Effect of Circuit Loading on the Production of Oscillations in Halogen-Quenched G-M Counters

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RECENT work at the Material Laboratory on halogen-quenched Geiger-Müller counters indicates that circuit loading affects the frequency and amplitude of the two forms of pulse oscillation described by Le Croissette[1]; namely, (a) oscillations in the amplitude of the pulses occurring just after the dead time, and (b) continuous oscillations. Previous work by the same author[2] had indicated that changes in circuit parameters had no appreciable affect on either form of oscillation, and that the oscillations of type (b) resembled sine waves and their production required a critical pressure of air as a counter gas contaminant. At the Material Laboratory three types of commercial halogen-quenched G-M tubes were investigated: two high-sensitivity tubes and one medium sensitivity. The latter and one of the former, operated at 700 volts, contained neon, argon, and chlorine at pressures of approximately 500,1, and 1 mm Hg, respectively. The third tube had a lower gas pressure, to permit operation at 300 volts. An analysis of pulse shapes, based on rise times, dead times, and the registration of spurious peaks was made using photographs, statistical techniques, and oscillographic measurements. The results indicate that the production and registration of spurious peaks are greatly affected by the loading conditions imposed by the circuit in which the G-M tube operates. The pulse rise time and tube dead time are affected to a lesser extent. Continuous oscillations were observed when the operating voltage was increased considerably. These oscillations were definitely not of the sine-wave type shown by Le Croissette as type (b), nor was air necessary as a contaminant. The continuous-oscillation type of waves had rapid rise times, (roughly, 1 microsecond for the 700-volt tubes, with an anode resistance of 1 megohm), and comparatively long decay times (approximately 20 microseconds). The 300-volt tube had longer rise and decay times. Pulse shapes resembling type (a) were observed, except that the amplitudes of the oscillations were a considerable part (as much as one-third) of that of the initial pulse, while the rise times were 1 to 3 times the initial pulse rise time. The shapes were affected by the associated circuitry.

These effects may be considered as analogous to the external loading of a gas discharge tube.[3] An equivalent G-M tube circuit may be represented by a nonoscillatory, series RLC circuit with the components representing the gaseous discharge effects of dissipation, inductance, and the analog of the ion sheath propagation respectively, in response to a step function input representing the analog of the discharge. The oscillatory pulses would have similar equivalent circuits, with different component values. A Laplace transform for the circuit describes the dynamic circuit characteristics, but the occurrence of oscillations is related to the reaction of the loading circuit on the quenching action of the G-M tube.

The following general conclusions may be drawn: (1) a decrease in resistance of the anode resistor, from an initial resistance of 6 megohms, increases the incidence of pulses with oscillations of type (a), and decreases pulse rise time and tube dead time. (2) As the capacitance across the G-M tube is gradually increased from a small value, the number of spurious peaks due to oscillations first decreases then increases, except at certain applied voltages, while the rise time increases steadily and the dead time is variously affected. (3) A parallel circuit consisting of resistance and capacity in series (in parallel with only the anode resistor) causes an increase in the number of oscillatory pulses, with various effects on the dead time and rise time. With circuitry which differentiates the oscillations, the majority of these oscillations will register as separate pulses.

The pulse oscillations are considered by Le Croissette to be caused by metastable states in the filling gas of the halogen-quenched tube. The present results indicate that the characteristics of the oscillations are determined in part by the circuitry associated with the tube, and that pulses of type (b) (continuous oscillations) may occur without the addition of air to the gas fill of the tube.

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Mechanical Device for Producing Density Gradients in Liquids*

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LIQUID density gradients are becoming of increasing importance in both the centrifugation and electrophoresis of biological materials.[1-3] For high resolution it is important that the gradients be smooth, reproducible, and of accurately known characteristics. Methods previously available for producing density gradients[4,5] have not been found satisfactory, partly because of the high viscosity of some of the solutions required, and partly because of difficulties in mixing and in controlling flow rates. Diffusion in layered systems may be used to produce smooth gradients,[6] but the time required in tubes containing 60–70 ml of sucrose or protein solutions is prohibitively long.

