the temperature of the evaporator lowered until evaporation no longer takes place.

The substrate temperature is now reduced to 150°C in about 4 min, and at this temperature the evaporator is brought up to a temperature that will give rapid evaporation of the aluminum. Then the shutter is re-opened and the remainder of the aluminum is evaporated to completion in a matter of 2 min (Fig. 2).

Essential to the adherence appears to be careful cleaning and evaporation of some aluminum at a temperature of about 250° or higher. However, if all aluminum were to be evaporated at this temperature, poorly reflective films would be obtained. For this reason the evaporation is performed in two stages: a small amount at a high temperature to achieve good adherence, the remainder at a lower temperature to achieve good optical quality. Intervals between these steps are kept at a minimum to avoid excessive contamination.

[1] J. W. Swaine, Jr., and R. C. Plumb, J. Appl. Phys. 33, 2378 (1962).

Argon Resonance Line Lamp for Vacuum Ultraviolet Photochemistry*

ARTHUR L. LANE† AND ARON KUPPERMANN

Gates and Crellin Laboratories of Chemistry,‡ California Institute of Technology, Pasadena, California 91109

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THE use of rare gas resonance line lamps as sources of monochromatic radiation for photochemical studies is well known.[1–5] Argon is ideally suited for photoionization studies of the simpler hydrocarbons which have ionization potentials below 11.6 eV. It has resonance lines at 1048 Å (11.83 eV) and 1067 Å (11.62 eV), with no other emission lines between 1050 and 2000 Å when pressures less than 1 Torr are used. However, to prepare argon lamps emitting only these two lines, great care must be taken to avoid impurities which might emit other undesired lines. In the past, this has generally required baking the lamp and its windows at 100 to 400°C while maintaining a vacuum of 10^{-6} Torr. This leads to design and configurational constraints and may necessitate the use of silver chloride window seals. The addition of a miniature titanium sublimation pump to the lamp greatly simplifies the preparation of a very clean light source.

The lamp is made of Pyrex glass with the tube containing the discharge about 31 cm long, 25 mm o.d., and 2 mm thick (Fig. 1). The ends are ground flat to facilitate the mounting of the lithium fluoride windows. Each end of this tube is equipped with a small water jacket to help cool the ring seals where the 65/40 O-ring joints mount the lamp to a reaction vessel.[6] The sublimation pump housing, a cold

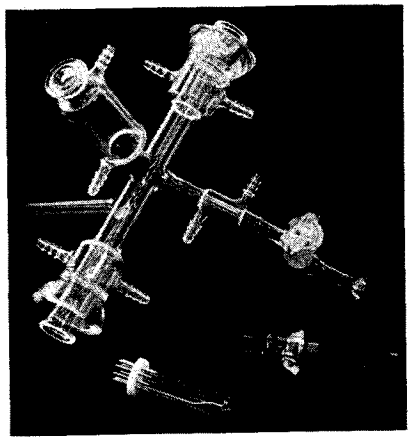

FIG. 1. Argon resonance line lamp. The water-jacketed titanium pump housing is the appendage in the upper left rising above the main discharge tube. The two models of the titanium sublimation pump are shown in the foreground: on the left, the commercial assembly and on the right, the compound titanium-tungsten filament assembly.

finger for liquid nitrogen cooling, and the gas inlet are attached to the side of the main tube. The pump housing is a 35 mm i.d. water-jacketed tube, into which the titanium filament assembly fits and is vacuum sealed by an O-ring joint. These filament assemblies are eight separate 0.65 mm titanium wires on a single Teflon flange and are commercially available.[7] Alternatively one can prepare filaments by twisting together two 0.4 mm titanium wires on a 0.5 mm tungsten support wire. The gas inlet tube provides the connection to a vacuum line from which it can be isolated by a lightly greased high-vacuum stopcock.

The LiF windows[8] are attached to the window seats of the lamp with Torr-Seal.[9] A mercury-free, oil diffusion pumped, high-vacuum line is used to evacuate the lamp to about 10^{-7} Torr. While pumping continuously, one titanium filament is heated to white heat by passing 8 or 9 A at 6 V through it. The thicker, compound filament requires about 20 A at 6 V. The titanium sublimes onto the cooled inner wall of the water jacket around the filament assembly, and when an opaque layer is formed the filament is turned off. Research grade argon is added to the lamp until a pressure of 0.035 to 0.080 Torr is achieved.[10] The stopcock is closed and the lamp is ready for use. A 2450 MHz microwave generator with about 85 W of radiative power is used to sustain the argon discharge, which is initiated by a Tesla coil. One end of the lamp is attached to the entrance

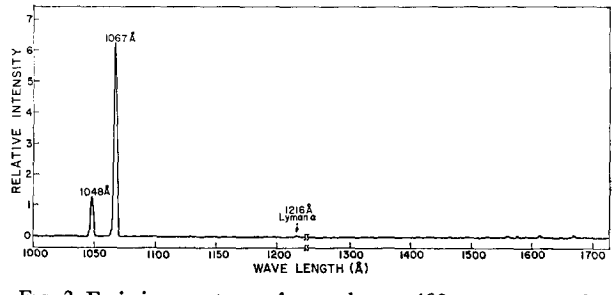

FIG. 2. Emission spectrum of argon lamp—100 μ entrance and exit slits, 100 Å/min scan rate from 1000 to 1225 Å, and 200 Å/min from 1230 to 1720 Å.

arm of a McPherson model 235 half-meter vacuum monochromator in order to monitor the spectral purity of the lamp during a photolysis. A typical spectrum is shown in Fig. 2.

