposure to light. The test has unique advantages:

- A. The temperature of the sample is maintained at a near-constant value throughout exposure.
- B. Temperature differences are minimized between clear, light or dark pigmented stocks during exposure.

The apparatus consists of a means for exposing multiple samples of plastic film to an intense source of light. The unique feature is that the exposure is performed in a refrigerated bath of distilled water.

II. DISCUSSION

A. Apparatus

The fundamental difference between this and earlier devices is the use of water as a liquid cooling medium to absorb heat from the lamp. Water is strongly absorbing in the infrared, yet is transparent to visible and ultraviolet light. Both light source and sample chamber are immersed in the same cooling medium. Also, use of a flat wall sample vessel aids in cooling the plastic films. The apparatus was developed for plastics films but can accommodate also other materials in layer forms: elastomers, coatings, even fabrics.

The apparatus is shown in Figures 1 and 3. The schematic drawing in Figure 2 shows the arrangement of components in the rack. The top portion of the rack is the refrigerated bath (schematic, Figure 4); the center portion is the power supply and the lower portion is the refrigeration unit.

1. The Light Source

The light source is a mercury arc photochemical lamp (550 watt, Hanovia 673A, Engelhard) (Figure 5). The lamp is powered by ballast, reactive transformer core and coil (Hanovia 20651-1).

An auxiliary light source used was an ordinary street lamp (400 watt W400A33-1/3.2A,1 mercury 8, Bonus Line, General Electric Co.) The lamp was powered by ballast C304G101, 400 watt, code FC, Type H33, General Electric Co.).

Samples are irradiated by light rich in visible and ultraviolet with minimum content of infrared. Important photochemical reactions are promoted by light of wavelength range 300 to 700 nanometers. The short wavelength range 300 to 400 nanometers is particularly energetic. In plastics, the critical wavelengths are in the ultraviolet and, to a lesser degree in visible light. In contrast, infrared does not promote photochemical reactions. The only function is that of simple heating, to raise the temperature of the sample.

2. The Refrigerated Bath

The refrigerated bath at the top of the unit is stainless steel with a cooling coil of copper, nickel plated. The bath is insulated with Fiberglas. The compressor unit is located in the lower portion of the rack.

The capacity of the refrigeration unit should be equal to or slightly greater than the heat generated by the light source. If the two are balanced the temperature of the bath will be constant. In the first trial of this concept, a light source of 400 watts was used with a refrigerator of 0.2 HP. The unit described here used a light source of 550 watts with a refrigerator of 0.33 HP. In both cases the temperature of the bath was 41°-43°F. The refrigerant was Freon 12.

Refrigeration permits the temperature of the sample to be controlled during the test, as low as 50°F. (Table I). It is possible to differentiate thereby between reactions caused by light and those caused by heat. The usual overheating of dark-pigmented stocks is minimized. Also, it is possible to mount samples closer to the source of light and thereby shorten the time period of exposure.

Table I

TEMPERATURE OF PLASTIC FILMDURING IRRADIATION

<u>Arc Lamp Source Watts</u>	<u>Cooling Medium, (Sample Chamber)</u>	<u>Cooling Medium, Temp., °F.</u>	<u>Temp. of Film, °F.</u>		
			<u>Clear Poly Styrene</u>	<u>PVC White Film</u>	<u>PVC Black Film</u>
550	Air, (Cyl.)	88	113	119	168
550	Water, (Cyl.)	58	87	92	136
400	Water, (Cyl.)	40	50	62	86
550	Water, (Flat)	40	50	45	48

3. Plastic Film Sample Chambers

The apparatus retains all the advantages of "Controlled-Atmosphere" testing, reported earlier. Each sample is mounted in a pyrex chamber (Figure 6). Twelve chambers can be accommodated, mounted coaxial with the light source. Chambers are spaced at 30° intervals on the periphery of a circle of 4" radius (Figure 4). Chambers are supported in a jig, two parallel plates, spaced one above and one below the lamp. The plates are slotted to receive the flat face cross-sectional shape of the chamber. Each chamber is held in position thereby, without the need for auxiliary clamps.