The problem has been solved for the present purposes by the use of a mechanical device (Fig. 1) which employs differentially driven glass syringes and a magnetic stirrer to mix the effluent liquids. The two upper syringes serve as evaporation-free reservoirs for filling the differentially driven syringes. The two syringes are moved by rods of length B which connect the syringe plungers with two arms of length R which are set 90° from each other on the same rotating shaft. In operation, the shaft connecting the two arms is turned only $\frac{1}{4}$ turn. The movement of each syringe as a function of the angle Φ which the

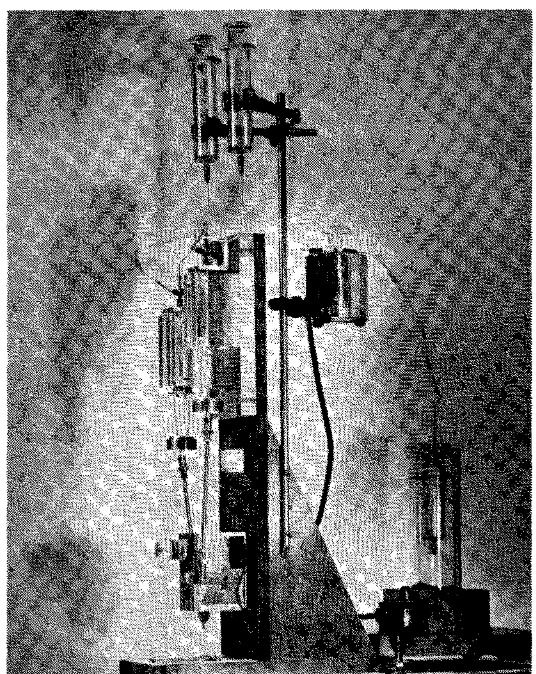

FIG. 1. Gradient engine (Model 3) as set to deliver a 60-ml gradient. Drive motor is mounted behind the triangular supporting plate.

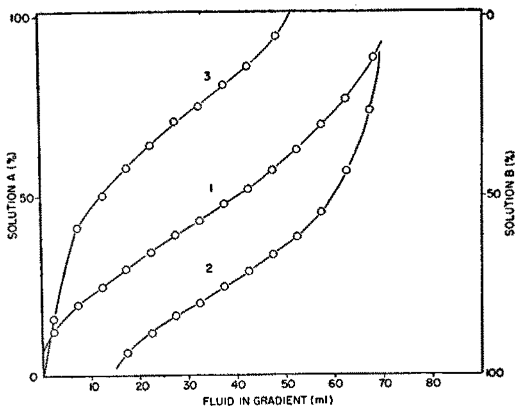

FIG. 2. Gradients obtained with various driving-arm radii. In curve 1 the radii are similar. In curve 2 the radius of the arm driving the syringe with solution A is 3.0 cm, that driving the solution B syringe is 5.9 cm. In curve 3 the radii were 6.0 and 3.0 cm for solutions in A and B syringes, respectively.

corresponding arm makes with the vertical direction may be calculated from the equation:

$$M=R\cos\Phi+[B^2-(R\sin\Phi-D)^2]^{\frac{1}{2}},$$

where M is the vertical distance between the rotating shaft and the upper end of the rod connected to the syringe plunger, and D is the horizontal displacement between the rotating shaft and the syringe axes. The characteristics of the gradient curve cannot be accurately calculated from this equation, however, since the lag caused by the volume in the mixing device must be considered.

The curves actually obtained by densitometric analysis of gradients produced by mixing two solutions, one of which contained a dye, are shown in Fig. 2. Similar studies have been made with sucrose solutions analyzed refractometrically. In curve 1, the radius of the driving arm R is the same for both syringes; curves 2 and 3 illustrate the results obtained when the radii are dissimilar. Considerable variation in the gradient is thus possible with the same device. Similar differences may be obtained by using two syringes of different diameter. The amount of fluid in the gradient may be varied by adjusting the radius R of both arms proportionately.

