Welding by beams of electrons
Small particles mean big business

Take a small rod of tungsten and place it in a vacuum. Form the emitted electrons into a beam with electric fields. Then pass the beam through a hole in a positively charged plate. With magnetic or electric fields, focus the beam and position it on a target.

This recipe was used a century ago to produce a beam of electrons in the historic cathode-ray experiment which serves as the starting-point of knowledge of the electron.

The Crookes' tube experiment for cathode-rays has gone a long way since 1879. Heating the cathode and adjusting the accelerating voltage on the tungsten cathode and the beam current — a measure of the flow of electrons in the beam — permits this basic apparatus to be used as an electron microscope able to magnify objects over 50,000 times. It also can be used as a television picture tube or oscilloscope (the target then being a fluorescent screen), as an analytical apparatus using electron diffraction, as an X-ray microprobe or as an apparatus for machining, melting and refining metals.

Aided by operating grants from the National Research Council of Canada, a team of engineers from Carleton University in Ottawa is putting the Crookes' tube principle to yet another use — electron beam welding. Dr. J. A. Goldak, Dr. M. J. Bibby and G. A. Burbidge form the nucleus of the only laboratory in Canada working on applications of electron beam technology. With a pair of electron beam welding (EBW) facilities which they designed and built — to their knowledge the only laboratory-built ones in Canada — they are exploiting EBW in a variety of ways, thereby stirring up interest among several Canadian and foreign firms.

"The basic design was developed by Crookes in 1879," Dr. Goldak says. "Patents on these systems were taken out as long ago as 1905 and Von Ardenne in the 1930s gave a good conceptual description of the process. However, the commercial development of electron beam welding did not take place until the 1960s. We had a valuable answer just looking for the right question."

In just six years, this team has amassed an impressive list of accomplishments in electron beam technology. The range of their successful applications could well serve as a broad base for establishing an EBW expertise for Canadian industry. A few examples will serve to indicate the potential of electron beam technology.

● The research group at Carleton was the first in the world to study rock drilling with electron beams. Dr. Goldak's mining experience provided the thrust to enter this field which is now being rapidly developed by American scientists.

"The electron beam cuts rock like a hot knife cuts through butter," Dr. Goldak says. "A hole one inch deep can be cut in rock in a few seconds and this is done almost noiselessly. Electron beam rock drilling could eliminate almost all blasting in urban areas — only the crackle of the electron beam would be heard. It has enormous potential for drilling, mining, quarrying and digging tunnels."

● A study of the electron beam welding of rails was carried out by the Carleton University team in collaboration with Canadian National. EBW would cost much less than flashbutt welding and one-thirtieth of the thermite method. The Carleton engineers developed the EBW techniques to weld rails with whatever mechanical properties (strength, toughness, resistance to fatigue) the railway specified.

● Dr. Goldak and his associates have manufactured the first electron beam welded microwave filter. Only certain wavelengths of high-frequency radio waves can pass through this filter. The performance of the filter depends on the mechanical accuracy of construction and particularly on the weld and consequent electrical conductivity in joints between thin foils of metal and the walls of the filter. There are 36 of these welds, along with eight other welds in each filter. This microwave filter was produced at Bell-Northern

G.A. Burbidge with electron beam welding apparatus at Carleton University. ● G.A. Burbidge et le dispositif pour SFE à l'Université Carleton.
Heat exchanger constructed with electron-beam welding. ● Echangeur de chaleur, construit au moyen du soudage à faisceau électronique.