4. Instrumentation

Some features of the instrumentation are as follows:

A. There is a thermoregulator in the water bath to prevent overheating if the refrigeration fails. When the temperature exceeds a pre-set value, power to the lamp is disconnected by heavy duty relay.

B. Ultraviolet light is monitored in the wavelength range 300 to 400 nanometers. The sensor is a selenium photovaltaic cell (B3M, International Rectifier) covered by a filter glass (7-60, ultraviolet transmitting, Corning Glass). Current from the sensor is indicated on a micro-ammeter and plotted on a recorder as the voltage drop across a precision resistor. The "area" under the recorder trace is the integrated value of light intensity multiplied by time. Also, the current is amplified by transistor to power a relay, which, in turn, operates an elapsed-time meter (Figure 1.).

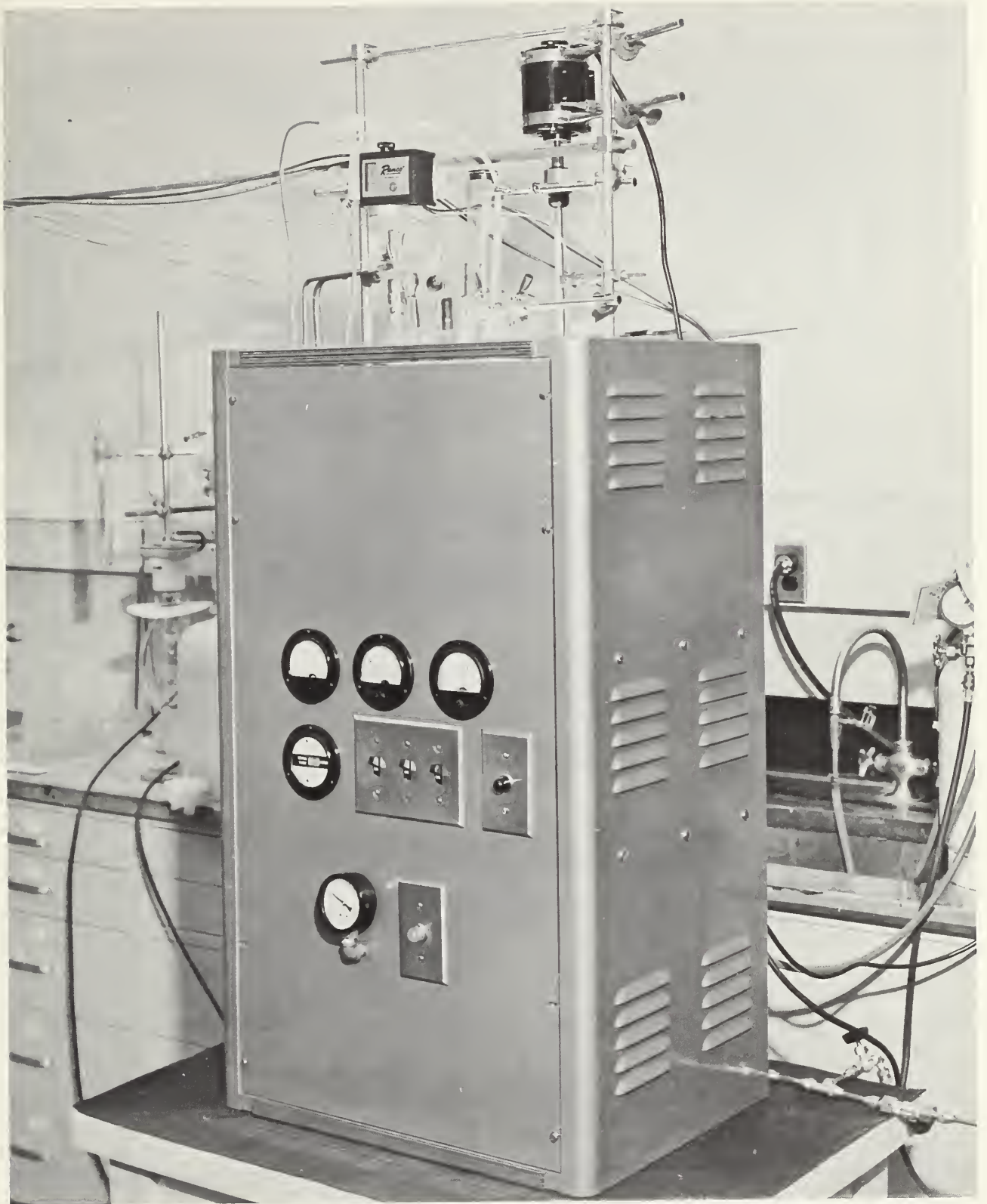


Figure 1. APPARATUS FOR LIGHT-EXPOSURE TESTING. FRONT VIEW OF RACK.