As shown in Fig. 1, the syringes are mounted between solid V-blocks of Lucite which distribute their pressure over the length of the barrel. Various clamps which were tried initially deformed close-fitting syringes sufficiently to make them bind. The syringes were lubricated with silicone stopcock grease.[7] The nose of each syringe projects through a metal stop which fixes the position of the syringe. The vertical mounting position allows air bubbles to be easily expelled. Filling is accomplished through metal stopcocks attached to two additional syringes mounted above the device. All connections are made through polyethylene tubing.

Mixing of the solutions is accomplished first in a stainless steel T of 18-gauge tubing which then connects with a 1.2 ml mixing chamber. This is constructed from a 3-mm straight bore Pyrex stopcock and contains a small glass-covered magnetically driven mixer. The light end of the gradient is delivered to the bottom of the centrifuge tube first, and the increasingly dense solution is run in underneath it.

A 2-rpm Bodine motor drives the shaft holding arms R through two reduction gears at the rate of one turn every 384 minutes, or 92 minutes for the slightly less than $\frac{1}{4}$ turn actually used. The worm which moves the drive-arm shaft is readily disconnected, allowing the syringes to be moved by hand for filling. All parts containing solution are readily removable for washing. An etched plate on the side of the drive-arm gear box indicates the number of worm gear turns and allows the position in the gradient to be accurately located. It is evident that extremely heavy construction has been used throughout. This has been found necessary because any small play in the syringe driving mechanism which alters even briefly the ratio of the speeds of the two syringes will seriously disturb the gradient. For convenience the device has been referred to as a gradient producing engine.

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Linear-to-Log Converter*

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IN the course of collecting single crystal x-ray diffraction intensity data for use in structure determinations, the optical density of each reflection spot must be determined. Of the many possible methods, we use an integrating Nonius Weissenberg camera to integrate the spot in one direction (omitting integration in the other direction to save time) and then we scan the spot normal to the previous integration direction with a Moll-type microphotometer whose output is traced with a Leeds and Northrup Speedomax linear recorder. Because of variation in spot width, the total intensity for each reflection must be obtained by integration of the potentiometer recording. Since the intensity is not a linear function of the ordinate, the integration is difficult, involving generally a replotting of the curve and integration by planimeter or a summation at discrete intervals. To eliminate possible errors resulting from the use of these methods, we have constructed from readily available components an integrator using a mechanical linear-to-log converter.

The integrator consists of a Westinghouse watthour meter with a guaranteed accuracy of 1% of full scale deflection, a 7.5-ampere Powerstat, a 500-watt heater, a constant speed, reversible drive for the chart paper from the recorder, and the linear-to-log converter.

The converter is a cam whose radius is proportional to the antilog of the angular displacement. A push rod carrying a pointer across the chart paper rides on the cam, which in turn is mounted on the shaft of the Powerstat. This converts the translational motion of the pointer into a rotational motion of the cam and Powerstat and thus into a voltage, which is proportional to the intensity represented by the ordinate height.

In operation, the chart paper with the densitometer recording is fed under the pointer at a constant speed (3 in./min) while the operator rotates the cam to cause the pointer to follow the curve. The output from the Powerstat is directed to the line coil of the

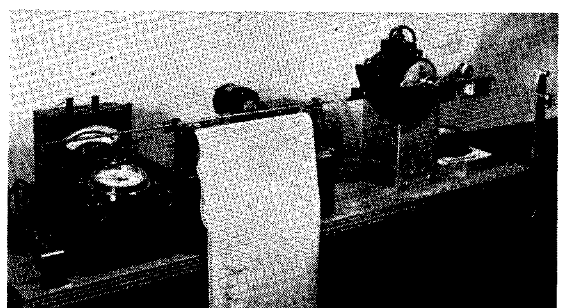

FIG. 1.