A review is given of a simple and economical method of generating high current electron beams in the range of a few hundred kiloamperes to multi-megamperes at voltages of from 100 kV to 1 MV. Mylar dielectric parallel plate transmission lines, switched with either solid dielectric spark gaps or gas spark gaps constitute the pulse forming network. Several such generators have been built that feed a 50 nsec width pulse through a low inductance insulator/vacuum interface to a field emission diode. The electron beam is generated in the diode region and accelerated through a thin window into a drift chamber. One such generator is described in detail.

General Description of Striplines

Generation of million ampere currents in pulses lasting tens of nanoseconds has been achieved with very high energy density pulse forming networks using reliable and convenient low inductance switching. The pulse forming network is composed of strip Blumlein transmission lines which are resonance charged by a Marx surge circuit. Such a Blumlein, Figure 1, may by analyzed as two transmission lines in series having the outer conductors continued to form a load line of matching impedance.

![Figure 1 Strip type Blumlein](image)

During the charging phase no voltage appears across the load because the opposing fields in the lines cancel each other. When the single switch located in one of the component lines at the end opposite the load is closed, the field in that line is reversed and the voltage into a matched load is equal to the charging voltage with a pulse duration twice the transit time of either line section. The strip transmission line is easy to construct and all the energy stored in the dielectric is available to the load. The linear current density into a matched load from a Blumlein is \( I / \sqrt{C} \) (MA/cm) and the energy stored in the generator at 350 kV is about 6.5 kJ.

While the dielectric-constant mismatch reduces the fields in the water adjacent to the body of the Mylar dielectric, it only partly alleviates high electric fields that may occur at the edge of a sharp conductor. To prevent breakdown of the water at such an edge, and the consequent tracking, which can occur over long distances on the Mylar, a liquid dielectric is used. After a trigger pulse, broke down in several parallel spark channels with a subnanosecond time constant.

![Figure 2 PML Generator Design](image)
electrode to which a fast rising pulse is applied. The switches can operate repeatedly with only occasional maintenance and are available over a large voltage range by simple pressure adjustment.

When the desired charge is reached, a self-breaking master switch is overvolted, and a pulse is injected into cables connected to the trigger electrodes in the gas slave switches. The synchronization of the gas switch closures and their inductance is such that the voltage applied to the diode has an e-folding risetime of 12 nsec. Voltage applied to the tube before the line is switched (prepulse) is reduced to less than one percent of the main pulse amplitude by adjusting the inductance in the charging leads from the Marx.

The electron accelerator tube must be capable of conducting 0.5 megampere for short times (50 nsec) and hence must have a very low inductance if it is expected to reach peak voltage during the pulse length. To minimize the inductance, the thickness of the solid insulator forming the vacuum container and the cathode plate - anode plate distances are made as small as possible consistent with an accelerating voltage of 500 kV while the insulator diameter was made as large as conveniently possible. The result, as shown in Figure 3, is an insulator 7.6 cm thick and 90 cm in diameter. The cathode-anode plate distance is 1 cm and the parallel surfaces are subjected to fields up to 500 kV/cm in vacuum. The cathode plate is oiled to suppress electron emission. Outside of the tube insulator a short, hollow, truncated metal cone connects the cathode plate to the negative output side of the generator.

The field emission diode typically consists of a 6.2-cm-diameter, 600 needle cathode and a 0.25 mil aluminized Mylar anode. Impedance of the field-emission cathode may be varied by calibrated adjustment of the anode-cathode spacing while the tube is under vacuum. During each shot the thin anode target ruptures and debris is scattered throughout the tube. The tube separates so that the anode plate, vacuum system, and experiment chamber lift off. The insulator is cleaned, all tube surfaces reoiled, and a new anode installed.

The field emission diode is a component due to the inductance of the cathode must be subtracted. Typical traces for diode voltage and current are shown in Figure 4.

Studies have been conducted to determine diode impedance as a function of anode cathode spacing and time. Current density has been determined as a function of time and position by utilization of a segmented Faraday cup as the anode. Also, experiments are being conducted in transporting and guiding the very high current electron beam.

The PIML facility is a reliable high current electron accelerator. Physics International has constructed two generators for the Defense Atomic Support Agency by paralleling modules similar to the PIML system. One of these, DML, produces an electron pulse of 100-keV mean energy, 300 kA peak current, and a FWHM duration of 40 nsec when operating into a matched load (0.3 ohm). The other, SNARK, was constructed to produce a 50 kJ beam and has a peak current of about 1 MA.

References