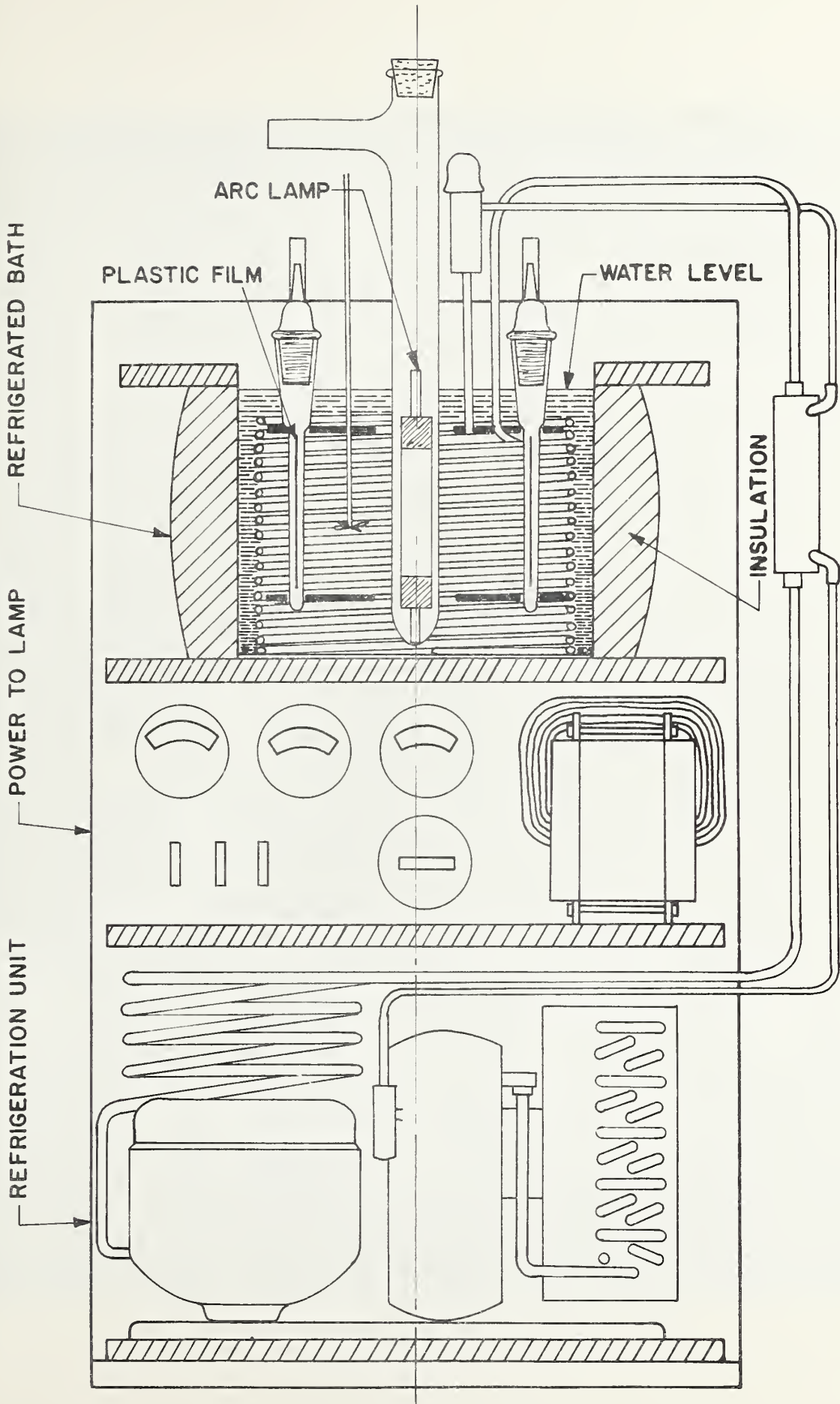


Figure 2. APPARATUS FOR LIGHT-EXPOSURE TESTING. SCHEMATIC, FRONT VIEW.

