ACCELERATOR CONFERENCE

an exchange of information on low-energy accelerator techniques in physics and industry

Cambridge, Massachusetts, October 14–16, 1958

A Report by **Fay Ajzenberg-Selove**

THE conference, organized by High Voltage Engineering Corporation (HVEC), had two aspects. One was that described by the subtitle above, and the other, perhaps the more immediately exciting one, was the discussion of the capabilities of a new physics tool of extreme importance, the tandem generator. The conference was held at the Commander Hotel in Cambridge at a time when the air is crisp and the leaves beautifully colored and Cambridge appears as entrancing and exotic as any of the locales of any of the conferences reported in *Physics Today*. About two hundred and fifty people attended the meeting. The interests of the participants were about evenly divided between basic and applied physics.

On the first day of the conference, Prof. Van de Graaff (Massachusetts Institute of Technology and HVEC), introduced by J. G. Trump (MIT), gave an excellent presentation of tandem techniques.

Tandem generators, which are built by HVEC, are extrapolated, subtle versions of the common basement variety of Van de Graaff generators which no self-respecting laboratory seems to be without these days. For instance, a two-stage tandem accelerator, illustrated in Fig. 1, consists essentially of two ordinary 5–6.5-Mev Van de Graaff generators horizontally aligned in a single tank and with a single high-voltage terminal. Positive ions from an r-f source are accelerated through 40 kev, and then pass through a canal containing gas at low pressure. The positive ions pick up electrons; most pick up enough electrons to become neutral; a few become negative ions. These negative ions are then accelerated to the positive high-voltage terminal, acquiring 5–6.5 Mev. At the high-voltage terminal, the negative ions pass through a stripping tube filled with oxygen, and with very high probability they become positively charged[1]. The positive beam is then accelerated to ground through another 5–6.5 Mev, and after passing through the usual analyzing magnet hits the target with an energy of 10–13 Mev[2]. Assuming 13 Mev to be the energy acquired by a hydrogen ion, helium ions could acquire an energy of 19.5 Mev and oxygen ions an energy of 58.5 Mev! But more elaborate tandems are already being planned: the four-stage tandem accelerator, pictured in Fig. 2, of Rube Goldbergish complexity, would impart 26 Mev to hydrogen ions and 117 Mev to oxygen ions. There are even plans for a 200-Mev Cl beam!

Such machines are very important: intense beams of particles whose energies are high, easily variable, and precisely determined will revolutionize research in nuclear structure. Tandem beams will mean that the level structure of the heavy nuclei can be studied accurately and extensively for the first time, that new

Fay Ajzenberg-Selove is Associate Professor of Physics at Haverford College, Haverford, Pennsylvania. She has been studying the level structure of light nuclei, principally in collaboration with Prof. T. Lauritsen of California Institute of Technology. Dr. Selove is the editor of *Nuclear Spectroscopy*, a book to be published by Academic Press in 1959.

[1] The use of negative ions and the tandem principle were first suggested by W. H. Bennett in 1937. Further work was done by L. Alvarez in 1951 and by R. G. Herb's group over the last few years.

[2] For a more comprehensive discussion of tandems, see, e.g., J. L. Danforth, *Canadian Electronics Engineering*, July 1958.

