One possibility of more effective utilization of beams from linear electron accelerators

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Modern accelerators, their beam guidance system that determines the organization of the accelerator experiments, and the measuring apparatus are all expensive. Therefore the question of effective utilization of accelerator installations is quite timely.

Figure 1 shows a schematic diagram of a linear electron accelerator. This diagram is standard regardless of the energy E_0 to which the electrons are accelerated. Since the electrons reach 0.99 of the speed of light already at ~3 MeV, the injector section, consisting of the electron gun, the buncher, and a short bunching waveguide with variable structure, constitutes a very insignificant fraction of the accelerator. Thus, the linear electron accelerator consists practically entirely of perfectly identical accelerating sections of fixed structure.

If the accelerator is not an injector for another machine, but is used for nuclear research, then the acceleration energy can vary in a wide range. In small accelerators ($E_0 \leq 100-150$ MeV), one uses as a rule only a "direct" beam, which emerges at the end of the accelerator, and the beam energy is varied by varying the microwave power applied to the sections. In large accelerators, rated hundreds of MeV and higher, to be able to work in different energy bands, it is customary to use in addition to the direct beam also electron beams extracted from part of the accelerator.[1]

From the point of view of the efficiency of accelerator utilization, this procedure is not optimal. When measurements are made on a beam extracted from part of the accelerator, the second part of the accelerator is simply not used. When the energy of the electrons in the direct beam is decreased, either one turns off some of the sections, which likewise do not take part in the acceleration process, or else the sections operate without utilizing the entire microwave power.

The accelerator utilization efficiency can be greatly increased in the following manner (Fig. 2). Since all the accelerating sections are similar in structure, the electron beam from the injector section can be introduced into any section along the accelerator, i.e., any group of sections can work as an autonomous accelerator. If additional injectors are installed to be able to inject electrons into any ith group of sections, separated by magnetic sections for beam extraction, then the accelerator can operate as several independent accelerators. The electron beams obtained simultaneously from different sections of the accelerator can in this case have maximum intensity I_0 which does not depend on the operating conditions of any other part of the accelerator.

Electron injection and beam extraction at several points along the accelerator offers a number of new possibilities that should be taken into account when new accelerators are designed.

1. An accelerator of this type is transformed, as it were, into an electron research center, consisting of a number of electron accelerators with different energy ratings.[2] The total operation time of the different beams can in this case greatly exceed the operating time of the accelerator.

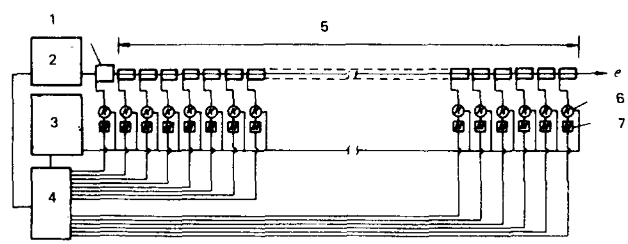

FIG. 1. Schematic diagram of linear electron accelerator.
1) Injector
2) Injector modulator
3) Microwave power exciter
4) Synchronization block
5) Accelerating sections
6) Klystron
7) Modulator

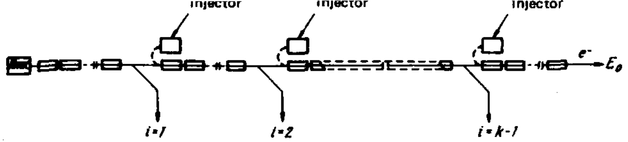

FIG. 2. Proposed system with more effective accelerator utilization.

2. The economy gained from such a utilization of the accelerator greatly exceeds the expenditure for the additional injectors and for additional beam-extraction rooms.

3. Since several investigations are usually carried out simultaneously with small accelerators having different energy requirements, such a system should be effective also for small accelerators, starting with 50—100 MeV.

4. The simultaneous presence of several intense beams with energies $\sim E_0/3$ or $E_0/4$ can be extensively utilized, without hindering the basic research, by groups working on applied problems.

The particular injectors can vary in type. It is advantageous to use for this purpose short injector sections rated ~2—3 MeV. The simplest, cheapest, and most reliable may be the injection system proposed in[1] (gun and accelerating resonator).

It should be noted that the possibility of injecting electrons in any gap between sections could offer the best solution of the problem of varying the energy of the accelerator beams. The transparent injector discussed in accelerator technology in connection with the linotron might turn out to be very convenient for this purpose.

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1) For example, the Saclay 600-MeV linear accelerator is provided with a room in which an electron beam of energy ~200 MeV is extracted.

2) For example, by dividing the accelerator into three equal parts: three accelerators rated $E_0/3$, two accelerators one rated $E_0/3$ and the other $2E_0/3$, or one accelerator rated E_0.

[1] V. A. Boĭko, R.M. Voronkov, and V.A. Danilichev, Zh. Tekh. Fiz. **44**, 888 (1974) [Sov. Phys.-Tech. Phys. **19**, 569 (1974)].