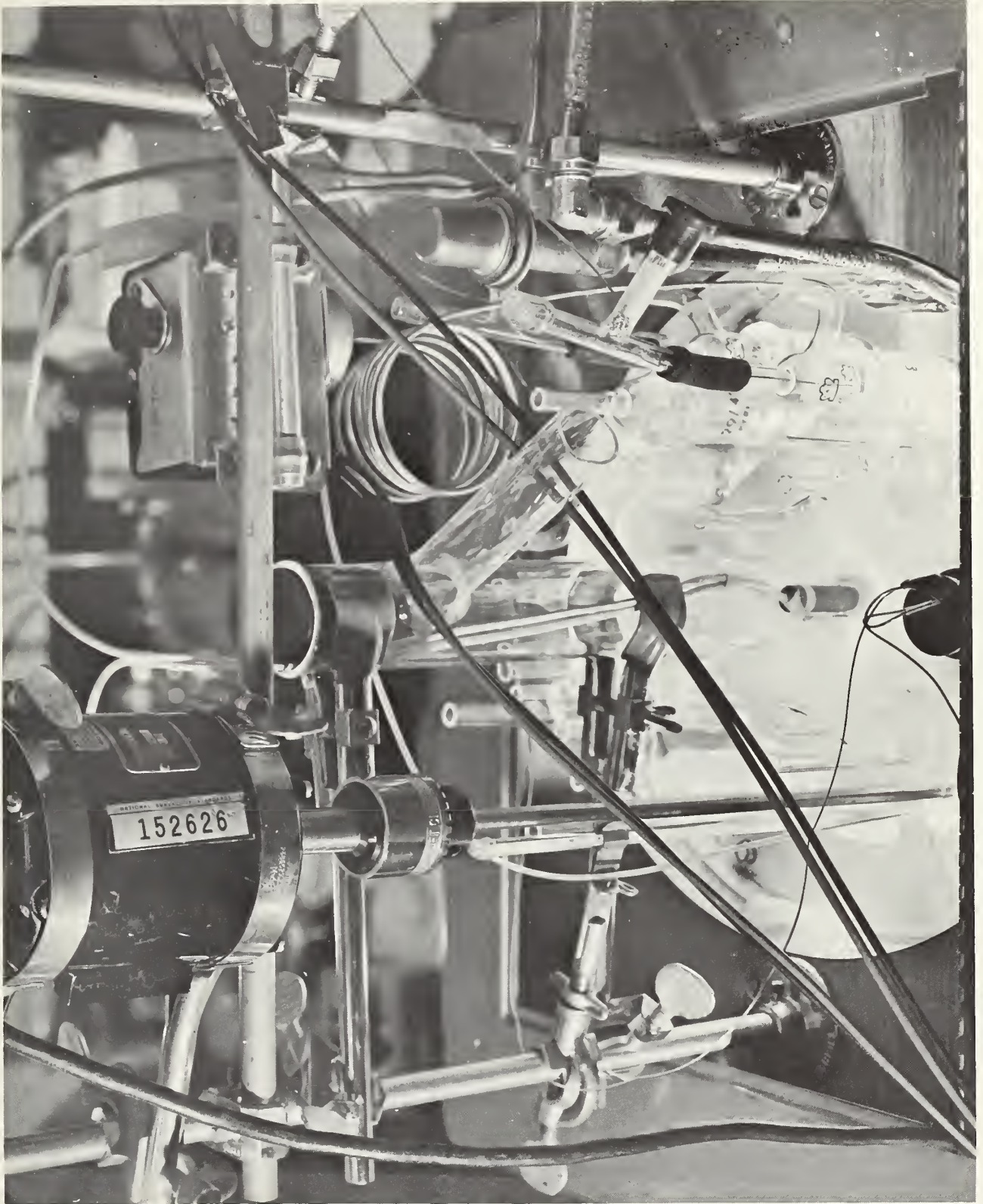