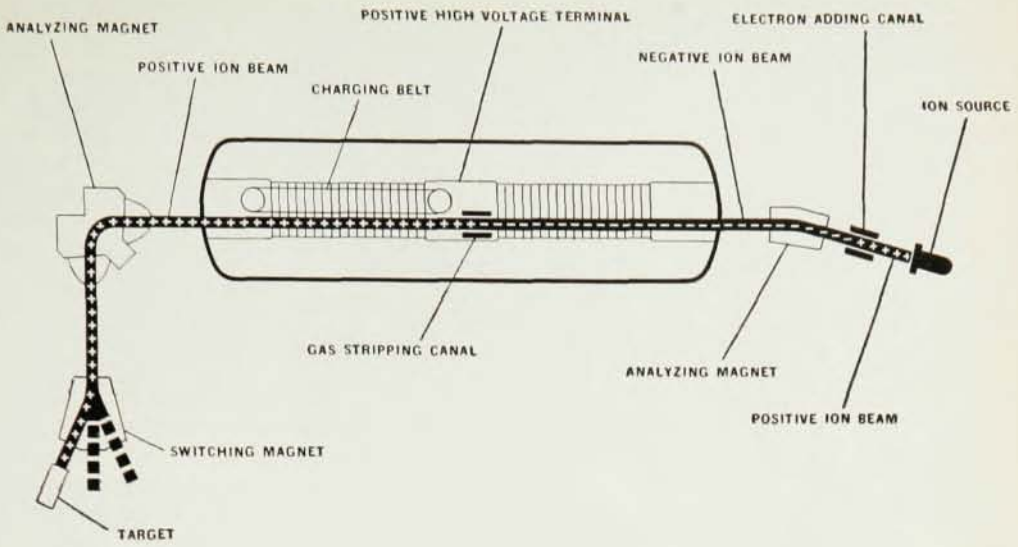

Fig. 1. Two-stage tandem accelerator.

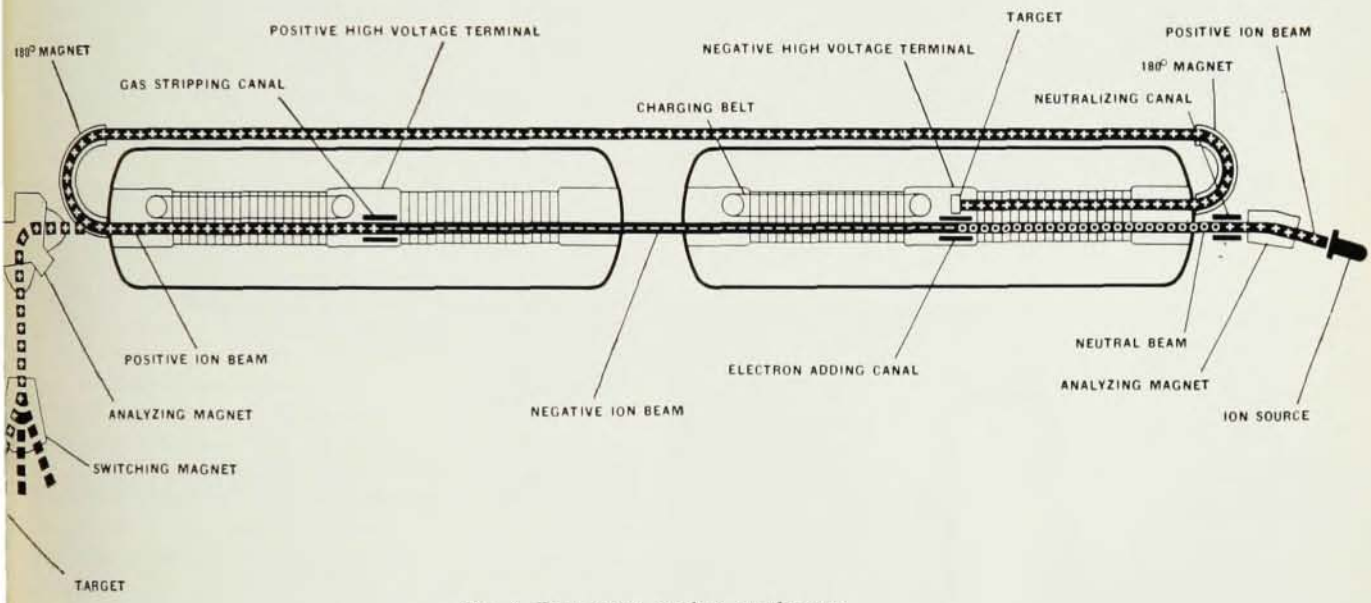

Fig. 2. Four-stage tandem accelerator.

