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ETHYLENE CHEMILUMINESCENCE OZONE MONITOR*

Gary J. Warren and Gordon Babcock

Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

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Chemiluminescence produced by ethylene gas in contact with ozone has been used by Nederbragt et al., in an instrument for monitoring ozone produced by an accelerator.[1] Ethylene and air are simply mixed near a photomultiplier (pmt) and the signal is proportional to ozone concentration. The reaction is fast, dry and insensitive to NO_2, SO_2 and Cl_2. The associated electronics and gas handling equipment are not complicated and can easily be adapted to a portable monitor for Industrial Hygiene surveys or research projects involving ozone measurements.

This note describes the construction and calibration of a portable ozone monitor using this reaction. The instrument consists of a mixing chamber, pmt, nanoammeter, high voltage supply, pump, flowmeters and ethylene supply. The mixing chamber (constructed from a 100 ml beaker) is shown attached to an EMI 9536S pmt in Fig. 1. (The EMI 9536S was chosen for its low dark current.)

The nanoammeter (Fig. 2) is a MOS-FET input operational amplifier with an open loop gain of approximately 10,000. The circuit consists of two cascaded differential stages which drive the single-ended output stage. The output supplies negative feedback to the input stage and drives the indicating meter. Drift resulting from battery aging is suppressed by the high open loop gain and a constant current supply to the common source terminal of the MOS-FET input stage. Overall drift is less than 0.2% of full scale per month.

The entire ammeter circuit is constructed on a "floating chassis" which is stacked upon the pmt power supply. This configuration allows the cathode to be operated at ground which eliminates erratic currents probably due to glow discharge. Guarding techniques are used to prevent stray leakage paths from affecting the meter readings. Additionally, two low leakage zener diodes connected in series opposing between the input gate and the guard point prevent destruction of the

input device by voltage surges. Pmt high voltage is supplied by forty-eight thirty-volt batteries in series. The battery life is essentially their shelf life because the current drain is small.

Instrument operation is simple: Air containing ozone is drawn through the center tube (Fig. 1) at one liter/min. Ethylene is injected at 13 mls/min into the outer tube, and the two streams meet at the pmt face. The ethylene flow rate is not critical for an air flow rate of one liter/min; an increase in ethylene flow by a factor of three results in a 30% change in output current. Ethylene is obtained in a 2 ft^3 lecture bottle. A bottle will last for 70-hours operation.

The monitor was calibrated using the buffered KI method.[2] Ozone generated by a GE 04S11 bulb was pulled simultaneously through the monitor and an impinger containing the buffered KI solution. The net current (current measured at a particular concentration minus pmt dark current) is plotted as a function of the measured concentration in Fig. 3. The pmt dark current was 2×10^{-10} amp at 1440 volts. A 10% error would result from completely ignoring the dark current at a concentration of 10 parts per hundred million. At lower concentrations, errors in subtracting dark current become more serious.

One serious problem with using the monitor around an accelerator is its sensitivity to radiation. A radiation field of one (1) mr/hr from a radium source will produce a current equivalent to 6 parts per hundred million. This trait can be used to some advantage by using a small source to check instrument operation. If low concentrations are being measured the instrument must be shielded or a sample pulled through tubing from the radiation area.