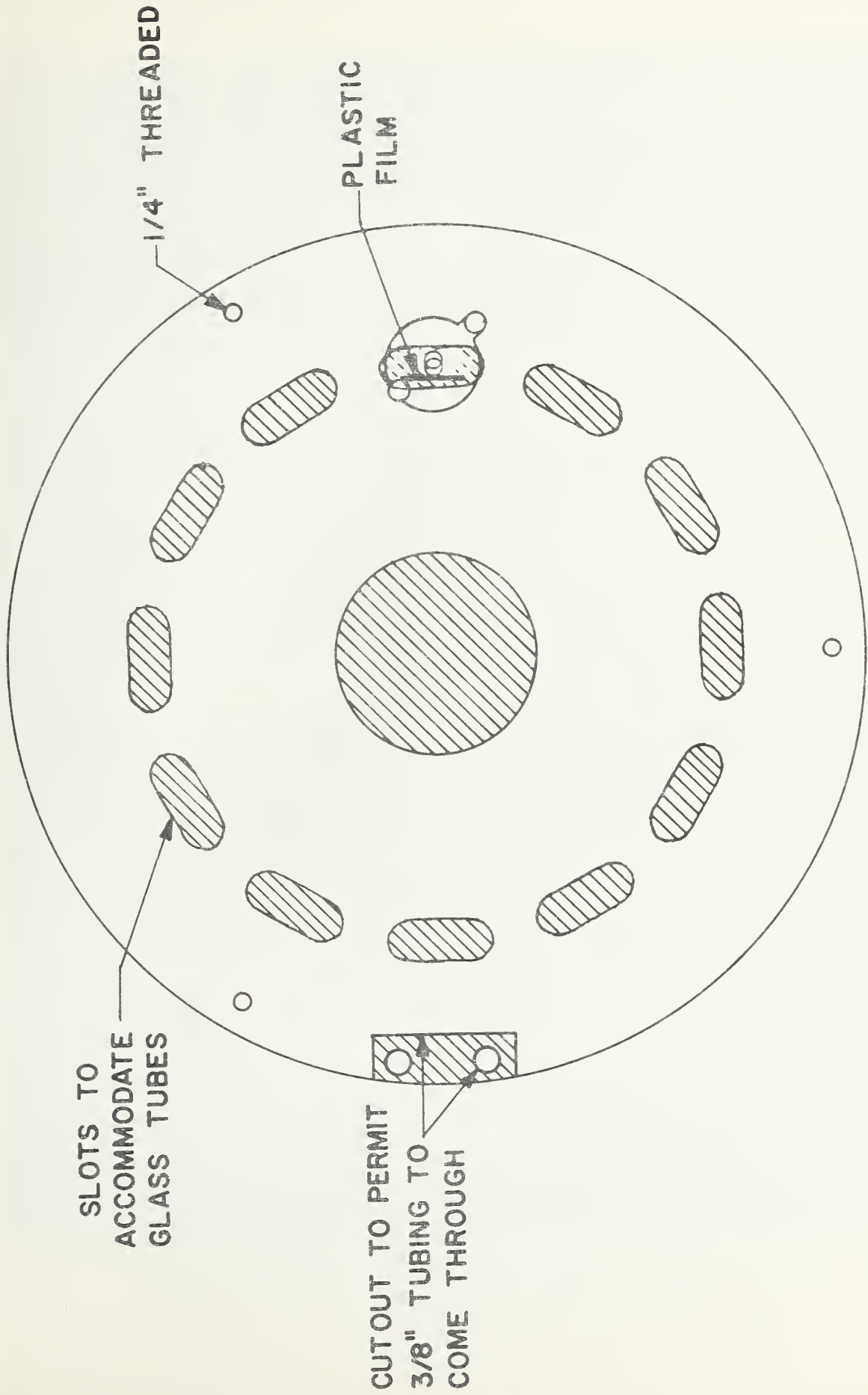