nuclides can be created and studied through endoergic reactions, that scattering studies can be carried out continuously over large energy ranges, that reaction mechanisms can be studied in detail as a function of energy and with a wide choice of incident and outgoing particles. All these studies, and many more, will change and amplify our ideas of the structure of nuclei. This will be of importance not only to physicists engaged in basic research but also to the many scientists working in astrophysics and in fusion, fission, and industrial research whose interest in "low-energy" accelerators was demonstrated once more at the conference. The first two-stage tandem is operating at the Chalk River Laboratory of Atomic Energy of Canada. Tandems are also being constructed for Wisconsin, Florida State University, Caltech, and Australia. With these laboratories already embarked on tandem programs, and half a dozen other laboratories actively considering the purchase of the machines, which, including building and initial equipment for a two-stage machine, involves an initial outlay of about $\$1.5 \times 10^6$, the remarkable interest of the new tool is evident. The first experiments with a tandem have been performed. They were carried out during the performance tests of the first tandem[3].

The next speaker, F. Ajzenberg-Selove (Haverford), discussed gaps in the data on the light nuclei, stressing in particular the types of experiments which can be

[3] Gove, Kuehner, Litherland, Almqvist, Bromley, Ferguson, Rose, Bastide, Brooks and Connor, *Phys. Rev. Letters* **1**, 251, (1958).

R. J. Van de Graaff of Massachusetts Institute of Technology and High Voltage Engineering Corp.

Left to right: banquet speaker W. B. Lewis, W. W. Buechner, and F. Ajzenberg-Selove.

performed with Van de Graaff generators with energies less than 8 Mev. There are many interesting experiments which still remain to be done, but these are becoming increasingly complex. This complexity may make it somewhat difficult for new groups entering the field (due to the proliferation of low-energy (<3 Mev) Van de Graaff generators) to contribute usefully to it. Triton, He^3 beams, and, as was pointed out by S. K. Allison, Li beams are particularly convenient for low-energy work because of their large mass excesses which often yield high positive Q-values. The Chalk River group has been particularly ingenious in utilizing to the fullest extent possible their low-energy Van de Graaffs: E. Almqvist of Chalk River talked on the comprehensive work at that laboratory on He^3 reactions in the light nuclei[4]. The next speaker was H. B. Willard (Oak Ridge), who spoke on polarized beams.

In the afternoon there were talks on various techniques: measurement of neutron cross sections and resonance shapes (R. M. Williamson, Duke), neutron time-of-flight equipment (W. M. Good, Oak Ridge), subcritical assemblies (J. M. Hendrie, Brookhaven). On the second day, D. Luckey (MIT) talked about injection problems in high-energy machines, and R. L. Caldwell (Magnolia Petroleum Co.) discussed activation analysis—the nondestructive testing technique whereby the activation of rock samples when properly interpreted indicates whether an oil deposit is present or not. Papers were also presented by S. Rubin (Stanford Research Institute) on charged particle spectroscopy and analysis and by C. P. Sargent (MIT) on time-of-flight techniques with the MIT linear accelerator (for which the injector is an electrostatic generator). There were further sessions on electron techniques and their applications to solid-state, chemical, and biological research (Walter Brown, Bell Telephone Laboratories, C. D. Wagner, Shell Development Co., H. L. Andrews and K. Wright, National Institutes of Health and MIT). On the third day there was a session on industrial irradiation techniques (F. W. Lampe, Humble Oil, D. A. Trageser, HVEC, and W. Van Winckle, Ethicon). The final session was a panel discussion on dosimetry, moderated by R. H. Ellis of *Nucleonics*, with C. Artandi (Ethicon), G. J. Atchison (Dow Chemical), and J. J. Mayernik (Merck), as panelists. Visits to the HVEC plant were also arranged.

Surprisingly there was sufficient time for questions, huddles, and the social amenities. Particularly pleasant were the cocktail party and the banquet at which Dr. W. B. Lewis of Atomic Energy of Canada spoke on Rutherford, the Geneva spirit, and the encouragement of basic research.

It was altogether a very useful conference, and those of us who attended are much in the debt of the organizers of the conference and, in particular, of D. M. Robinson and A. J. Gale of HVEC. Copies of the proceedings may be obtained from High Voltage Engineering Corporation, Burlington, Massachusetts.

[4] Bromley, Almqvist, Gove, Litherland, Paul and Ferguson, *Phys. Rev.* **105**, 957 (1957).