per ion pair will be decreased. It is hoped that some of the high values of "k" will be understood in the light of these remarks.

The results shown in this table indicate that the mobility is at least a factor of 10 smaller than would be expected from the theory of Frohlich and Mott.[3] From this theory it can be calculated that the mobility is of the order of 2400 cm/sec. per volt/cm at 77°K. As indicated above, these results should not be considered as constants of the material since neither the strain pattern nor the purity of the crystals is known. The energy per ion pair in a favorable case (E) has been observed to be as low as 13 to 16 electron volts per ion pair. This value is about twice as large as that given by van Heerden. For the reasons given above, this result should be considered only as an approach to the true value.

All crystals have been obtained from the Harshaw Chemical Company and were made by H. C. Kremers.[4] Crystals A, B, E and crystals C, D were received in two separate groups from Harshaw. Another crystal not shown in the table, which was received in still another shipment, showed no pulses larger than noise, even though it was annealed.

Essentially all of the above information was given by one of the authors (R.H.) at the Symposium on Short Pulse Techniques and High Speed Counters held at the Brookhaven National Laboratory, August 14 and 15, 1947.

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The "Gigator"[1]—a Proposed New Circular Accelerator for Heavy Particles

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THE synchrotron proposed by Veksler and McMillan[2] seems at present to be suitable only in the form of the synchrocyclotron for the acceleration of heavy particles to high voltages.

In order to reach extreme high voltages with heavy particles it would, however, be a great advantage to possess a circular accelerator constructed essentially like the electron synchrotron but with an increasing frequency of the accelerating voltage and with an approximately constant orbit, for accelerating ions. It seems possible that above a certain voltage such accelerators both as regards weight and cost will be much more favorable than the synchrocyclotron used today. A practical realization of this idea meets with considerable difficulties, however, because of the large change in velocity of the ions (for instance in the ratio 1:15) and because of the resulting large frequency variations in the accelerating voltages which consequently occur.

Already in the beginning of 1946 the undersigned[3] (quite independently and without knowledge of the proposals made by Veksler and McMillan) proposed new accelerating machines similar to the synchrotron. The proposals involved also a new method for overcoming the aforesaid difficulties. This is achieved by selecting the increasing frequency of the accelerating voltage to be M times higher than the circulating frequency of the particles, the multiple M being reduced in sudden steps as the particle velocity increases, that is, as the particle frequency increases. If, for instance, the accelerating frequency can be varied 25 percent by some mechanical means, then the multiple M may have the values 25, 20, 16, 13, 9, 8, 7, 6, 5, 4 in succession, and in this way a velocity range of 1:7, 8 (corresponding to a voltage increase for protons from 1 to 67 mv) can be dealt with.

The accelerating frequency must in this case be modulated according to a saw-tooth curve (i.e., a timely, relatively slow rise and a rapid fall).

This method can, of course, be used with any success only when it becomes possible to bring the ions from one synchronous condition to another synchronous condition (with smaller multiple M) without an excessive loss of ions.

This transition can be achieved very simply and with a minimum of phase disturbance to the ions if two separate accelerating systems accelerate the ions alternately. The two accelerating systems may then, for instance, work with the successive multiples $M=25$–16–9–7–5 for the first system and $M=20$–13–8–6–4 for the second system. To begin with, the particles shall be accelerated from the first system with $M=25$ and then (when the velocity and the frequency have increased to 125 percent) suddenly change over to the second system where they are now accelerated with $M=20$. Next the particles will shift back to the first system again, being now accelerated with a multiple $M=16$, and so on. During the transition period the first high frequency generator (with the large multiple) has to be de-excited, while the second generator (with the lower frequency and correspondingly smaller multiple) is energized to the full accelerating voltage. Since both accelerating voltages, even if they are "synchronous," may have a certain phase difference during the transition period, a small frequency change in the resulting accelerating voltage can occur during this time. This frequency variation can, however, be made considerably smaller than the limiting value dictated by the limit of stability of the phase oscillations, so that presumably a large part of the ions can be brought into the new synchronous condition.

The choice of a high multiple M for the accelerating frequency has the additional advantage (which may also be of interest as regards the electron synchrotron) that the phase oscillations become correspondingly smaller and also the radial oscillations $\Delta R/Ro$ are reduced in the ratio $1:(M)^{\frac{1}{2}}$. The result of this is that a narrow magnetic guide field can be used, and the magnetic wattless power required for exciting the accelerator will be correspondingly smaller.

[1] 1 Gigavolt (GV) $=10^9$ volt.
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