

tions and length of uniform field as functions of coil spacing. At first the field variation rises slowly with increasing coil spacing while the length of the uniform field region increases relatively rapidly. As the spacing is increased, a point of diminishing returns is reached, but even at a spacing 20% greater than the Helmholtz spacing, the field is within $\pm 1.5\%$ of the average value over the entire length of the axis from one coil plane to the other.

In Fig. 2(b) we compare coils at the optimum spacing with those at the Helmholtz spacing. For the latter spacing we measure the length of uniform field to the point where the field falls to twice the designated variation below the central (maximum) field. A 40 to 50% increase in length of the uniform field is obtained by changing from the Helmholtz to the optimum spacing. Thus the new spacing is distinctly superior, unless field uniformity far off-axis is equally important as on-axis field uniformity.

* Supported by the National Science Foundation.

¹ Frederic R. Crownfield, Jr., Rev. Sci. Instr. 35, 240 (1964).

² Arthur H. Firester, Rev. Sci. Instr. 37, 1264 (1966).

Exploding Wire System with *in Vacuo* Preparation of Lithium Wire*

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AN extrusion die-electrode combination developed by Oktay¹ has been used to provide *in vacuo* extrusion of a 0.005 cm lithium wire for an exploding wire system. *In vacuo* extrusion prevents contamination of the wire and should provide a cleaner spectrum with less continuum radiation, which is essential for studying scattered light. It also allows a higher system repetition rate by avoiding a pump-down phase.

An overall schematic of the system is shown in Fig. 1. The total system inductance is 230×10^{-9} H giving a period of 11.2 μ sec. Normal operation is at a pressure of 10^{-5} mm Hg and a charging voltage of 1 to 20 kV. A typical range of reliable operation without adjustment for the spark gap switch is from 4 to 10 kV, but this by no means represents the optimum operation of this type of switch.

As can be appreciated, the main problem with *in vacuo* extrusion of the lithium wire is not the extrusion itself, but the preparation of a straight wire which is connected to

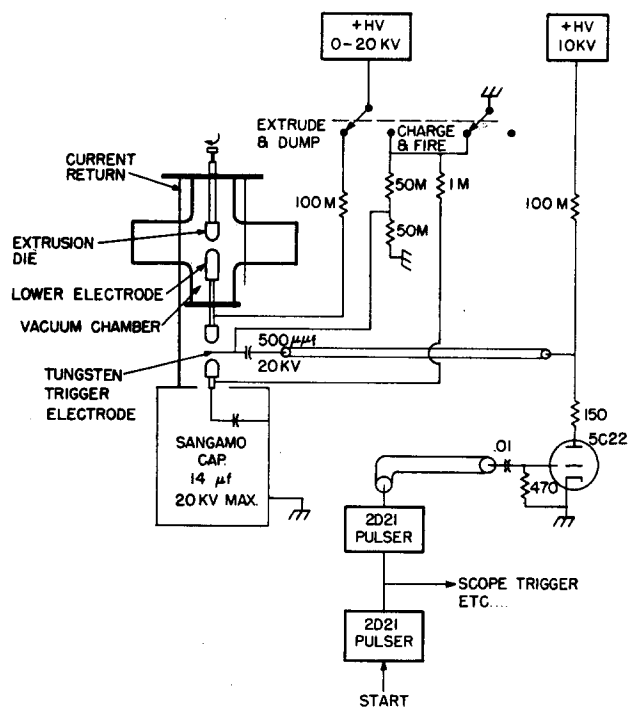


FIG. 1. Schematic diagram of the exploding wire system.

both electrodes. The extrusion mechanism shown in Fig. 2 uses a simple O-ring sliding seal around a hardened steel rod which is forced down on the lithium in the extrusion die-electrode by the screw at the top. A potential difference of several kilovolts between the extrusion die and the lower electrode in the vacuum chamber is used to hold the lithium wire between the electrodes and also to stretch the wire straight. It is necessary that the pressure be less than 10^{-4} mm Hg (in air) to maintain this voltage with minimal current. Obtaining a straight wire requires some dexterity in the manipulation of the high voltage and the extrusion pressure on the lithium. Normally 1 or 2 kV is used while the wire is extruded to a point about 2 mm above the lower electrode. The pressure on the lithium is then released and the voltage is raised to about 5 kV. This pulls the wire down to the lower electrode and once it makes contact it tends to stay in place.

Charge accumulation on the inside glass walls of the vacuum chamber will cause the wire to swing towards the wall if the potential between the electrodes is released before the wire has contacted the lower electrode. These charge accumulations can also cause a slight bowing of the wire once it is in place. This problem can be eliminated with a grounded metal grid around the wire or a conducting coating on the inside of the vacuum chamber near the wire.

After some practice it is possible to obtain a useful wire 50% of the time. Those wires which are not suitable because of kinks or deviations from the optical axis of the system are vaporized with an 8 μ F capacitor charged to 400 V.