REFERENCES

1. G. W. Nederbragt, A. Van Der Horst, and J. Van Duijn, Nature 206, 87 (1965).

2. Air Industrial Hygiene Methods in Air Pollution Measurement SDPH 1-20 (1960).

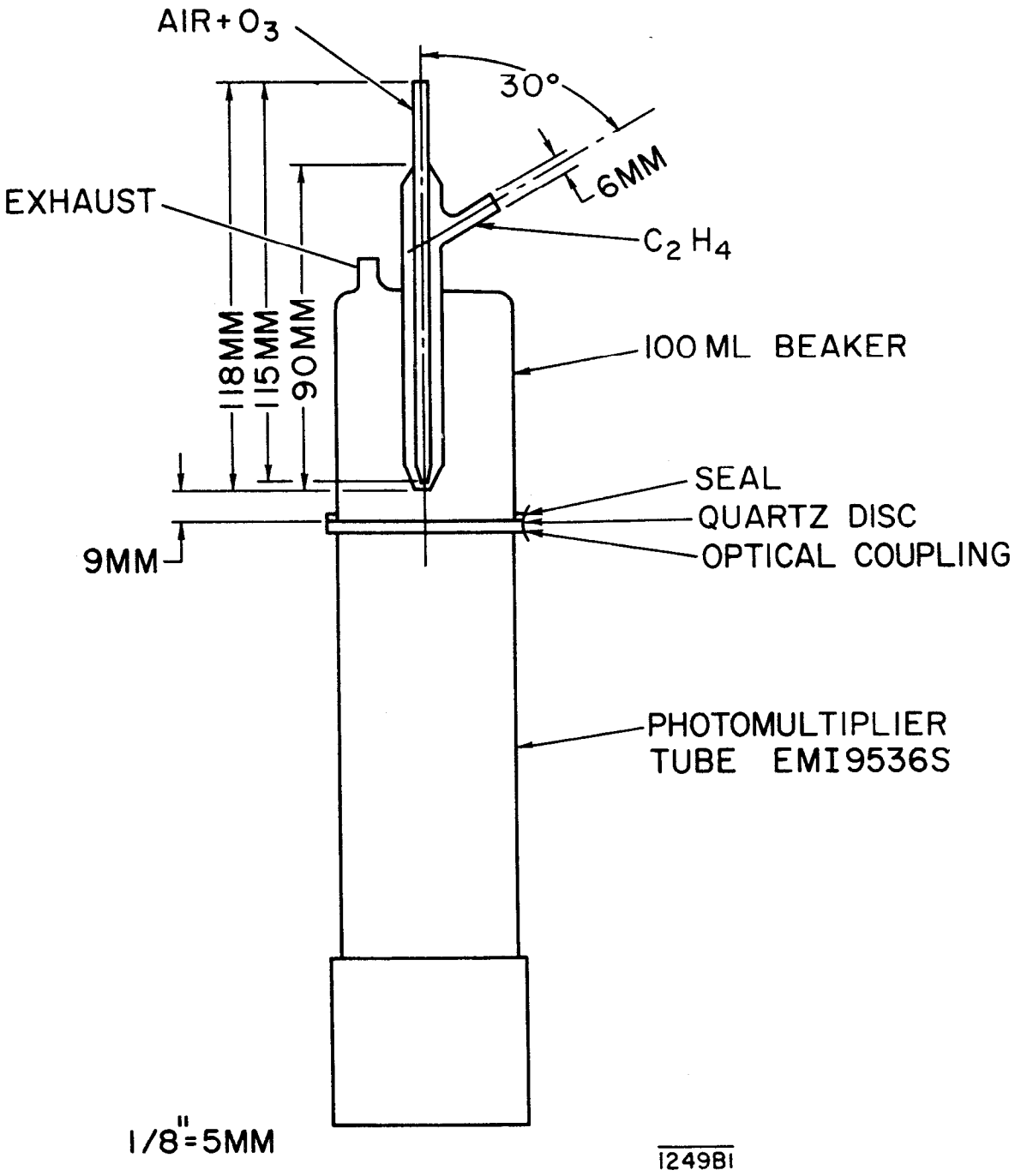
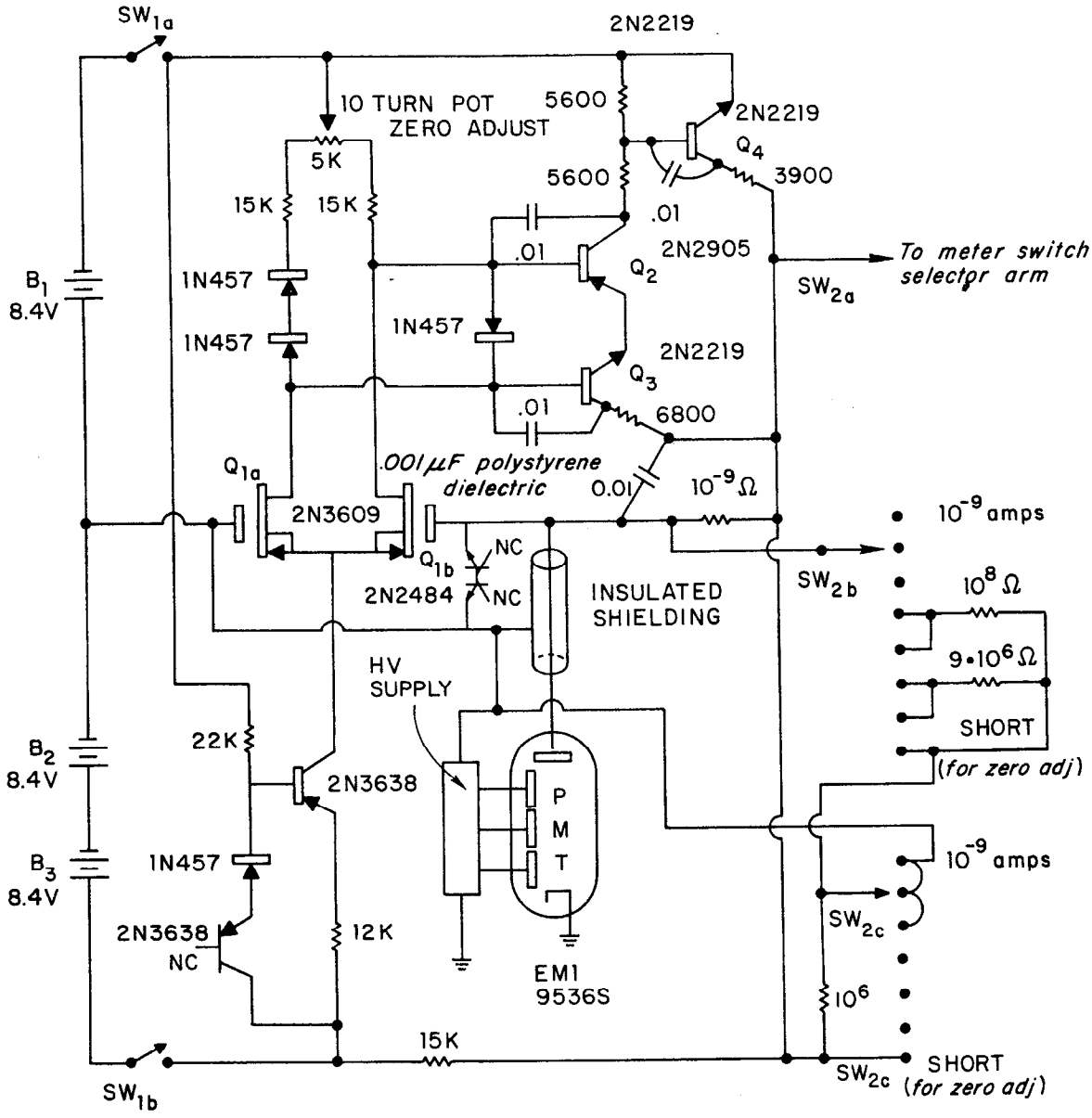