Figure 3. APPARATUS FOR LIGHT-EXPOSURE TESTING. TOP VIEW.



SLOTS TO
ACCOMMODATE
GLASS TUBES

1/4" THREADED

PLASTIC
FILM

CUTOUT TO PERMIT
3/8" TUBING TO
COME THROUGH

Figure 4. APPARATUS FOR LIGHT-EXPOSURE TESTING. SCHEMATIC, TOP VIEW.

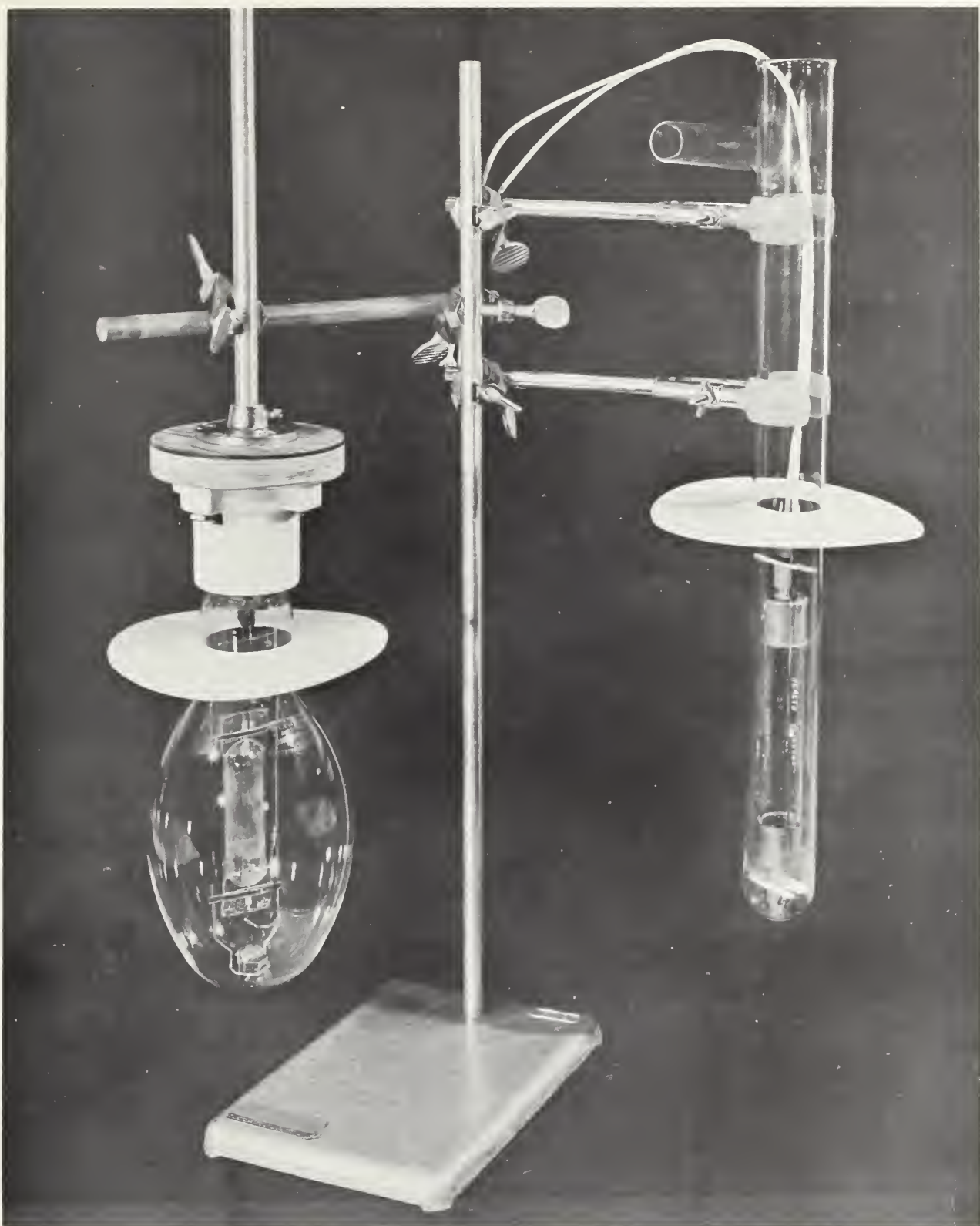


Figure 5. MERCURY ARC LAMPS USED IN EXPOSURE TESTING. LEFT: "STREET" LAMP, 400 WATTS. RIGHT: PHOTOCHEMICAL LAMP, 550 WATTS.