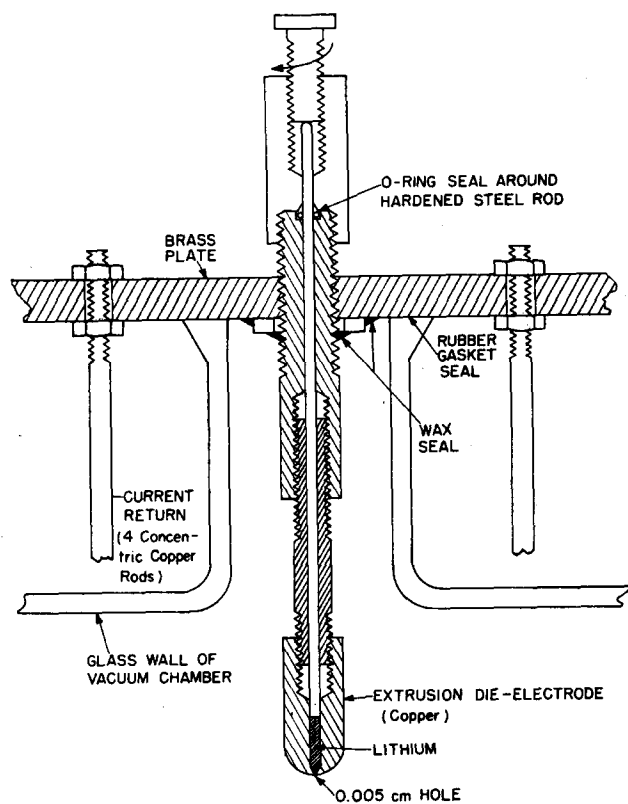


FIG. 2. Scale drawing of the vacuum extrusion mechanism.

The author would like to acknowledge the many suggestions by E. Oktay which were incorporated into the design of the vacuum extrusion mechanism.

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¹ E. Oktay, D. R. Bach, and W. Rekwitz, "Extrusion Die-Electrode Combination for Exploding Lithium Wire," *Rev. Sci. Instr.* **39**, 924 (1968).

Electrical Calibrator for Calorimetric Systems*

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IT is usual to calibrate a bomb calorimetric system by burning standard benzoic acid under prescribed conditions.^{1,2} The technique of comparison experiments, utilizing a standard substance for combustion and reaction calorimetry, is eminently satisfactory and accounts accurately for all heat loss corrections. However, for many

calorimetric studies, particularly in heat capacity calorimeters, it is desirable to calibrate directly in terms of electrical energy. This communication describes a method which uses electronic components to provide a rapid and direct digital indication of the voltage across the calibration heater and the total coulombs passed through it. The procedures for the determination of the electrical energy equivalent of a calorimeter are thus simplified, while the measured performance of such a calibration system shows precision and accuracy comparable to that of the established techniques.

The measuring circuit, Fig. 1, makes use of a precision analog-to-frequency converter and an electronic counting unit for readout. These units indicate voltage directly when the counting cycle is gated for a precise number of seconds, as in measuring the potential across the heater R_h with switch S_1 in position 1 (Fig. 1). A source of constant voltage for the heater is assured by electronic regulation and a dummy heater, R_d . Continued observation of the voltage count permits accurate averaging of the voltage during an identical heating period at the conclusion of the calibration run. The voltage measuring circuit is calibrated by referring to a certified Eppley No. 100 cadmium cell prior to each use of the apparatus.

The total coulombs passed through R_h during the heating cycle, which may be of arbitrary duration, are displayed as the time integral of voltage across R_1 , a 1 Ω precision series resistor. By deactivating the internal time gating of the counter, the voltage across this resistor can be integrated. Until the heater switch S_2 is opened, the counter accurately integrates this with respect to time. Correction for the actual resistance value of R_1 then yields the total coulombs passed through the heater. Alternatively, simultaneous measurements may be carried out with duplicate analog-to-frequency converters and pulse counters.

This calibration system has been evaluated and exten-

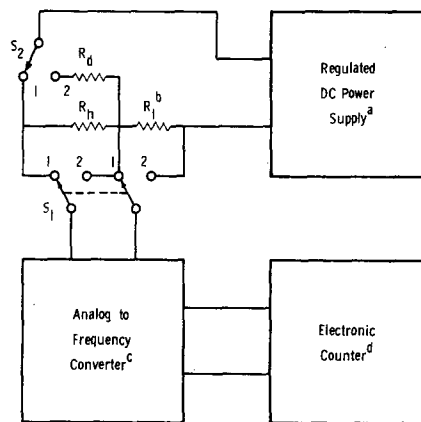


FIG. 1. Calibrator circuit diagram, with the following components: a—Lambda No. C-481; b—Leeds and Northrup No. 4205; c—Dymec No. 2210; d—Hewlett-Packard No. 521C.