Fig. 1

Mixing chamber and pmt assembly.



$B_1 = B_2 = B_3$ = Mallory TR286 8.4 volt battery. SW_2 is a steatite 3 pole 8 position with make before break contacts.

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OZONE MONITOR

Fig. 2

Nanoammeter.

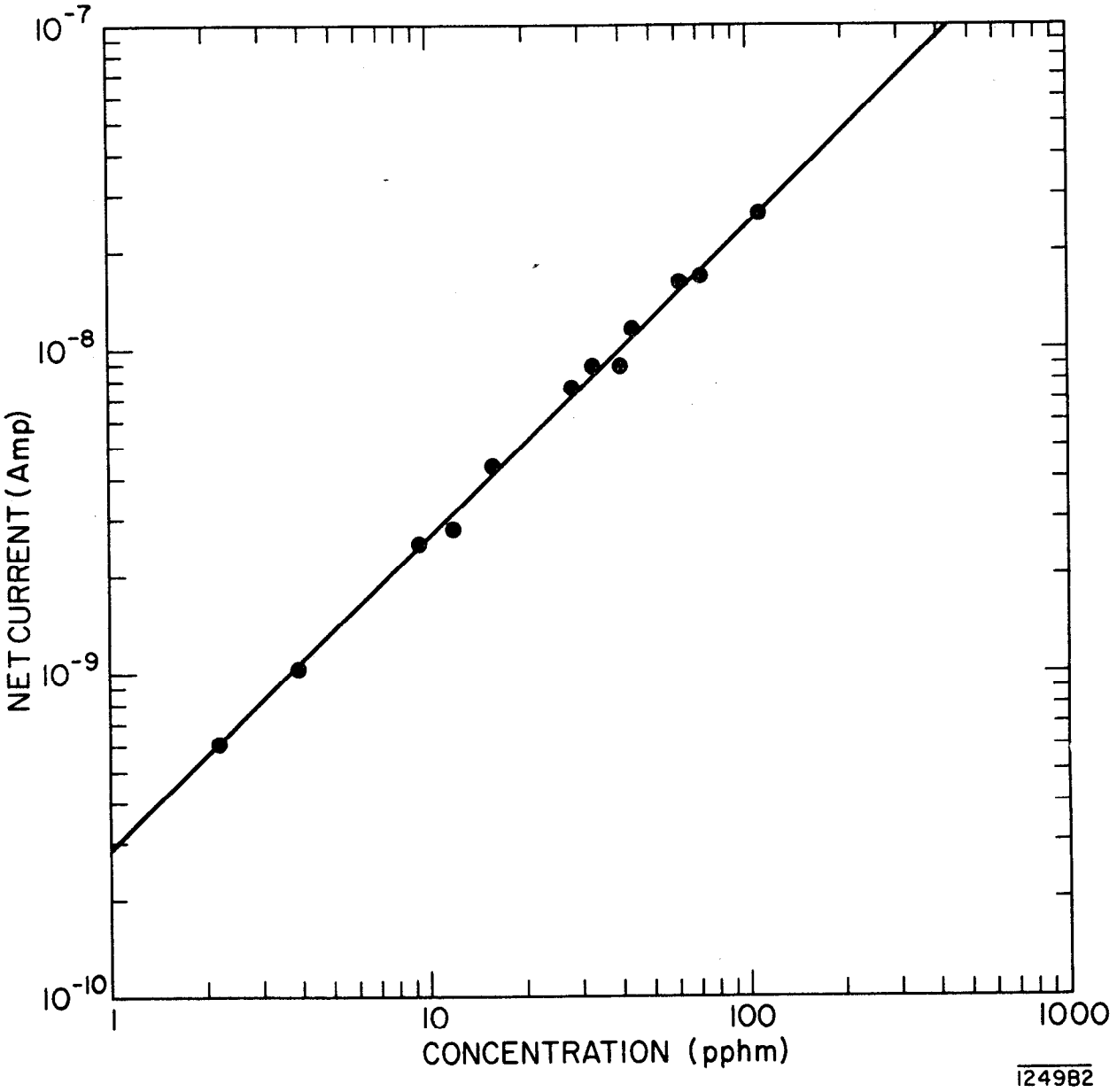

Fig. 3

Net current as a function of ozone concentration (parts per hundred million).