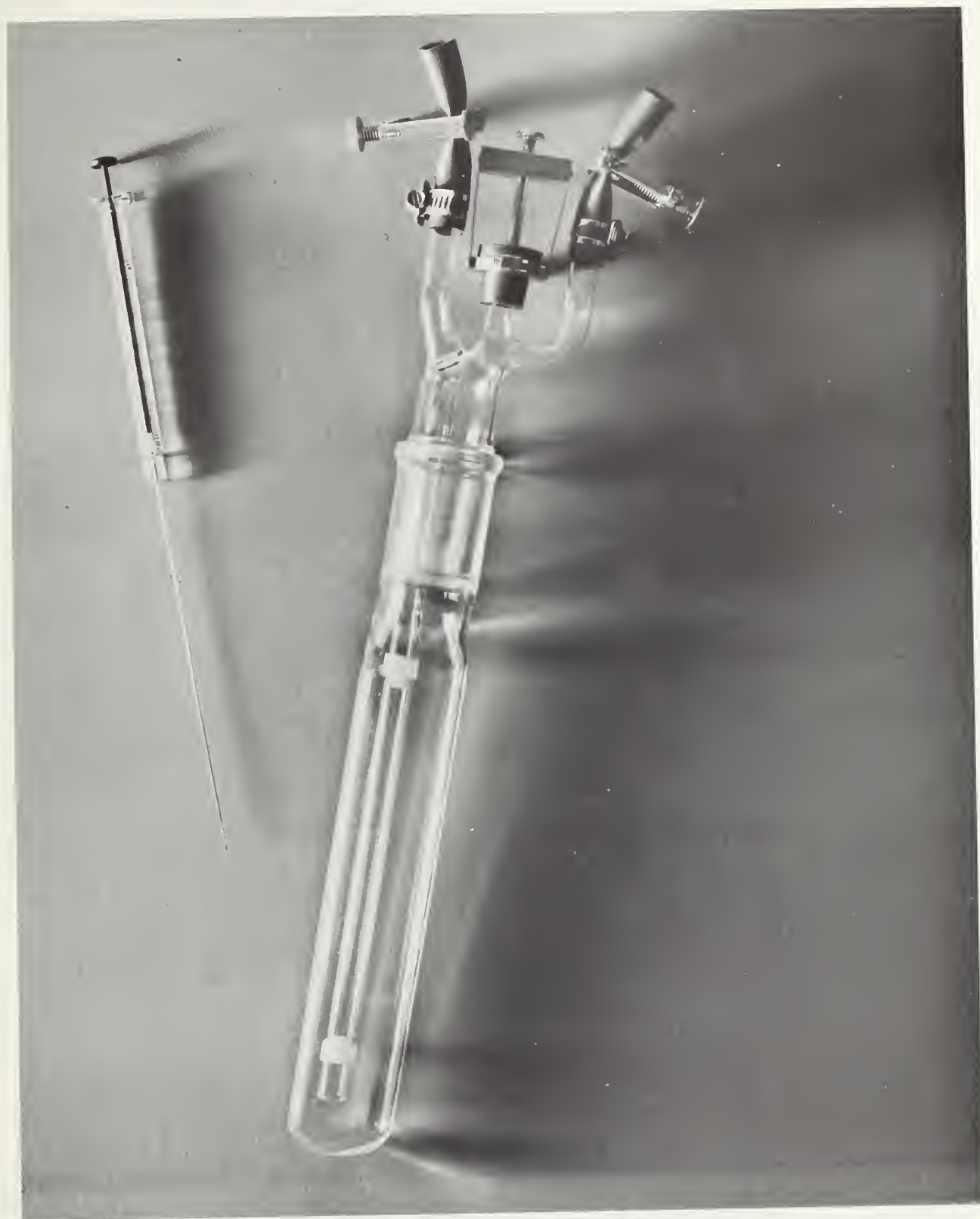


Figure 6. PYREX CHAMBER FOR SUPPORTING PLASTIC FILM. SYRINGE WAS USED TO CHARGE "ACTIVATOR" CHEMICALS.

