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## Flexible High-Voltage Supply for Experimental Electron Microscope

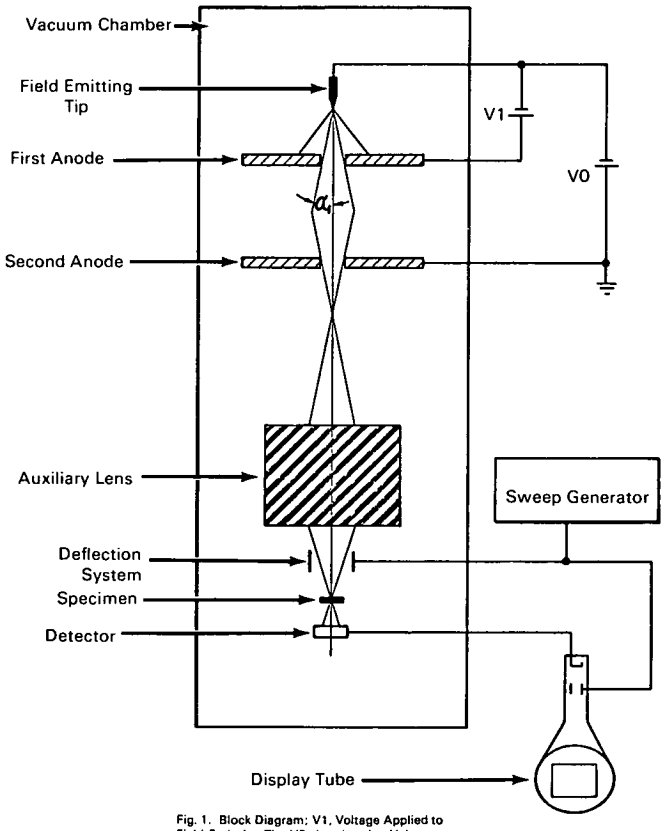


Fig. 1. Block Diagram: V1, Voltage Applied to Field-Emission Tip; V0, Accelerating Voltage

### The problem:

To develop a power supply to operate a new scanning electron microscope. Commercially available microscopes use high-voltage supplies typically providing output voltages ranging from 10 to 100 kv, output currents of 500 $\mu$a, and instabilities and ripples on the order of 10 parts per million (ppm). A filament electron source, referenced to the high-voltage terminal, is heated to the appropriate temperature with radio-frequency power supplied through a high-voltage isolation transformer. The new scanning microscopes, using field-emission sources and energy-analyzers, however, require modified power supplies.

(continued overleaf)

## The solution:

A system of power supplies for operating a new scanning electron microscope. The high-voltage supply is variable from 0 to 30 kv in steps of 0.58 v; it has a peak-to-peak ripple of 50 mv and an instability of 4 ppm/hr. A corona-free "hot top" provides ample space for circuits referenced to the high-voltage output, and includes a 0.6-to-1.6-kv supply for a field-emission electron source. This supply exhibits an instability of 20 ppm/hr and a peak-to-peak ripple of 10 mv. Use of rechargeable batteries as an energy source, within the hot top, eliminates noise and leakage problems typically encountered when high-voltage isolation transformers are used for this application.

## How it's done:

The new scanning microscope (Fig. 1) uses a field-emission tip for the electron source, a new electron gun that simultaneously accelerates and focuses electrons from the source, and one auxiliary lens to produce a final probe size at the specimen on the order of angstroms. Since electrons are emitted from the field-emission tip when the voltage is on the order of 1 to 3 kv, the conventional filament supply can be eliminated and replaced with a d-c-voltage supply. This supply is specified to have an output voltage variable from 0.5 to at least 1.5 kv with the vernier control having a resolution of 100 mv, to have an instability less than 20 ppm/hr and a peak-to-peak ripple less than 10 mv, to provide at least 100 $\mu$a while in regulation and to current-limit at about 1 ma, and to produce no overshoot when activated and to be operative with the high voltage (V0) applied.

The current from the field-emission tip usually ranges from 0.1 to 100 $\mu$a, but only a very small portion is allowed to pass through the aperture in the first anode and is used as beam current. In fact the leakage current and beam current, which typically total less than 0.05 $\mu$a, make up the entire load current on the V0 supply. The V0 supply is specified to be variable from 0 to 30 kv, with the vernier control having a resolution of at least 1 v, to have an instability less than 4 ppm/hr and a peak-to-peak ripple less than 100 mv, to provide at least 0.1 $\mu$a while in regulation, and to produce no overshoot when activated and to be undamaged by overloads.

Normal operation of the new microscope requires the two voltage supplies specified above. In addition the surface of the field-emission tip eventually becomes contaminated and requires periodic cleaning to keep the emission current stable. This cleaning entails pulsation of a current through the filament upon which the tip is mounted; the contaminants are boiled off by conduction heating. The tip flasher is specified to deliver a current ranging from 6 to 10 amps, to have a compliance voltage of at least 10 v, to provide a current pulse adjustable in width from 0.05 to 0.5 second, and to be operative while the high voltage V0 is applied.

In addition the new power supply is easy to service, includes an electrometer for monitoring leakage current or tip current, and provides space and power for additional circuits referenced to the high-voltage terminal.

## Notes:

1. Manufacturers or modifiers of electron microscopes may be interested.
2. Inquiries concerning this innovation may be directed to:

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## Patent status:

Inquiries concerning rights for commercial use of this innovation may be made to:

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