We have operated lamps of this type during the past two years, and have found that peak fluxes of 1×10^{14} photons/sec are achieved when photolyzing propane in an LiF-windowed cell. At these fluxes the transmission of the lamp LiF window decreases by 70% in about 1 h. Photolyses run at fluxes of 10^{12} photons/sec produce in less than 1 h adequate decomposition products for gas-chromatographic analysis and extend the lifetime of the lamp windows to about 10 h for the same 70% loss of transmission.

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‡ Contribution No. 3556.

[1] H. Okabe, J. Opt. Soc. Am. 54, 478 (1964).
[2] H. Okabe and J. R. McNesby, Advan. Photochem. 3, 161 (1964).
[3] A. H. Laufer and J. R. McNesby, J. Chem. Phys. 42, 3329 (1965).
[4] R. D. Doepker and P. Ausloos, J. Chem. Phys. 43, 3814 (1965).
[5] P. Ausloos and S. G. Lias, J. Chem. Phys. 45, 524 (1966).

[6] Kerosene is far more transparent to 2450 MHz microwaves than water and will allow the discharge to expand almost to the window.

[7] Available from Vacuum Instruments Corp., 6 Stepar Place, Huntington Station, New York, N. Y.

[8] Cleaved or polished LiF windows are available from Harshaw Chemical Co., Crystal-Solid State Division, Cleveland, Ohio.

[9] A very low vapor pressure epoxy cement available from Varian Associates, Palo Alto, Calif.

[10] Available from Air Reduction Company, 150 East 42nd St., New York, N. Y.

Time Mark Generator for an X-Y Recorder*

R. E. Fassnacht and J. R. Dillinger

Department of Physics, University of Wisconsin, Madison, Wisconsin 53706

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To monitor the superconducting-to-normal transitions of the isotopes of zinc,[1,2] the output of a modified dc Wheatstone thermometer bridge was applied to the X axis of an X-Y recorder, and the output of a mutual inductance circuit, the detector used to detect the transitions, was applied to the Y axis. It was necessary to establish rates of temperature change such that adequate thermal equilibrium among the samples and the thermometer would be assured. During the taking of critical field data, it was necessary to determine and adjust the rate of warming prior to the transitions, and to permanently record this rate for assistance in the analysis. To accomplish the above, a time mark generator was developed which would insert readily identifiable signal pulses into the Y axis at regular time intervals.

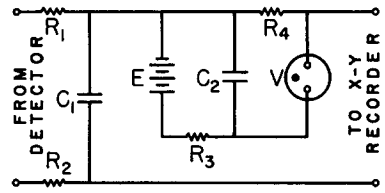

FIG. 1. Time mark generator circuit. $C_1=100\ \mu F$, 15 V; $C_2=1.0\ \mu F$ (Mylar); E=90 V; $R_1=R_2=1200\ \Omega$; $R_3=9\times10^7\ \Omega$; $R_4=680\ \Omega$; V=NE2.

The time mark generator, shown in Fig. 1, was placed between the detector output and the recorder. It consists of a simple neon light relaxation oscillator (C_2, E, R_3, R_4, V) and a filter (R_1, R_2, C_1). The time mark originates when the oscillator breaks down through R_4, superimposing a short voltage pulse upon the dc voltage from the detector. The period of the time marks was about 1 min for the components used in this circuit. These time marks can be distinguished from noise pulses originating in the external circuitry by their short duration. Noise pulses have a time constant determined by the filter.

* Work supported by the U. S. Atomic Energy Commission and the Wisconsin Alumni Research Foundation.

[1] R. E. Fassnacht and J. R. Dillinger, Phys. Rev. Letters 17, 255 (1966).
[2] R. E. Fassnacht and J. R. Dillinger, Phys. Rev. 164, 565 (1967).

High-Speed Explosive Shutter for Shock Tube Research*

A. A. Boni

Department of the Aerospace and Mechanical Engineering Sciences and Institute for Radiation Physics and Aerodynamics, University of California, San Diego La Jolla, California 92037

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TIME-INTEGRATED spectra in shock tube studies may be obtained by the use of a spectrograph equipped with a photographic plate attachment. However, for quantitative studies, it is often required to limit the exposure time. It is desirable to have shutter closing times much shorter than the exposure times, which range typically from 50 to 200 μsec. Since the radiant energy may be low, it is not always feasible to use the magneto-optic or electro-optic devices which attenuate the light beam. In shock-tube work, it is also necessary to trigger operation of the shutter when the shock wave passes some convenient reference station in order to obtain synchronization with the physical process being studied. The most common trigger device is the thin-film, heat-transfer gauge.[1] Output of these gauges is typically 1 to 3 mV. Hence, some pulse-